READERS' PROBLEMS

"THE WIRELESS WORLD" SUPPLIES A FREE SERVICE OF TECHNICAL INFORMATION

The Service is subject to the rules of the Department, which are printed below: these must be strictly enforced in the interest of readers themselves.

A selection of queries of general interest is dealt with below, in some cases at greater length than would be possible in a letter.

Wasted Energy.

I have a 50-volt house-lighting plant, with a battery of accumulators. Would it be practicable and economical to charge my 6-volt L.T. battery from this source? V. W. P.

It would be practicable, but not economical. This is because more than four-fifths of the energy consumed from your battery would be wasted in heating the necessary voltage-dropping resistance.

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An Old Friend.

Have you ever published any constructional details of the band-pass filter arrangement shown in Fig. 1 (a) of the article entitled "Selectivity and Quality," which appeared in your issue of October 30th? If you have not, I should particularly welcome a word of advice as to the number of turns suitable for the inductance L_1, which, I assume, acts as a coupling between the two separate tuned circuits. E. B. C.

If you consider carefully the circuit diagram of several recent *Wireless World* receivers, such as the S.G. Regional set and the 1930 Everyman Four, you will see that the filter arrangement to which you refer is similar in essentials to the aerial-grid circuits of these sets. We have redrawn this conventional filter circuit, showing it in comparison with the aerial input arrangement of the sets mentioned in Fig. 1 (a) and (b) respectively.

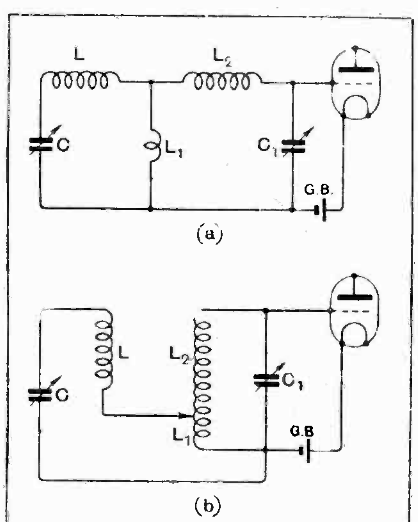

Fig. 1—Conventional inductance-coupled filter (a) compared with a popular aerial circuit arrangement (b).

It should be realised that the coupling inductance L_1 is common to both circuits, and, instead of using a separate winding for the purpose of coupling, one can make a tapping on to either of the tuning coils; this latter arrangement is that adopted in *The Wireless World* sets.

It should be pointed out that in the arrangement shown in Fig. 1 (b), inter-circuit coupling is not purely inductive, as there is also a mutual inductance effect, and it is only in this respect that there is difference between the arrangements.

Full details of the windings are given in the articles in which the receivers are described.

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0.0003 or 0.0005.

I notice that in the many two-circuit aerial tuners described in "The Wireless World" of late, a 0.0005 mfd. condenser is invariably used for aerial tuning. Is this absolutely necessary? I have several spare 0.0003 mfd. condensers, and should like to use one of them, if possible, in altering my present receiver. L. C. G.

Unless a fairly large condenser is used for aerial tuning, it will be found that it is impossible to cover the entire broadcast band without a change of aerial coil, this in spite of the fact that the disturbing effect of aerial capacity is to a certain extent removed by the usual practice of fitting a fixed condenser of 0.0002 mfd. in series with the aerial.

If you wish to use one of your present variable condensers for the aerial circuit, it will be found necessary to make provision for changing coils, or, alternatively, to use so small a series condenser in the aerial circuit that signal strength will almost certainly be considerably less than it need be.

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A Source of Electrical Interference.

I am puzzled as to the reason why I should be troubled by interference from my domestic electric light wiring, while my next-door neighbour, whose supply is from the same source, is quite free from this interference. Our houses are almost identical, the wiring systems are similar, and neither of us uses any electrical machinery or appliances other than lamps. Can you explain? F. D. R.

Very possibly there is an intermittent disconnection in your wiring, and we advise you to examine all switches, fuse boxes, junctions, etc. If these are in order, it is probable that your trouble is due to a failure of the earthing system, and you should make sure that the sheathing of the wires (or the metal conduit, if used) is properly "bonded" together and connected to earth.

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Why a Bigger Condenser is Necessary.

After handling a friend's receiver fitted with differential reaction, I decided to instal one of the new three-element condensers in my own receiver, and chose a capacity of 0.0001 mfd., which is the same as that originally used. The condenser is connected in the manner shown in your journal some time ago; but, much to my surprise, reaction control is not so good as it was before making the alteration; in fact, it is impossible to obtain oscillation except when the moving vanes are fully in mesh with the set of fixed plates which are in connection with the reaction coil. Do you think that the reaction windings of my coils are unsuitably proportioned for this method of control? J. W.

It must not be taken that the feed-back through a differential reaction condenser of 0.0001 mfd. is equal to that of a normal condenser. This is due to the fact that there is a by-pass effect, as the second stator is connected to earth; in consequence, there is less energy passed back through the reaction coil, except when the rotor is at the "full-on" setting.

We expect your trouble will disappear if you fit a condenser with a capacity of, say, 0.0002 mfd. between the rotor and each stator. We recommend this course because the larger capacity will probably improve detection efficiency, but, if you prefer it, matters could be improved by adding turns to the reaction coil.

RULES.

(1.) Only one question (which must deal with a single specific point) can be answered. Letters must be concisely worded and headed "Information Department."

(2.) Queries must be written on one side of the paper, and diagrams drawn on a separate sheet. A self-addressed stamped envelope must be enclosed for postal reply.

(3.) Designs or circuit diagrams for complete receivers cannot be given; under present-day conditions justice cannot be done to questions of this kind in the course of a letter.

(4.) Practical wiring plans cannot be supplied or considered.

(5.) Designs for components such as L.F. chokes, power transformers, etc., cannot be supplied.

(6.) Queries arising from the construction or operation of receivers must be confined to constructional sets described in "The Wireless World" or to standard manufacturers' receivers.

Readers desiring information on matters beyond the scope of the Information Department are invited to submit suggestions regarding subjects to be treated in future articles or paragraphs.

Job's Comfort.

Signals from the new 2LO spread over a fairly wide section of my tuning dials, and I have come to the conclusion that, unless I make a radical improvement to my receiver, the opening of the alternative programme station will entirely prevent reception on the lower part of the tuning scale, even if there is no mutual interference between the two transmitters. Before starting reconstruction of my set, I should like to ask you if it is logical to assume that interference from the new station will spread over a band of wavelengths of the same width as that occupied by the present transmission. R. T. S.

We fear that you are over-optimistic in making this assumption. It is proposed that the alternative-programme station shall work on a lower wavelength than that of the present 2LO, and, as the circuits used in ordinary receivers tend to become less selective at the lower end of the tuning scale, it will be found that the band of frequencies over which interference is present will be wider.

Using the High-power Pentode.

I am thinking of making the Foreign Listeners' Four, as described in "The Wireless World" for July 31st and August 7th, and should like to know if it would be possible to use a P.M. 24A. pentode valve in the L.F. position. If so, will you give me some idea as to the alterations that will be necessary? I can get a power transformer delivering 310 volts across each half of the high-tension secondary, and with suitable low-tension outputs. L. P. A.

There is no reason why the new high-voltage pentode valve should not be used in this receiver, and we give in Fig. 2 a circuit diagram showing the necessary modifications.

You will see from the diagram that the potentiometer controlling the screening grid voltage is retained; there would be no harm in increasing its value slightly in order to counteract the increase in current through it, which is due to the higher voltage delivered by the rectifier. It will be necessary to insert a voltage-dropping resistance in series with the feed lead for the H.F. valve anodes, and also to increase the value of the resistance provided in the original design for the detector anode circuit. It is advisable to decouple the screen circuit of the pentode in the manner shown, and, as you will doubtless realise, care must be taken to see that the low-tension windings of the power transformer which feeds the output valve filament is redesigned, in order that it may deliver a lower voltage suitable for the pentode filament.

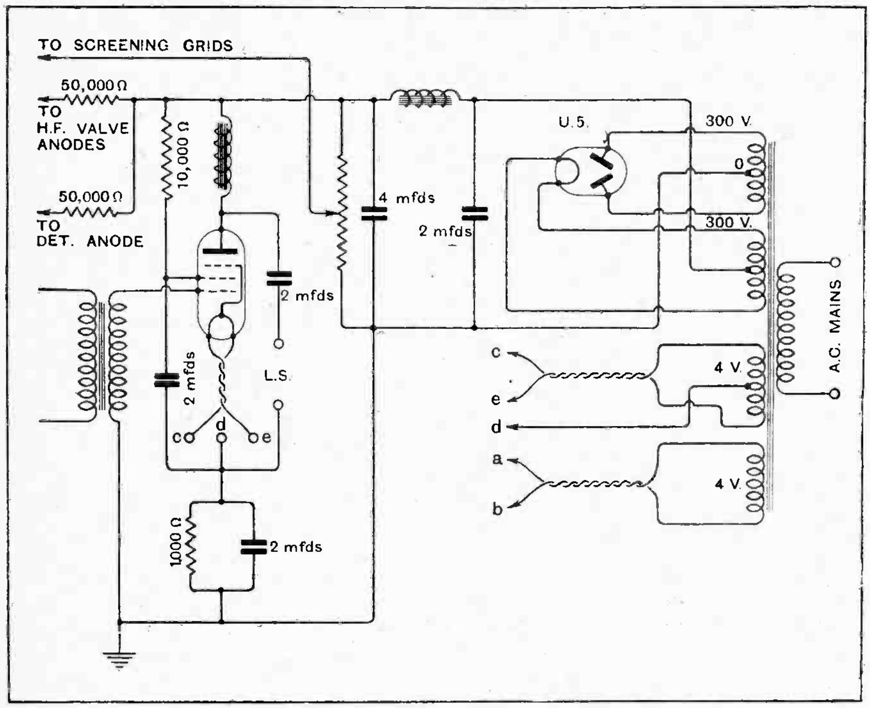

Fig. 2.—Super-power pentode output valve for the "Foreign Listeners' Four": diagram showing circuit modifications.

Side-band Loss.

Will you give me an idea as to the probable loss of side-bands in the "1930 Everyman Four" receiver? E. F. E.

It is not possible to give a definite answer to this question, as a good deal depends on the way in which the set is operated. As you will know, a coupled tuned aerial circuit is provided, and if the receiver is operated in such a way that there is a tendency towards double-humped tuning—but there should not be more than a mere tendency towards this effect—there is no reason why there should be any serious loss. Matters are so arranged in the design that there is a certain amount of "pulling" between aerial and secondary circuits, without the need for observing any special precautions in operation. This tends to correct any high-note loss in the tuned intervalve circuit, and the overall result is that the set gives "bright" reproduction.

Two Sets Compared.

Will you please give me an idea as to the relative selectivity of the "1930 Everyman Four" and the "Wireless World Kit Set"? Up to and including the H.F. stage, both receivers have many obvious points of similarity, and I am undecided as to which to choose. T. F. C.

Both these receivers are well above the average in the matter of selectivity, but there can be no doubt that the "1930 Everyman Four" is the better of the two in this respect. Not only does it include a more selective form of aerial coupling, but all the circuits in it are of lower H.F. resistance, and—as important as anything else—it makes use of anode bend detection, which always tends to prevent the spreading of unwanted signals, provided their strength is reduced by detuning to a value considerably less than that of the signals which it is desired to hear.

FOREIGN BROADCAST GUIDE.

KOENIGSWUSTERHAUSEN

(Zeesen) (Germany).

Geographical position: 52° 17′ N. 13° 37′ E.

Approximate air line from London: 588 miles.

Wavelength: 1,635 m. Frequency: 183.5 kc. Power: 30 kW.

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

Relays Berlin (Witzleben) and other German stations, but gives an alternative main evening programme; works throughout the day from 5.55 a.m. G.M.T. with talks, etc., including the following principal standard daily transmissions, G.M.T.:—

5.55 a.m. weather; 6 a.m. physical exercises from Berlin; 11 or 11.30 a.m. gramophone records; 1.30 p.m. children's hour; 7 or 7.30 p.m. main evening concert.

A male announcer. Call: *Achtung! Achtung! Hier Koenigswusterhausen und der Deutscher weltrundfunksender auf welle ein und dreissig komma acht und dreissig.* (This is Koenigswusterhausen and the German world transmitter on 31.38 m.).

When relaying Berlin, this station, as well as Magdeburg and Stettin, are included in the call.

Interval signal: Metronome. 120 beats per minute.

Closes down with the German National Anthem, played to the melody of the Old Austrian Hymn (Haydn).

Under the heading "Foreign Broadcast Guide," we are arranging to publish a series of panels in this form, giving details regarding foreign broadcast transmissions.

The Wireless World

AND RADIO REVIEW
(17th Year of Publication)

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CONTENTS OF THIS ISSUE.

VALVE DATA SUPPLEMENT.

WITH this issue we publish as a separate sheet a Valve Data Supplement, giving technical and other information regarding representative radio receiving valves on the British market.

Readers will find that the information published is very much more complete than anything which has hitherto been attempted, as, for instance, the inclusion of a column giving the A.C. power output in milliwatts of some eighty-five different valves. This information has not been available previously and should prove of very great value to those concerned with the design of receivers. The inter-electrode capacities of most of the screen grid valves are given and the maximum attainable stage gain of these valves, calculated on the basis of the inter-electrode capacity.

The inclusion in this issue of an article having special bearing on the Valve Data Supplement provides, it is believed, all the assistance necessary to readers who wish to make the best use of the information which the supplement contains.

VALVE SUPPLIES.

MANY readers have written to us stating that they have found it impossible to obtain certain valves of the new Mazda series, such as have been incorporated in the designs of recent *Wireless World* receivers, through the usual trade channels.

On enquiry from the manufacturers, we learn that the demand for these valves has been so great that it is impossible at present to issue adequate supplies to retailers, although we understand that the position is rapidly improving.

As a temporary measure, however, until production is able to cope with the demand, the manufacturers have kindly undertaken, at our request, to supply valves if readers of *The Wireless World* write direct to them at the Edison Swan Electric Co., Ltd., Service and Installation Department, 1A, Newman Street, Oxford Street, W.1, ordering the valves they require and stating for what *Wireless World* receiver they are to be used. It is essential that applicants should give the name and address of their local radio dealer. Valves will be despatched to readers by post, c.o.d., the charge being the usual retail selling price of the valves, plus cost of postage. Prompt application should be made for the valves by readers who wish to avail themselves of this opportunity, as this special arrangement can only be regarded as a temporary measure.

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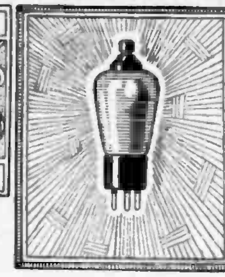
THE HAGUE CONFERENCE.

AN interesting report has recently been received of a statement made by the Chairman of the U.S. Delegation to the recent Radio Conference at the Hague on his return to Washington.

The statement would lead one to suppose that the American delegates had things very much their own way at the Conference. In his report the Chairman says: "The proposals and studies prepared in Washington last summer and sent out by the U.S. to all nations were taken as the basis of discussion at the Hague, and in almost every case were adopted, not always with our original wording, but with our original intent." The Chairman is also reported to have stated, "I think, perhaps, the splendid technical contribution made by the U.S. Delegation at the Hague in 1929 will enable the next meeting at Copenhagen, in 1931, to dodge the troublesome 'English' questions by authorising the use of the 'American' language instead of 'English.'"

It would appear that the U.S. attaches more importance than other countries to the question of obtaining a dominating position in International radio discussions.

MEASURING THE INTERELECTRODE CAPACITY OF SCREEN-GRID VALVES



Details of the Apparatus Used.

By T. H. KINMAN

(Of the British Thomson-Houston Company's Engineering Laboratory at Rugby).

THE importance of reducing the interelectrode capacity between the anode and control grid in screen-grid valves in order to obtain a degree of stable amplification at high frequencies is well known and has been the subject of recent discussion.[1]

A method of measuring this capacity was described by A. W. Hull and N. H. Williams in 1926,[2] and more recently another method has been described by N. R. Bligh, B.Sc.[3] The method described in this article is based on the substitution method, outlined by Hull and Williams, in that the valve capacity is determined by observing the capacity change required in a standard condenser connected in parallel with the valve capacity when coupled between an R.F. source and amplifier to obtain the same amplifier output reading when the valve capacity is removed. The bare theoretical circuit arrangement is shown in Fig. 1, in which the R.F. source is coupled to a screened amplifier A through the valve capacity C_v and standard variable condenser C. A meter M indicates the degree of coupling between the R.F. source and amplifier caused by the coupling capacities $C_v + C$.

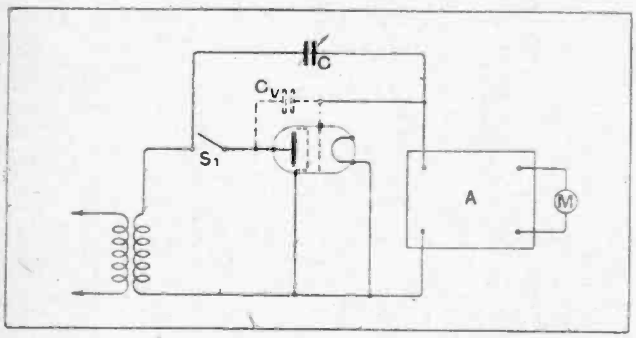


Fig 1.—Schematic diagram of apparatus used for the measurement of valve interelectrode capacities.

The meter reading is noted when both C_v and C are in circuit. When S_1 is open C_v is removed from circuit and C is then increased until the original meter reading is obtained. The *change* in capacity to produce this effect is equal to the coupling capacity of the valve and can be determined from the known physical constants of the condenser C which will be described later.

The three interelectrode capacities present in a screen-grid valve are represented in **Fig. 2** by C_{as}, C_{gs}, and C_v respectively, the value of C_v, which is desired, being but a small fraction of C_{as} or C_{gs}.

In testing this circuit it was found that the results obtained were not consistent with the above simple theory, the cause being traced to the shunting effect of the anode-to-screen capacity of the valve under test. The effect of this capacity when switched in or out of circuit is to react upon the R.F. source and alter the impressed voltage or frequency or both, so vitiating the readings. This effect was small with the early types of valves such as the Hull, or where the capacity C_v is relatively large, but with valves of the AC/S type, the anode-screen capacity is relatively larger and the coupling capacity C_v very small, therefore the effect of the former capacity must be taken into account.

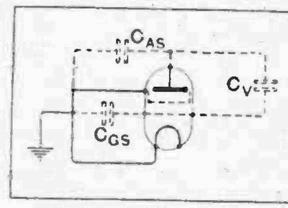


Fig. 2.—Equivalent circuit showing the three interelectrode capacities present in a screened valve.

This difficulty was overcome by using a small variable condenser C_1, as shown in Fig. 3, to replace the valve capacity C_{as} when the switch S_1 was operated, C_1 being adjusted to balance exactly the effect of C_{as} on the input voltage. In order to adjust C_1, however, it was necessary to remove the coupling through the valve to the amplifier when the switch S_1 connects the valve in circuit, otherwise the effect of the capacity coupling through C_v would be included in the balancing adjust-

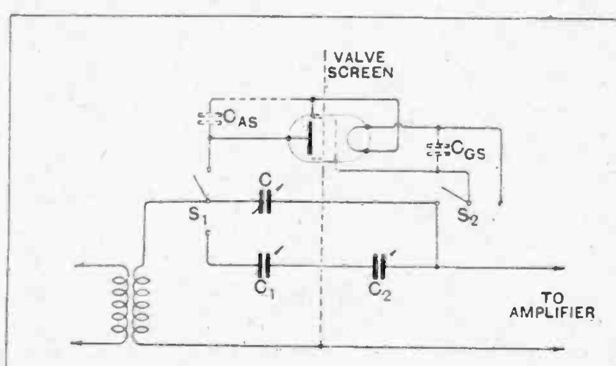


Fig. 3.—The circuit arrangement which was designed to overcome the shunting effect of the anode-to-screen capacity of the screened valve.

[1] See *Experimental Wireless*, June, 1929, page 293; also *The Wireless World*, July 24th, 1929, page 68.
[2] *Physical Review*, Vol. 27, April, 1926.
[3] *Experimental Wireless*, June, 1929, page 299.

Measuring the Interelectrode Capacity of Screen-grid Valves.—

ment. The coupling capacity C_v was, therefore, removed by means of switch S_2, which disconnected the control grid from circuit, a small condenser C_2 being provided to compensate for the removal of the valve capacity C_{gs}, which is normally in shunt with the input circuit of the amplifier. C_2 can, however, be dispensed with, but a compensating adjustment on the input tuning condenser would then be necessary. It was found more convenient to use a separate condenser as indicated in Fig. 3 for this purpose.

It is not overstating the case to say that the great strides made in stable H.F. amplification during the last year are, to a large extent, due to the advent of the screened valve with an interelectrode capacity of the order of one hundredth of a micro-microfarad or less. This progress has been greatly assisted by the design of highly specialised apparatus for measuring minute capacities. In the accompanying article an interesting description of such equipment is given.

It may be of interest to point out that whilst C_2 can obviously be made to equal C_{gs} in capacity, it will not usually include the H.F. resistance introduced by the valve, valve-holder, etc. The damping effect of C_2 on the input circuit of the amplifier will, therefore, be less than when C_{gs} is in circuit, and a larger output reading obtained. The magnitude of the reading for this adjustment is, however, immaterial, as will be explained later.

Description of Apparatus.

The complete circuit arrangement is given in Fig. 4. The H.F. oscillator needs no special description other than that it provided a constant high-frequency and output voltage across the coupling coil to suit the particular H.F. amplifier employed. The frequency actually used in these tests was 750 kilocycles. The variable condenser C was specially constructed for the tests. It consists of a brass tube as one electrode and a thin wire as the other, the capacity change being obtained by moving the wire along the axis of the tube and measuring the displacement on some convenient scale. In this particular case the wire was coupled by an insulating link to the movement of a standard micrometer which not only provided a scale, but also gave a very fine and accurate adjustment. Fig. 5 shows the appearance of this condenser. The capacity change per centimetre of movement was calculated from the following equation: $C = 1/2\left(\log_e \frac{R_1}{R_2}\right)$; where C is the capacity change per cm. length; R_1 is the radius of tube electrode, and R_2 the radius of wire electrode.

In constructing such a condenser, certain precautions are necessary:—

(1) The electric field between the electrodes must be confined inside the tube. This is effected by suitable external screening.

(2) The "fringing" capacity between the ends of the tube and wire must be practically constant over the working range of the condenser, and must also be small compared with the true radial capacity between wire and tube, i.e., the tube must be long and the axial movement of the wire a fraction of its length within the tube.

It will be understood that the adjusting mechanism must be insulated and well screened from both electrodes, whilst the earth capacity of the wire which projects outside the tube must be constant. The wire itself must also move without deviation along the true axis of the tube. The condenser shown in the photograph had a capacity change of 0.01075 cms. per revolution of the micrometer, and this was sub-divided to give a fine adjustment of 0.00043 cms. variation for 1/25th of a revolution.

The switch S_1 was of the so-called anti-capacity type, having the additional feature of a screening member

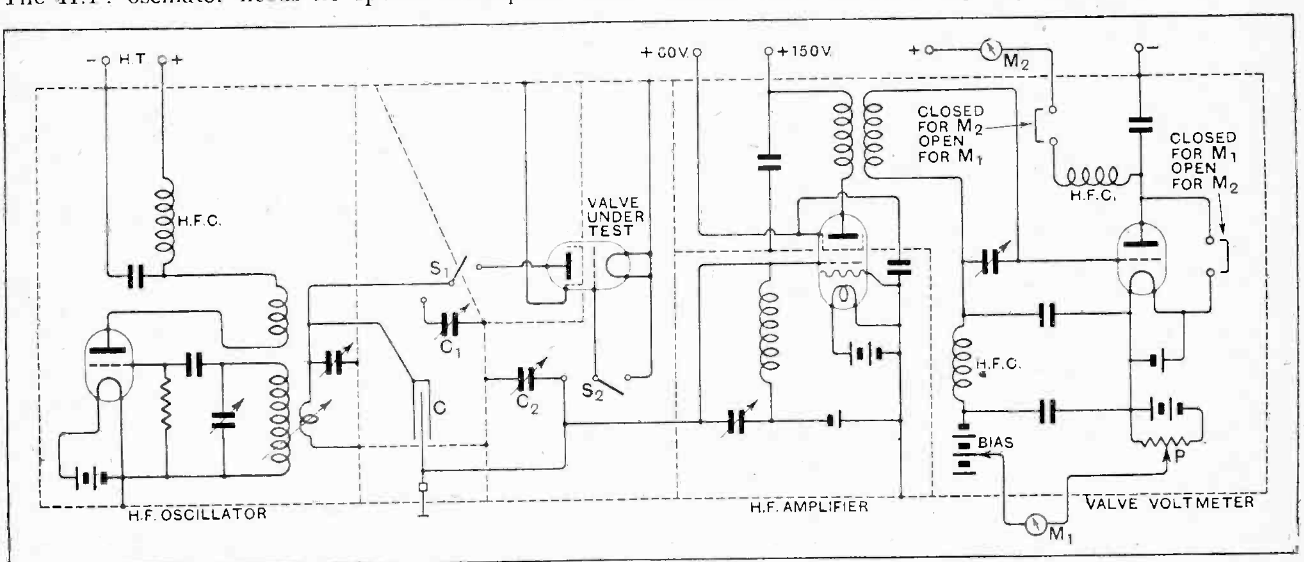


Fig. 4.—Complete circuit diagram of equipment containing essentially a valve voltmeter, H.F. amplifier, valve under test and an H.F. oscillator.

Measuring the Interelectrode Capacity of Screen-grid Valves.—
between the moving contact and the fixed contact which connects to the anode of the valve under test. A slit was cut in this screening member to allow of the passage of the moving contact. The mounting of the valve under test required some attention to ensure that all the electrostatic coupling between anode and control grid was inside the valve. In practice, a metal partition is usually provided with a circular hole through which the valve is inserted, thereby screening the wire connection to the anode from that to the grid. In the present arrangement a double screen was provided to allow valves of differing lengths being used without alteration to the screening.

Certain types of valves, similar to the Hull construction, require an earthed metal screen over the entire bulb. In fact, the capacity C_v can be reduced to some extent in any valve by completely covering the bulb with tin-foil and earthing it. The external screen apparently neutralises the coupling effect of the magnesium coating inside the bulb, which may, in some cases, extend from the anode terminal round to the pinch to which the control grid is anchored. In some types of screen-grid valve the magnesium coating is earthed by the makers. When this is the case, an external bulb screen, as distinct from partitioning screen, will obviously be superfluous. The radio-frequency amplifier consisted of only one tuned H.F. stage and employed a Cosmos AC/S valve, which enabled a circuit amplification of well over 100 : 1 to be obtained. A multi-stage aperiodic amplifier would have certain advantages over the tuned type, providing the overall amplification was of the order mentioned. The indicating meter M_1 was a microammeter in series with the grid circuit of a negatively biased triode, and not only served as an indicator but also measured the voltage developed across the tuned circuit by noting the bias voltage required just to bring the meter pointer to zero.

A more sensitive indicator was found desirable when measuring valves of the smallest capacity, and this was provided by connecting the same or another microammeter M_2 in the anode circuit of the triode. This latter arrangement does not give a direct voltage reading without calibration, but removes the damping on the tuned output circuit by eliminating the necessity of grid current flow through M_1. A greater output voltage will, therefore, result, apart from the added μ of the triode. The potentiometer P was used for adjusting the meter to some convenient setting on its scale whilst making the measurements.

Method of Operation.

The amplifier was tuned to the frequency of the oscillator and adjusted so that the maximum output voltage and negative bias could be used on the valve voltmeter without overloading the H.F. amplifier. This was done with switches S_1 and S_2 closed to include the valve coupling capacity C_v, *i.e.*, S_1 upwards and S_2 to left-hand contact. The next step was to adjust C_1 to the value of C_{as}. With S_1 closed to the anode (upwards) and S_2 on the right-hand contact, condenser C_2 was increased to replace C_{gs} until substantially the same meter reading was obtained. Switch S_1 was then closed to C_1 (downwards) and C_1 adjusted until the same meter reading was shown. This gave the correct setting for C_1 as a substitute for C_{as}. S_2 was then closed to the left and C_2 reduced to zero or to its original setting. The meter reading was now noted. Switch S_1 was now thrown up, putting the valve capacity C_v in parallel with C, which was reduced until the previously noted reading was again obtained. The value by which C had to be changed gave the required capacity of the valve.

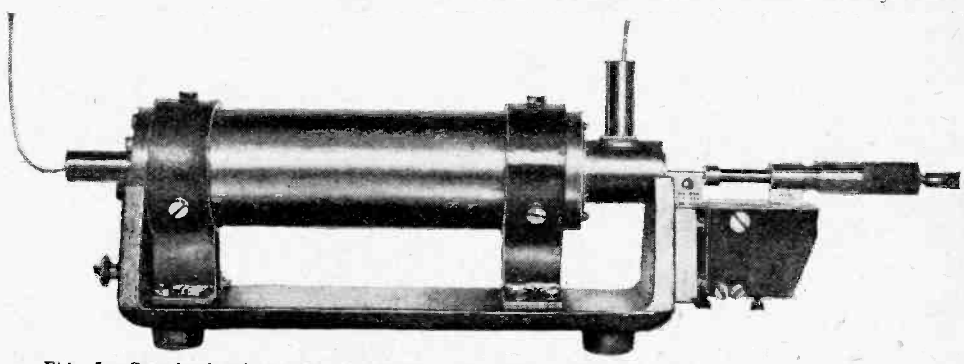


Fig. 5.—Standard micrometer condenser. The illustration shows the chassis supporting the condenser, and micrometer adjustment. The wire and tubular electrodes are inside and concentric with the screening tube seen in the photograph, and the terminal connections to the condenser are indicated by the two wires which project through the smaller screening tubes.

Precautions were found to be necessary, as erratic or

TABLE I.

Valve.	No.	Capacity ($\mu\mu$F).
Mazda 215SG	1	0.0085
	2	0.0086
	3	0.0072
	4	0.0067
	5	0.0072
	6	0.0089
Cosmos AC/S	1	0.0072
	2	0.0072
	3	0.0067
	4	0.0076
	5	0.0074
	6	0.0065
U.S.A. Hull Type	1	0.012
	2	0.012
	3	0.010
Hull Type AC/S	1	0.0095

Since the capacity measurements shown in the above table were taken, the Mazda 215SG and the Cosmos AC/S (now called the Mazda AC/SG) valves have been altered in construction and the interelectrode capacities have been reduced respectively to 0.005 cms. and 0.0045 cms.

Measuring the Interelectrode Capacity of Screen-grid Valves.—inconsistent readings are sometimes caused by high resistance paths between the various electrodes inside the valve, and may even prevent the capacity of the valve being measured. It was, therefore, found advisable to subject each valve to a high voltage insulation test between the different pairs of electrodes before capacity measurements were attempted.

Results Obtained.

A large number of valves have been tested with the apparatus described, covering values from 0.100 cms. to 0.0017 cms. capacity, the accuracy obtained on the lowest figure being within 10 per cent. Table I gives results of measurements made on stock Mazda and Cosmos valves, and includes also capacities of some American type valves which may be of general interest.

An important point in connection with screen-grid valves which does not appear to be generally realised is that the interelectrode capacity should be reasonably uniform between different valves of the same make and type, otherwise when a valve is replaced instability may result.

In conclusion, it may be stated that capacity measurements have been made also on other types of valves mentioned by Mr. Bligh, the results on which agree generally with his. In fact, a method similar to his has been tested, using only 100 volts input and employing a calibrated R.F. amplifier voltmeter to compensate for the low output voltage. The writer is grateful to Mr. R. C. Clinker for his useful advice regarding the construction of the standard condenser, and has to thank the British Thomson-Houston Company, Ltd., for permission to publish the results of the work done in the Engineering Laboratory at Rugby.

NEWS FROM THE CLUBS.

A Record Junk Sale.

An exceptionally large number of components were disposed of at the Junk Sale organised by Slade Radio (Birmingham) at their last meeting. The Society is now appealing for more members, and it is thought that there must be numbers of enthusiasts in the Birmingham district who may be unaware of the Society's existence. Application for particulars should be made to the Hon. Secretary, 110, Hillaries Road, Gravelly Hill, Birmingham.

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Stations While You Wait.

An entertaining demonstration was given before the South Croydon and District Radio Society on November 19th, when Mr. Taylor, a former member, showed the capabilities of the Philips All-Mains 4-valve set. Scarcely a station named by members proved out of reach of this fascinating receiver, its only apparent shortcoming being its inability to receive signals without an aerial. It was shown, however, that even the merest apology for an aerial would suffice, as, indeed, was proved when the chairman himself touched the aerial socket and provided the audience with the pick of Europe's radio! The receiver embodies two screen-grid H.F. valves, leaky grid detection, and a pentode stage to the loud speaker, all valves being indirectly heated by A.C.

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

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New Society in Essex

The opening of the new Brentwood and Warley Wireless Club was celebrated in an auspicious manner on Wednesday last by a public debate on "The Merits and Demerits of the Brookmans Park Transmitter," which showed that the first of the regional stations is a subject of great interest to listeners in Essex.

New members will be warmly welcomed.

The Hon. Secretary of the Brentwood Club is Mr. M. B. Edwards, 38, Junction Road, Brentwood.

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How Metal Rectifiers Work.

A cinematograph display illustrating the use of metal rectifiers was given in the course of a lecture before the Kensington Radio Society on November 14th by a representative of the Westinghouse Brake and Saxby Signal Co., Ltd. At the Society's meeting on December 12th Mr. R. Waldo Emerson will demonstrate a 6-valve receiver. The meeting will be held at 8.30 p.m. at 20, Penywern Road, S.W.5.

Hon. Secretary, Mr. G. T. Hoyes, 71a, Elsham Road, W.14.

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Valve Mysteries Explained.

Valuable technical data regarding the design of radio valves was given at the meeting of the Muswell Hill and District Radio Society on November 20th by a representative of the Mullard Company. The fundamental principles of the screen-grid and pentode valves were described, and members received some useful hints which cleared up several mysteries.

Hon. Secretary, Mr. C. J. Witt, Coniston Road, Muswell Hill, N.10.

Set Wiring Explained.

The Queen's Park and District Division of the Wireless League are resuming their series of monthly meetings on Thursday, December 5th, at 8 p.m., when it is hoped to demonstrate the wiring up of a well-known radio receiver. Amateurs are cordially invited to attend these meetings, which will be held on the first Thursday in each month at 37, Enbrook Street, Harrow Road, W.10.

Full particulars of these and other interesting events gladly supplied by the Local Secretary, Mr F. Batho, at the above address.

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Sets of the Future.

Mr. Haynes, Assistant Editor of *The Wireless World*, recently lectured before a large audience of members of the Wembley Wireless Society, taking as his subject the question of selectivity.

In view of the interference now experienced from the new broadcasting station at Brookmans Park, Mr. Haynes's remarks were most helpful. Valuable suggestions were made for the cutting out of this station and receiving other stations quite near in the wavelength scale.

The lecturer also touched briefly on the forthcoming design of sets and outlined the modifications which will take place next year. From Mr. Haynes's remarks it was clear that we have not yet reached finality in the design of wireless receiving sets, and in the future their design and construction will call for considerable ingenuity from a mechanical as well as an electrical point of view.

Hon. Secretary, Mr. H. E. Comben, 24, Park Lane, Wembley.

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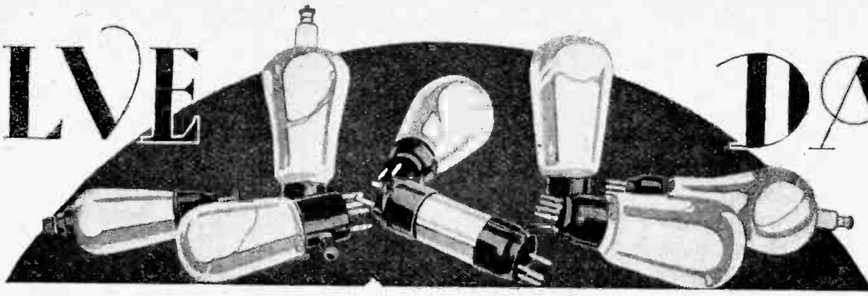
Anode Converters.

Anode converters and motor generators as applied to wireless and gramophone amplification were discussed by Mr. Woodall, A.M.I.E.E., of the M-L Magneto Syndicate, at a recent meeting of Slade Radio (Birmingham). A number of anode converters, rotary transformers, and motor generator sets were on view. The evening concluded with a demonstration given with the assistance of the Radio Gramophone Development Co., who kindly supplied the necessary apparatus.

RADIO AND THE ARCHITECT.—Broadcasting has given architects a new outlet for original expression. The building shown above houses the Bucharest transmitter, which provides Hungarian listeners with all-day programmes on 550 metres. The power is 20 kW.

VALVE DATA



Interpreting the Information given in "The Wireless World" Valve Data Sheet.

PROGRESS in receiver technique depends to a large extent on progress in valve design. The set is built around its valves, and the hope of really successful performance can only be fulfilled if the various valve constants now so willingly given by the manufacturers are understood and applied to the best advantage. The separate valve data sheet accompanying this issue is wider in its scope than that which we published in February of this year. In it there are about 165 representative British valves classified under five main headings—a step rendered necessary by the growing list of special-purpose valves, no two classes of which can be easily categorised under the same sub-headings. It is the aim in these notes to explain briefly the various data in each section which will be taken *seriatim*.

THE supplementary valve data sheet which accompanies this issue contains a number of important new features which are the subject of discussion in these notes. The publication of the A.C. power output in milliwatts of some 85 valves should make the scientific design of the output stage of an amplifier considerably easier. The degree of unobjectionable distortion which is permissible is taken as 5 per cent. second harmonic. The tabular matter giving the maximum possible stage amplification of screen-grid valves taking into account interelectrode capacity will undoubtedly prove of assistance in constructing H.F. amplifiers. All symbols and formulæ used are explained in the appendix at the end of the article.

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Screen-grid Valves.—Certain data such as filament volts and amps. are omitted as they are obvious in nearly every case from the type name. The best performance will be obtained with the maximum anode and screen voltages specified, but anode voltages down to about 100 minimum may be used with a slight reduction in screen volts. Anode voltages below this figure may bring the operating point to the negative resistance "kink" in the characteristic which will result in uncontrollable oscillation.

A knowledge of anode current is necessary when it is desired to reduce the voltage from an H.T. eliminator. The value of the voltage-dropping resistance required, for instance, to feed the anode of a Marconi S.410 valve with 150 volts from an eliminator giving 230 volts is

$$230\text{-}150 \div 3.8 \text{ mA. (expressed as amperes)} = \frac{80}{0.0038} =$$

20,000 ohms approx. The average anode current figures given assume maximum anode voltage, optimum screen volts, and 0.9 volt negative bias for battery-fed valves and 1.5 volt bias for the indirectly heated A.C. type. There is very little "straight" portion in the grid volts-anode current curves of a screened valve—the mutual conductance and hence signal strength increasing as the signal is impressed nearer and nearer to zero grid volts.

Taking into account the large H.F. stage gains now obtained and the limited grid swing acceptance of the detector, it is safe to allow about $\frac{1}{5}$-volt as the largest signal which the valve preceding the detector will have to handle. The bias need not exceed a fraction of a volt provided that no grid current flows at zero grid volts. This condition obtains in the battery-fed S.G. valves, and a bias of 0.9 volt is given as being conveniently obtainable from the special battery developed by Messrs. Siemens for *The Wireless World*. With indirectly heated A.C. valves, due chiefly to the fact that there is no voltage difference between the ends of the emitter, grid current may flow when the grid is quite a large fraction of a volt negative and a bias of $1\frac{1}{2}$ volt is desirable.

Screen current is not published, as it would be unsatisfactory to obtain screen potential from a considerably higher voltage source by the use of a series resistance. A potentiometer should be employed passing 2 to 3 mA., which is about four times the screen current of an average S.G. valve. Mutual conductance is omitted in favour of an H.F. performance factor given by $\frac{\mu}{\sqrt{R_0}} \times 100$. This shows a true figure of merit for an H.F. valve used with an H.F. transformer of optimum ratio. For a given signal a valve with a performance factor of 80 will give twice the H.F. output as compared with one having a performance factor of 40. If a *Wireless World* type of transformer wound with Litz on a 3in. former with a fine wire primary is used as an inter-valve coupling—and such is to be recommended on the score of stability when the receiver is mains driven, it can be assumed that the dynamic resistance R of the secondary is about 250,000 ohms. The optimum transformer ratio is $\sqrt{\frac{R}{R_0}}$, which in the circumstances becomes 500 divided by the square root of the valve's A.C. resistance. Where the valve has a greater A.C.

Valve Data.—

resistance than 250,000 ohms and a step-down ratio is theoretically correct, a 1 to 1 ratio is specified in the tables as being a compromise between tolerable selectivity and signal strength. The stage amplifications attained when using optimum transformer ratios are given by the expression $\frac{1}{2}\mu$ N, but in nearly every case the figure exceeds the limit of stable amplification possible (compare cols. giving stage amp. neutralised and max. stage amp. unneutralised). This means that there are only one or two screened valves on the market which will not oscillate when used with a *Wireless World* type of transformer of *optimum ratio* unless neutralised.

Where selectivity is of the utmost importance, amplification must be sacrificed by using fewer primary turns on the transformer than are dictated by theory When a 3 to 1 transformer, for instance, of the type already mentioned is used, stage amplification is given by $\frac{N\mu R}{R+N^2R_{o}}$ and the results are given in the last column but one. The figures do not reach the limit of stable amplification, and neutralisation is therefore unnecessary. From this it will be seen that the removal of primary turns is conducive to greater stability and better selectivity, but signal strength is reduced.

We now come to the constant which makes or mars the screen-grid valve from the point of view of maximum stable amplification, namely, residual anode-grid capacity. By the expedient of arranging two screening grids in cascade or by using a cross-mesh screen the interelectrode capacity has been reduced in two or three cases to the low figure of approximately 0.005 $\mu\mu$F. Expression (a) in the appendix gives the maximum possible amplification before oscillation sets in due to the feed back through the small condenser formed by the grid and plate of the valve. This formula is solved for practically all the screen valves shown, and the figures obtained are given under the heading—Max. stage amplification unneutralised—which is next to the anode-grid capacity column. As an example of the influence of interelectrode capacity it will be seen that the Mazda 215 S.G. valve has a stable amplification of 153 with a capacity of 0.005 $\mu\mu$F.; had this been 0.05 $\mu\mu$F.—still a very low figure—expression (a) shows that the amplification would drop to 60—rather less than that of the best neutralised triode. It is claimed that if copper gauze of fine mesh be wrapped round the bulb of the MS4 valve and earthed, the internal capacity is reduced from 0.0045 $\mu\mu$F. to 0.0025 $\mu\mu$F., provided that the valve is already contained within a screening compartment. This would increase the maximum unneutralised amplification to considerably over 200 times.

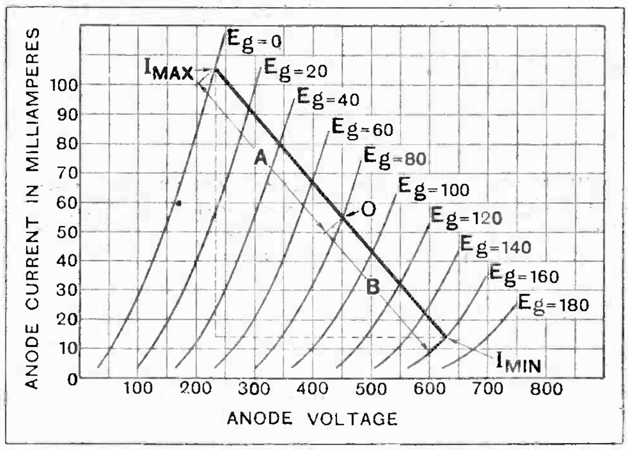

Fig. 1.—Anode volts–anode current curves for equal increments of grid voltage for a super-power valve. By pivoting the 5 per cent. second harmonic scale at the operating point O, the optimum load line (i.e. loud speaker impedance) and the power output triangle can be found for allowable distortion.

Miscellaneous Valves.—From these three-electrode valves having A.C. resistances greater than 13,000 ohms will be chosen the neutralised H.F. valves, certain anode and grid detectors, and early L.F. valves. As explained in the screen-grid section, if a *Wireless World* type of H.F. transformer is used the step-up ratio is obtained by dividing 500 by the square root of the valve's A.C. resistance. As an example let us take the Mazda AC/HL; the step-up ratio would be $\frac{500}{\sqrt{13,500}}=4.3$ and the stage amplification $\frac{1}{2}\mu N=\frac{1}{2}\times 35\times 4.3=75$. Similarly the Osram H.L.610 would require a step-up ratio of $\frac{500}{\sqrt{30,000}}=2.9$ and the stage amplification $=\frac{1}{2}\times 30\times 2.9=43$. It would be as well not to choose a valve for this function that has an H.F. performance factor $\left(\frac{\mu}{\sqrt{R_o}}\times 100\right)$ less than 14. The grid bias given is for amplifying conditions, and should be doubled for anode bend detection using the same anode voltage. The average anode current figures are useful for calculating voltage dropping resistances when deriving current from the mains as explained earlier.

Anode bend detectors can be of two distinct classes; first, those chosen from among valves having A.C. resistances greater than, say, 15,000 ohms, which can only accept peak voltages of 2 or 3, and must be followed by resistance coupling, and secondly, those with A.C. resistances less than 10,000 ohms which will accept peak voltages up to, say, 10, and can be followed by an L.F. transformer provided that its primary inductance is of the order of 150 henrys under working conditions. The first type will be found among the valves under discussion, and will not throw any appreciable load on the

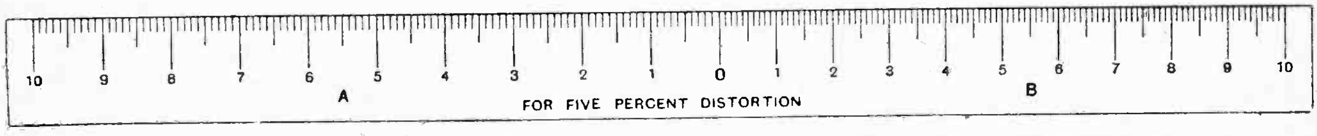

Fig. 2.—The 5 per cent. second harmonic distortion scale. The divisions on the left of zero are 11/9ths those on the right.

Valve Data.—
preceding tuned circuit, while the second type must be selected from the Output Valve section, and will load the tuned circuit to a certain extent. Suitable valves for this latter class are those having mutual conductances of about 2 and A.C. resistances of about 8,000 ohms.

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Output Valves.—This section contains valves with A.C. resistances less than 13,000 ohms, and as in the last series the grid bias figures are for amplifying conditions. The maximum undistorted output requires some explanation. This constant is extremely valuable in designing output stages under correct load conditions, and it is hoped that by the time our next data sheet is published the valve manufacturers will have agreed upon a standard basis of measurement. The figures given must be considered as a useful guide, but because two valves of obviously similar characteristics made by two different firms differ by, say, 10 per cent., the valve with the *slightly* higher output must not necessarily be considered superior. Valve makers differ in their method of fixing the bias point, there are indications in some cases of rather high biasing to obtain low anode currents; this contributes towards a slight disparity between valves of otherwise similar constants. A moving coil speaker for home use requires approximately a minimum of 1,000 milliwatts to give satisfactory volume, for public address work and large halls 5,000 milliwatts upwards is necessary, while a small cone loud speaker would give very good volume if it were fed with 500 milliwatts, and all the power that a portable set can give its loud speaker when 2-volt valves are used with 100 volts H.T. is about 150 milliwatts.

The graphical method of arriving at power output is probably the most accurate; it is, however, rather too laborious when 85 valves have to be examined! Typical valves of different classes have been checked by this method, and have been found to give sensibly the same figures as those derived from expression (b) in the appendix which has been used for column D. The graphical method which it is hoped will become standard is clearly described by K. S. Weaver in the November, 1929 issue of *QST*. The anode current-anode volts curves at a number of fixed grid voltages differing by equal increments are plotted as in Fig. 1. A scale is then made as in Fig. 2, such that each division on the left of 0 is $\frac{11}{9}$ths that of each division on the right. The point of maximum anode current and voltage gives the operating point O on one of the grid voltage curves, and it now remains to pivot the zero of the scale on the operating point to obtain the best angle (load line or optimum loud speaker impedance) at which the scale gives the same reading on either side of zero where two grid voltage curves are cut. Each of these curves must represent equal voltages either side of the operating grid voltage. For example, in Fig. 1 when the zero on the scale is pivoted at the operating point O on the grid voltage of 80, 10 on the left of zero will cut Eg=0, while 10 on the right cuts Eg=160 if the scale is held at the angle shown. In fact, A in Fig. 1 will be $\frac{11}{9}$ths of B.

It will be noted that the distance between Eg=160 and Eg=140 is less than that between Eg=0 and Eg=20[1], and as the anode voltage swings up and down the load line, second harmonic distortion will take place. It is generally agreed that 5 per cent. second harmonic is the maximum unobjectionable distortion permissible. The scale in Fig. 2 obtains the necessary load line for this condition, and if the dotted sides of the triangle shown in Fig. 1 are multiplied together as volts × amps. and divided by 8 the resultant figure is the A.C. power output in watts for 5 per cent. second harmonic distortion. Expression (b) in the appendix which is due to B. C. Brain[2] arrives at the same result from purely mathematical considerations. The mutilating effect on a pure sine wave by superimposing a second harmonic[3] (twice fundamental frequency) of 50 per cent. amplitude is shown in Fig. 3. The case is, of course, exaggerated, but the ear can detect 5 per cent. distortion more easily than the eye. It is often suggested that the D.C. anode dissipation (i.e., col. A × col. C) multiplied by 0.2 will give the maximum A.C. watts, but different classes of valves require a different factor—one must look up the answer first and then work out the problem!

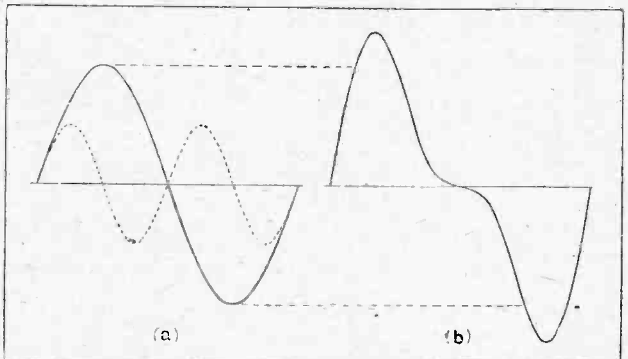

Fig. 3.—Second harmonic distortion. (a) Sine wave representing the fundamental and a 50 per cent. second harmonic (in dotted lines). (b) The two waves in (a) combined to form a distorted wave.

In comparing power output figures it is only fair to examine the grid bias (col. B) to see what input is necessary, it is also interesting to note the anode voltage required. The PX4, P650 and the AC/P1 should give adequate volume with a moving coil loud speaker using only 200 volts H.T. An interesting point is brought forward in the article by B. C. Brain, namely, that the power output is proportional to the 2.5 power of the anode voltage. That is, if the anode voltage is doubled the power output increases by $2^{\frac{5}{2}} = 5.6$ times—the advantage of high anode voltages where these are possible is obvious. The output from two valves in parallel or push-pull is approximately double that of one valve provided that the load is halved and doubled respectively. There is a slight advantage in push-pull in that even harmonics tend to be cancelled out, but with mid-point biasing there is no serious gain.

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[1] See article entitled "The Pentode under Working Conditions" elsewhere in this issue.

[2] See *Experimental Wireless*, March, 1929.

[3] See *Experimental Wireless*, July, 1926. Article entitled "Harmonics and their Effects on Wave Form," by J. F. Herd.

Valve Data.—

Pentode Valves.—It should be noted that out of 15 valves, 6 require a screen voltage less than that of the anode. This suggests a resistance to drop the necessary volts, and at the same time to decouple the screen circuit. The value of the screen current which is necessary to calculate this resistance is given in col. F. Amplification factor and A.C. resistance are omitted as they change considerably with small alterations in screen and control grid voltages, but the mutual conductance, which is given, remains fairly constant. In any case the A.C. resistance of perhaps some 40,000 ohms is no guide to the speaker impedance which should be about 7,000 or 8,000 ohms to avoid distortion and dangerous over-voltages as explained elsewhere in this issue. The power output in col. D is obtained graphically from a family of anode volts-anode current curves, and the limiting condition of distortion in this case is the third harmonic which again has to be reduced to 5 per cent. to become unobjectionable. In Fig. 4 a third harmonic of $33\frac{1}{3}$ per cent. amplitude (dotted curve) is shown combined with its fundamental. The resulting flat-topped wave (*b*) is particularly unpleasant. The formula in the appendix for power output cannot be used for pentodes. The enormous power output for small input grid swing is the feature of the pentode, as will be shown by an examination of the data sheet. There is an error in the valve data sheet in the pentode section; the grid bias sub-heading should read—for A and E—not—for A and C.

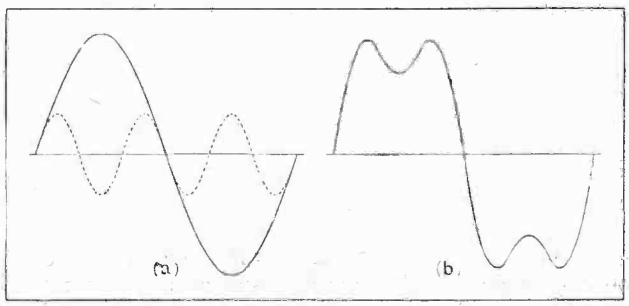

Fig. 4.—Third harmonic distortion. A wave of $33\frac{1}{3}$ per cent. amplitude and of 3 times fundamental frequency when combined with its fundamental gives a particularly objectionable flat-topped wave (b).

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Rectifying Valves.—In choosing a rectifying valve it is necessary to have the maker's regulation curve to see what voltage will be available at the terminals of the filter with the known load of the receiver. Connected across the output of a rectifying valve there must be a condenser which it is understood has been standardised at 4 mfds. by the manufacturers. This condenser, which must be considered as part of the rectifier and not part of the filter, is necessary to improve power factor (rectification efficiency). The use of *considerably* more than 4 mfds. may damage the valve, while 2 mfds. would mean a reduced output. The reduction of rectified output must never be carried out by dimming the filament as this tends to saturate the valve and causes its early destruction; furthermore, the impedance rises and the regulation curve becomes steep. The absorption of excess volts should be carried out with series resistances and sub-potentiometers where the feeds are extremely small. The figures given for maximum unsmoothed D.C. assume a 4 mfd. shunted condenser, but allowance is not made for any drop in output due to the resistance of smoothing chokes.

APPENDIX.

Max. stage amplification (unneutralised) with S.G. valves before threshold instability is reached at 200 metres taking into account anode-grid capacity is given by

$$A = \frac{-1+\sqrt{1+2\mu R_0 \omega C_0}}{\omega C_0 R_0} \quad \text{.......... } (a)$$

$$\text{Milliwatts output} = HK\mu\left(\frac{V_a}{\mu}\right)^{\frac{5}{2}} \quad \text{.......... } (b)$$

A = Stage amplification.
C_0 = Anode-grid capacity in farads.
μ = Amplification factor of valve.
R_0 = A.C. resistance of valve (ohms).
R = Dynamic resistance (ohms).
$\omega = 2\pi \times$ frequency (at 200 metres, $\omega = 10^6 \times 2\pi \times 1.5$).
N = Step-up turns ratio of H.F. transformer.
V_a = Max. anode volts.
E_g = Grid bias.
I_a = Anode current (mA.).
H = A coefficient depending upon the ratio of external to internal impedance in an output valve. If there is no watts dissipation limit, $H = 0.041$, but with large power valves the load impedance may have to be up to 4 times the A.C. resistance of the valve and H becomes a minimum of 0.032. See article by B. C Brain already referred to.
K = A constant obtained from the maker's valve curves.

$$= \frac{I_a}{\left(\frac{V_a}{\mu} - E_g\right)^{\frac{3}{2}}}.$$

V_a is obtained from col. A; E_g from col. B and I_a from col. C.

A COMPLETE INDEX TO RADIO LITERATURE.

THE December number of our sister journal, *Experimental Wireless*, completes the volume for the year, and contains an index to the technical articles on radio subjects which have appeared in all countries and in all languages during the past twelve months. From month to month *Experimental Wireless* issues with each number a service of abstracts and references to the world's wireless literature, and the December number contains the index to these abstracts for the year. The index is an invaluable source of information, especially to those who happen to specialise in the study of any particular branch of the subject.

In addition to this index, the December number contains an article on the design and use of a new type of valve voltmeter by Manfred von Ardenne, and a study of the effect of the ground on downcoming plane space-waves; there is also an important contribution by R. Wilmotte on "A Comparison of the Power Factors of Condensers."

OPERATING FILTER CIRCUITS

Practical Hints on Applying an Improved Tuning System.

By H. F. SMITH

BITTER complaints have already been registered by those whose long-distance reception has been eclipsed by the high-power transmissions from Brookmans Park, but it seems likely that the storm that has just subsided will renew itself with redoubled force when the twin station starts work. Over a wide area, listeners with out-of-date and unselective apparatus will find themselves in the unenviable position of being unable to receive even one programme without interference until their sets are altered.

Indignant listeners may even go to the length of demanding a refund of their broadcast licence fees, but it is certain that among the applicants there will be but few

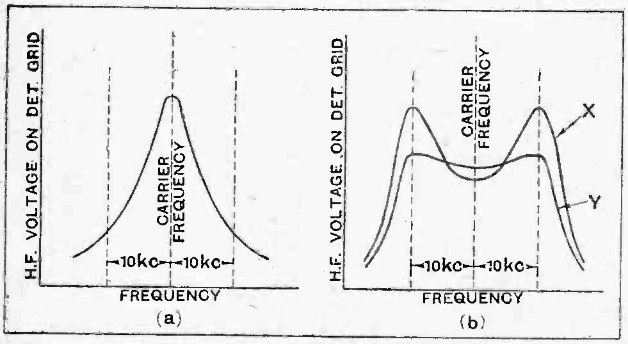

Fig. 1.—Resonance curve of conventional single circuit (a) compared with outputs obtainable from filter circuits.

Wireless World readers: to the true enthusiast, difficulties of this kind exist only to be overcome. Of the several possible lines of attack, none offers greater possibilities than the use of tuned filter circuits, which have already been discussed[1] at some length. It is suggested that an hour or two may profitably be spent in acquiring practical first-hand knowledge of the behaviour of these circuits in their simplest form before attempting to incorporate them in more complex and ambitious receivers. An attempt will be made in this article to show how apparatus already in the possession of the average set constructor may be pressed into service for setting up a receiver that will afford valuable experience, and, it is believed, convince even the most sceptical of the worth of this method of tuning.

Without retracing our footsteps over ground that has already been covered, the reader may be reminded that the kind of tuning we are now trying to avoid is that represented diagrammatically in Fig. 1 (*a*), which shows the response (or H.F. voltage output relative to the audio-frequency component or modulation of an incoming carrier wave) of an ordinary "good" tuned circuit under actual working conditions. By linking together two such circuits with very loose coupling, no improvement is effected with regard to high-note retention, but selectivity is vastly improved.

Flattening Out Tuning Peaks.

As coupling between the circuits is made closer, there is a tendency for the composite circuit to give a maximum response to two different frequencies, and it is this property that is so valuable as an aid to obtaining real selectivity combined with good quality. Tuning curves of the kind provided by this arrangement are shown in Fig. 1 (*b*). The first (X) is what may be expected of low-loss circuits. It is not ideal, as a little consideration will show that, assuming a perfect detector and amplifier to be operated from the voltages developed, there would be over-emphasis of the higher audible frequencies. In actual practice, this might well be unobjectionable, if only because it is hard to avoid some high-note loss in the amplifier, but, to be on the safe side, it is well to aim at something more like curve Y, which is afforded by circuits of average "goodness," used without any abnormal precautions to avoid incidental losses.

The advantages of what is sensibly a flat-topped resonance curve can be realised by careful operation of the circuit given in Fig. 2, which represents an anode bend detector, transformer-coupled to an output valve. This

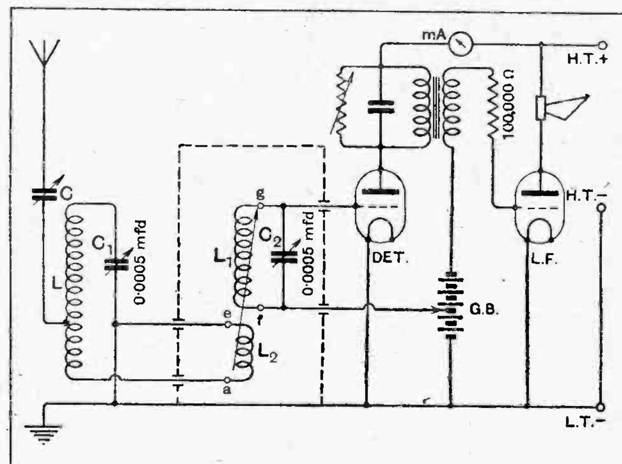

Fig. 2.—A simple local-station receiver for testing the effect of "double-humped" tuning. The anode bend detector valve should have a reasonably low impedance and an L.F. transformer with a large primary inductance should be used.

[1] *The Wireless World*, October 30th, 1929.

Operating Filter Circuits.—

combination can give really good loud speaker signals at a distance of a few miles, and it is primarily suggested to those living within "good crystal range" of a broadcasting station. For our present purpose we are concerned mainly with the tuning circuits, and considerable latitude is permissible with regard to the L.F. amplifier; for example, resistance coupling will serve quite well.

The secondary inductance L_1 may consist of about 56 turns of No. 24 D.C.C. wire on a 3in. former. Its coupling coil L_2 may have some 8 turns of finer wire wound on a sleeve which is an easy sliding fit on the main former, so that its distance from L_2 (and consequently the coupling) may be readily adjusted. A sectional sketch of these windings is given in Fig. 3; connections are indicated by lettering corresponding with Fig. 2. A more convenient form of coupling (from the mechanical point of view) can obviously be devised by those with the necessary facilities.

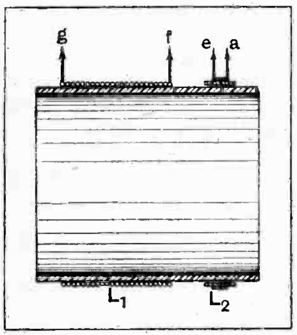

Fig. 3.—Construction of a coupler. Lettering of the terminal points refers to Fig 2.

Any reasonably good input coil (L) that is to hand may be used. Failing anything else, a winding similar to that specified for L_1, with a tapping at the 10th turn from the earthed end, will do admirably.

In order that inter-circuit coupling may be completely under control, the secondary winding and its coupling coil should be enclosed in a screening box, which may also accommodate the detector valve if space permits.

At very short range, some method of preventing detector overloading must be provided, particularly if the aerial system is efficient. A series aerial condenser (C) of some 0.00025 mfd., though not a perfect control, is effective enough, if one remembers that any variation in its setting will call for slight retuning. It is, perhaps, as well to state here that the whole essence of filter circuit operation is accurate tuning, and that the usual expedient of reducing incoming signal strength by detuning is quite out of the question.

Post-detection Volume Control.

Assuming that the input from the aerial is sufficient fully to load our detector, some means of preventing overloading of the subsequent valve must almost invariably be provided. For this purpose, a variable resistance of some 200,000 ohms may be connected across the L.F. transformer primary.

A sensitive milliammeter in the detector valve anode circuit is shown; this acts as an H.F. grid voltage indicator, and is a highly desirable refinement, but is by no means essential.

Having set up the circuit, local signals should first be tuned in accurately with the maximum possible separation between coils L_1 and L_2, making quite sure that there is no tendency towards double-humped tuning. If necessary, aerial input should be reduced, as it is much easier to work with a signal that is not overpoweringly strong. The setting of C_2 should be as critical as when "aperiodic" coupling is used, and a test may readily be made by temporarily joining the aerial to point *a* on L_2 after having removed the existing connection from this point. Coupling should be adjusted so that signal strength is changed as little as possible while making this comparative test.

Critical Adjustment of Coupling.

Reverting to the two-circuit tuner, we now come to the most critical operation—that of tightening coupling until the circuits begin to "pull" together and act as a true filter. If a detector anode meter is available, the simplest plan is to move the coupling coil towards the closed circuit winding until a maximum reading is indicated and then to make a further slight increase in the coupling until a definite but slight drop in current is registered. This is a sure indication that something approaching the desired results have been achieved, but a little experience is necessary to determine the best coupling for producing the proper degree of flatness. A good idea can be formed by noting the effect of rotating the condenser C_2; there should be little perceptible change in signal strength (as indicated by the meter), as its dial is turned through at least a single scale division, or perhaps 2 degrees of a 0-180 scale.

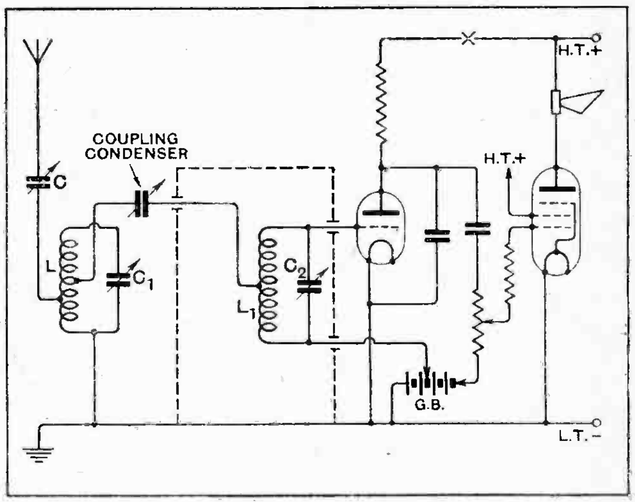

Fig. 4.—Another experimental receiver circuit with capacity coupling. A plate current galvanometer may be inserted at X.

If a meter is not available it is best to make progressive increases in coupling, "feeling" at each step for the desired broadening of tuning. In any case, it is essential that the variable condensers should be finally set exactly "in the middle of the signal," if the full benefit of a filter circuit is to be retained.

Where high selectivity is required, it is often necessary to adjust coupling so that the tuning curve "peaks" are rather closer together than shown in Fig. 1(b); in any case it is necessary at least to make provision for doing so when we come to deal with a long-range receiver with H.F. amplification.

CURRENT TOPICS

Events of the Week in Brief Review.

THE ROYAL CONSTRUCTOR.

H.R.H. the Duke of York is reported to have completed the construction of a wireless set in his "workshop" at 145, Piccadilly.

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NEARING THE THREE MILLION MARK.

In the House of Commons last week the Postmaster-General reported that the number of broadcast licences now issued was 2,869,000. The number was increasing, and he was confident that it would reach 3,000,000 before very long.

oooo

THE ALL-SEEING EYE.

A wireless "pirate" fined at the Thames Police Court asked if he could be informed of the names of the people who gave information about him.

Magistrate: You are not entitled to the information, and you must assume that there is an all-seeing eye which sees these things.

INVENTORS, FORWARD!

Louis Graveure, a Berlin concert singer, is appealing to scientists to invent a means of broadcasting whereby the waves will only be available to subscribers.

oooo

THE WIRELESS LEAGUE.

Members of the Wireless League are cordially invited to attend the annual general meeting, which will be held at the Royal Automobile Club, Pall Mall, S.W., on Friday next, December 6th, at 3 p.m. Sir Arthur Stanley will be in the chair.

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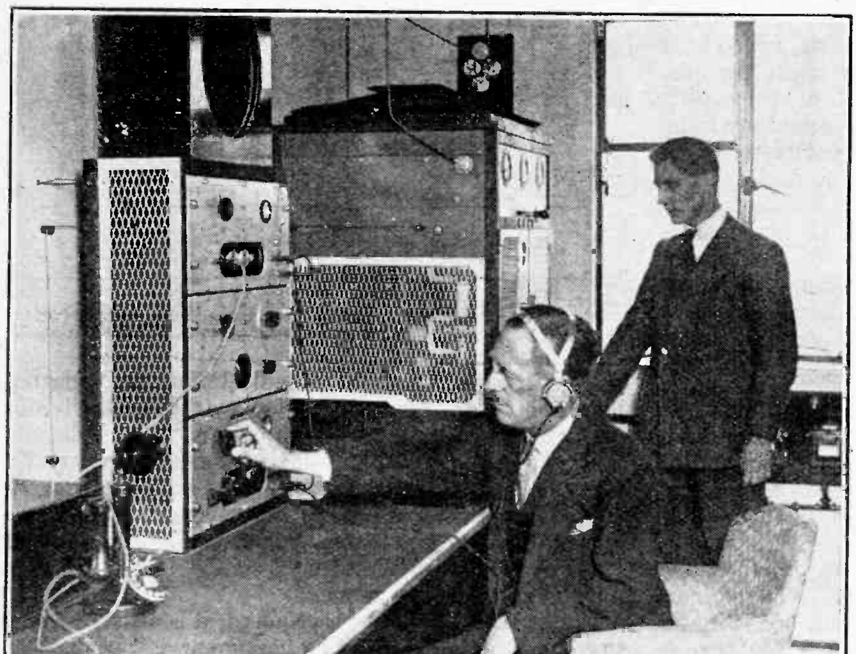
A NEW "KDKA."

KDKA, Pittsburgh, one of the pioneer broadcasting stations of the world, is to have a sister station at Saxonburg, Penn., early in 1930, according to the plans of the Westinghouse Electric Company. The new "KDKA" will concentrate on short-wave work, and for this reason the new site has been selected after an exhaustive search. The new station should make itself heard in Britain.



FLYING LESSONS BY WIRELESS. The new wireless installation at Heston Air Park School was officially opened last week by Sir Sefton Brancker, who is here seen adjusting the receiver. An illustrated description of the equipment appeared in "The Wireless World" of November 20th.

TONE CONTROL FOR ELECTRIC GRAMOPHONES.

Dr. N. W. McLachlan, M.I.E.E., F.Inst.P., will give a lecture, with demonstration, entitled "Experiments in Tone Control for Electric Gramophones," at the annual general meeting of the Incorporated Radio Society of Great Britain, to be held on Friday, December 13th, at 6 p.m., at the Institution of Electrical Engineers, Savoy Place, W.C.2.

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WIRELESS PRIZE HUNT.

An observation test of unusual interest will be provided in next week's *Wireless World* in the form of a Hidden Advertisements Competition. Wireless apparatus amounting in value to £20 will be offered to successful entrants, who will be able to choose their own prizes from goods advertised in that issue.

While calling for no technical skill, this intriguing test will challenge the competitor's powers of observation and his ability to make the best use of the clues provided. Full details will appear in our advertisement pages next week.

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RADIO SOCIETY'S HOSPITAL GIFT.

The Sheffield Wireless Society is presenting a broadcast receiving installation to the Firth Auxiliary Hospital for Women.

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A TECHNICAL TEST.

A Nottingham listener fined for owning and operating a set without a licence pleaded that he was only testing it. He admitted that he had committed a technical offence.

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WIRELESS FROM THE WILDS.

Short-wave wireless messages transmitted by Mr. Hinds for Major C. Court-Treatt, the British explorer, from a portable Marconi equipment in the wilds of Sudan, have been received as far afield as the United States of America.

Pitching their camps in the least-known parts of the Western Sudan, Major and Mrs. Court-Treatt and Mr. Hinds were able to maintain communication with Sudan Government wireless stations throughout their twelve months' travels in the jungle, where they were making the British Instructional film "Stampede."

Thus they were in regular touch with London through the Government stations and on a number of occasions their transmissions, on a wavelength of approximately 30 metres, were heard at a distance of more than 5,000 miles in Detroit, Michigan and Boston, Massachusetts.

The wireless transmitter used was a specially designed Marconi set of extremely small power and weight, the power being supplied by turning the handle of a small electrical generator.

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MUSIC WHILE YOU WAIT.

A Paris taxi owner has equipped his cab with a broadcast receiver. The loud speaker is in the roof and is said to drown traffic noises very effectively. Traffic blocks are forgotten.

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"SMALL ADS."

The return of the Christmas season makes it necessary to close for press earlier than usual with our issues of December 18th and 25th. Miscellaneous advertisements for inclusion in these issues can be accepted up to the first post on the Wednesday preceding the date of issue. Those for the issue of January 1st should be received not later than first post on Tuesday, December 24th.

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THE STENODE.

At a demonstration on Thursday last, Dr. James Robinson exhibited a receiver of his own invention in which high selectivity is sought by utilising only a narrow waveband. It is claimed that the apparatus is capable of receiving the modulated signal when sharply tuned to the carrier frequency, the audio frequencies being reproduced at their correct relative amplitudes. The device is called the Stenode.

The use of a narrow waveband has always been contrary to the views of *The Wireless World* as being inimical to quality reception; it is, therefore, possible that Dr. Robinson is making an original contribution of the first importance to our knowledge of the properties of resonant circuits. Some scepticism must prevail, however, pending the disclosure of precise technical details.

The device is understood to employ a quartz crystal resonator in conjunction with a superheterodyne which converts the original frequency to the natural frequency of the crystal. Dr. Robinson states that it is possible to restrict reception to a given transmission avoiding interfering frequencies as close as 100 cycles to that of the carrier.

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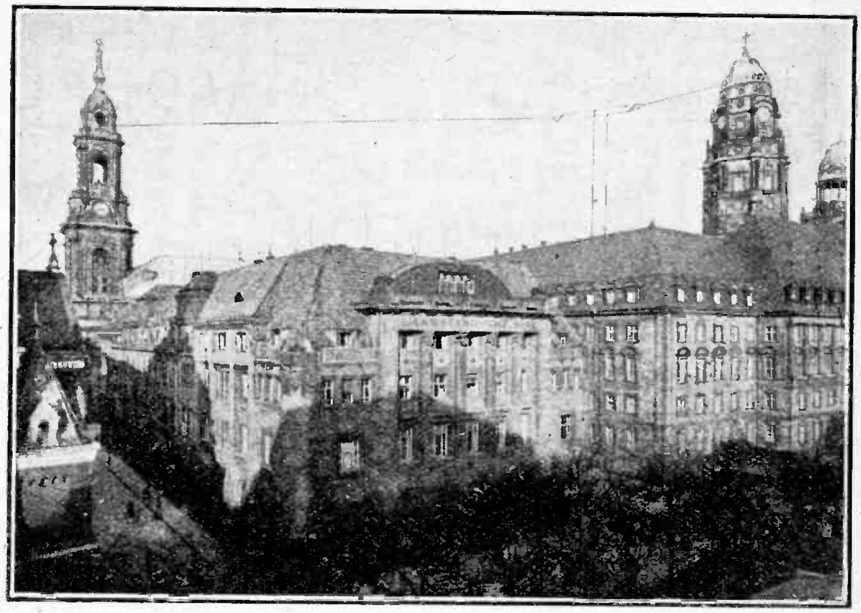
VALVE HOLDERS IN COURT.

In the Chancery Division of the High Courts of Justice on November 19th Mr. Justice Clausen delivered judgment in favour of the plaintiffs in the action brought by Benjamin Electric, Ltd., against Garnett, Whiteley and Co., Ltd. The plantiffs sued for infringement by the defendants of two patents, No. 222,086 (Benjamin Patent) and No. 240,918 (Burndept Patent), which relate to anti-microphonic valve holders. In delivering judgment, his Lordship said it became clear in the course of the case that if the plaintiffs' Patents, setting aside two claims in the Burndept Patent (which the plaintiffs asked leave to disclaim as separate claims), were valid, the defendants had infringed them.

On the question as to whether the defence of no subject-matter was to prevail, his Lordship said: "It was said that the plaintiffs' device (the Benjamin valve-holder) is a combination of old features; and it may be true that each separate feature in the combination can be found in some previous device. It appears to me, however, that the combination of these separate features is not a mere juxtaposition of old features but has produced an article which operates as a whole and is a new and useful article."



DRESDEN'S AERIAL. The aerial system of the Dresden relay station overshadows the bank and municipal buildings. The station relays Leipzig on a wavelength of 319 metres.

FORTHCOMING EVENTS.

WEDNESDAY, DECEMBER 4th.

Institution of Electrical Engineers, Wireless Section.—At 6 p.m. At the Institution, Savoy Place, W.C.2. Lecture: "Naval Wireless Telegraphy Communications," by Mr. G. Shearing, B.Sc., and Capt. J. W. S. Dorling, R.N.

Edinburgh and District Radio Society.—At 8 p.m. At 16, Royal Terrace. Auction Sale.

Queen's Park Radio Society.—At 8 p.m. At the Oddfellows' Hall, 593, Harrow Road, Paddington. Lecture by Messrs. W. F. Floyd, A.Inst.P., and E. J. Reid, B.Sc.

Muswell Hill and District Radio Society.—At 8 p.m. At Tollington School, Tetherdown, N.10. Lecture and Demonstration: "The Elementary Principles of Television," by Mr. T. Andrews.

North Middlesex Radio Society.—At 8 p.m. At St. Paul's Institute, Winchmore Hill, N.21. Debate: "Is the Moving Coil Loud Speaker Worth While?"

THURSDAY, DECEMBER 5th.

Ilford and District Radio Society.—Lecture: "Operation from A.C. Mains," by a representative of the Marconiphone Co., Ltd.

FRIDAY, DECEMBER 6th.

Bristol and District Radio Society.—At 7.30 p.m. In the Geographical Lecture Theatre, University of Bristol. Lecture and Demonstration: "The Philips Four-Valve Set," by Mr. Cooper, of Philips Lamps, Ltd.

MONDAY, DECEMBER 9th.

Newcastle-upon-Tyne Radio Society.—At 7 p.m. In the Physics Theatre, Armstrong College. Demonstration of Commercial and Amateur Loud Speakers.

TUESDAY, DECEMBER 10th.

Ryde Radio Society.—Visit to the Sandown Radio Society.

WIRELESS AT WESTMINSTER.

(From Our Parliamentary Correspondent.)

A New Wireless Act?

During the Committee stage last week of the Expiring Laws Continuance Bill, Captain Bourne, a Unionist member, moved to omit from the scope of the Bill the Wireless Telegraphy Act of 1904. He explained that at the time the Act was passed no one dreamt that we should get the elaborate system of broadcasting that we had to-day. A new Act should be passed, he urged, which would bring the law up to date.

Replying to this and many other points raised, Mr. Lees-Smith, the Postmaster-General, said that there was to be a wireless international telegraphic conference in Madrid in two or three years, and that the conference was likely to adopt certain conventions which would need legislation in the Parliaments of the ratifying States, so that the Government might have to bring in a Bill on this subject in three or four years' time. They did not want two Bills.

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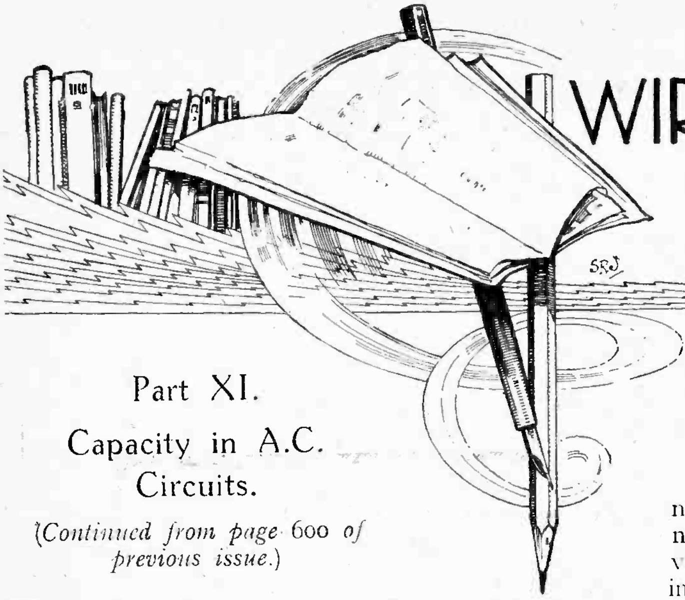
Brookmans Park Tests.

In regard to the experiments at Brookmans Park, said the Postmaster-General, the station was still working on a single wave, and the great change would come when it worked on the double wave, which would be initiated in a few weeks' time. It would not be initiated all at once, but probably it would be increased as the public accustomed itself to the new development. On the subject of television, he said that the Baird Television Company now had the right to use the B.B.C. stations for half an hour on five days a week out of broadcasting hours.

As to evasion of the payment of wireless licences, that was being gradually reduced.



WIRELESS THEORY SIMPLIFIED

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

Part XI.
Capacity in A.C. Circuits.

(*Continued from page 600 of previous issue.*)

THE behaviour of a condenser in an A.C. circuit is one of the most important aspects of our subject. Inductance and capacity together constitute the key to all radio communication. To those studying the effect of capacity in an A.C. circuit for the first time, some of the facts come as a complete surprise and others prove most intriguing and interesting. For instance, when it is known that no current can possibly flow through a condenser from one set of plates to the other on account of the insulating medium between them, it may come as a surprise to learn that on an A.C. source of supply a lamp can be made to light when connected in series with a condenser. To those new to the subject or those who have given the matter no thought, this must appear to be a contradictory state of affairs, because apparently we have an alternating current flowing round a circuit in which there is a gap across which no current can pass.

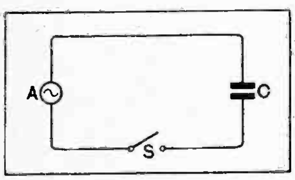


Fig. 1.—Simple circuit for connecting a condenser C across the terminals of an alternator A.

It is a very common practice to speak of an alternating current flowing *through* a condenser, but actually the current does not get through at all. It is only apparent. Our immediate object is to discuss this matter and see what really does happen.

It has already been shown that the rate at which the voltage between the plates of a condenser builds up is exactly proportional to the value of the charging current. If C is the capacity of the condenser in farads, the charging current at any instant is given in amperes by

$$i = C \times (\text{rate of change of voltage}) \quad \ldots\ldots \quad (1)$$

It will be realised that this relationship is of the same form as $e = I \times$ (rate of change of current) for an inductive coil, as explained in Part V (page 407), and we can therefore apply the same reasoning for determining the relationship between current and voltage when a condenser is connected to a source of A.C. supply.

Nature of the Charging Current

Suppose that a condenser of capacity C farads is connected through a switch S to the terminals of an alternator A as shown in Fig. 1. It will be assumed that the voltage at the terminals of the alternator varies according to the sine law so that when plotted as a curve to an angle base in the manner already described it gives a sine wave as shown by the full line curve of Fig. 2. Let E_m be the maximum value attained by the voltage every half cycle. Then the sine wave can be represented by a vector of length OE_m rotating about O at a speed of f revolutions per second, where f is the frequency. This means that the vector will have an angular speed of $2\pi f$ radians per second (see Part IV, October 16th issue).

Now suppose that the switch S is closed at an instant when the voltage is passing through one of its zero values and is increasing towards the positive maximum value. This instant is indicated by O in the graph of Fig. 2. Since the condenser C is now connected directly across the alternator terminals the voltage across it will be at every instant equal to the alternator voltage; and so, as the voltage rises, a charging current will flow round from one plate of the condenser to the other, being at every instant proportional to the rate at which the voltage is changing.

Clearly the voltage is changing at its greatest rate just as it passes through its zero values because the curve is steepest at these points. Therefore *the charging current will have its maximum value when the voltage is zero.*

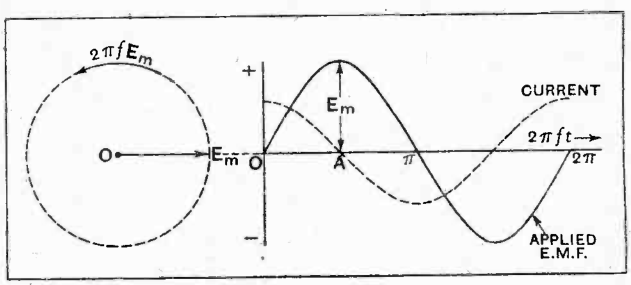


Fig. 2.—The speed of the end of the vector OE_m gives the maximum rate of change of voltage. The current taken by a condenser leads the applied voltage by a quarter of a cycle.

Just as the voltage is passing through its maximum value, it is neither increasing nor decreasing—its rate of change is zero—and therefore at this instant, denoted by A in Fig. 2, the condenser is being neither charged fur-

Wireless Theory Simplified.—

ther nor discharged—the charging current is zero. Beyond this point, when the voltage starts to fall again, the condenser begins to lose its charge, showing that the current must have reversed and is therefore negative.

Obviously, since the condenser is being charged up in opposite directions alternately by the alternator, the electrons representing the charges will be surging backwards and forwards round the external circuit, being first piled up on one plate by the action of the alternator, then withdrawn and piled up on the other, and so on. But none of them passes through the insulation between the plates. This surging backwards and forwards of the electrons constitutes an alternating current and would be indicated by an ammeter in the circuit. It has its maximum value when the voltage is zero and falls to zero when the voltage is a maximum as explained above.

A Condenser takes a Leading Current

We conclude then that the charging current is an alternating one *exactly a quarter of a cycle out of step* with respect to the voltage. Furthermore, this current will have a *positive* maximum value when the voltage is zero and increasing towards the positive value. So the current can be represented by another wave in the position shown by the dotted curve of Fig. 2. From these curves we see that the current reaches its maximum positive value a quarter of a cycle *earlier* than the voltage and we arrive at the extremely important conclusion that a condenser in an A.C. circuit takes a current which *leads* the voltage by exactly a quarter of a cycle or 90°. This is just the reverse of a pure inductance, which was found to take a current *lagging* by a quarter of a cycle. This opposition of phase angles is one of the things which makes tuning possible.

No Power Consumed by a Perfect Condenser.

The average power consumed by a perfect condenser in an A.C. circuit is zero for the same reason as that given in connection with a pure inductance, namely that the current and voltage are out of step by a quarter of a cycle, the power factor being zero. The energy put into the condenser during the first quarter cycle when it is being charged up is all recovered during the second quarter cycle, during which time it is completely discharged again, and so on. In practice some very small losses occur in the di-electric and plates, but except in special circumstances this may be entirely ignored.

The condenser and alternator combination of Fig. 1 can conveniently be compared, for purposes of mechanical illustration, with a pump and divided air cylinder similar to that described in Part IX, but in this case the pump must be of a type designed to drive the air first one way through the pipe, and then the opposite way alternately.

A possible arrangement of this sort is indicated in Fig. 3, where C is the main air reservoir divided into two equal compartments by a diaphragm D, and P is a reversible air pump which is reversed at regular intervals. In this way air is first withdrawn from compartment A and added to that already in B, so creating a pressure difference or back pressure between the two sides. When the pump begins to slow down before reversing, the excess air in compartment A starts to flow back in exactly the same way that the condenser loses its charge when the alternator voltage is falling.

When the pump is reversed the pressure in compartment A falls below the normal and that in B rises, etc. And so as the pump is periodically reversed the air molecules will be surging backwards and forwards between the two compartments.

In exactly the same way the alternator may be looked upon as a sort of electron pump which causes some of the electrons in the circuit to surge backwards and forwards between the two plates of the condenser. A little consideration will show that the mechanical system and the electric circuit in question are also similar as regards stored energy, and as regards phase difference if we assume that the air pressure exerted by the pump obeys a sine law with respect to time. The current of air in the pipe stops flowing just as the pressure exerted by the pump reaches its maximum value in the same way that the charging current of the condenser ceases at the instant the alternator voltage reaches its maximum value.

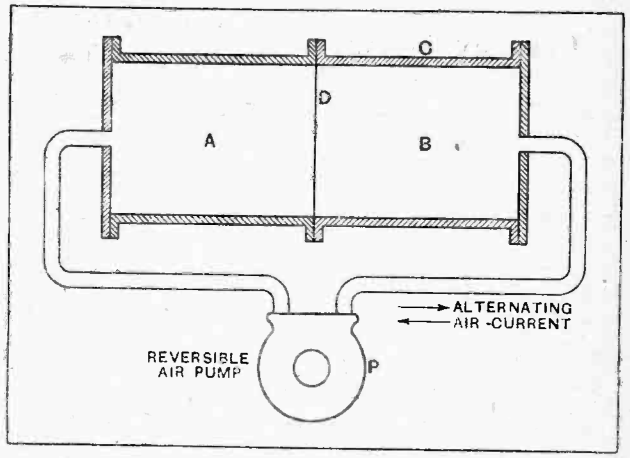


Fig. 3.—Divided cylinder and reversible air pump arrangement for illustrating the action of a condenser in an A.C. circuit.

Finding the Value of a Current.

Now that we know the phase relationship between current and voltage for a condenser we can find their relationship as regards magnitude, also by the aid of Fig. 2. The maximum value of the current will be $I = Cx$ (maximum rate of change of voltage) from equation (1) above. Now the maximum rate at which the voltage is changing is exactly equal to the actual speed of movement of the extremity of the vector OE_m, representing the E.M.F. wave as explained at some length on page 491 of October 30th issue in connection with the induced E.M.F. in an inductive coil. In the present case the speed, and therefore maximum rate of change of voltage, is $2\pi f \times E_m$ volts per second. Hence the maximum value attained by the charging current of the condenser will be:

$$I_m = C \times 2\pi f E_m = 2\pi f C \times E_m \text{ amperes.}$$

Wireless Theory Simplified.—

But for sine waves the R.M.S. value is 0.707 of the maximum value, and so to get the R.M.S. value of the current we multiply each side of the last equation by 0.707, namely:

$$I = 0.707 I_m = 2\pi f C \times 0.707 E_m,$$

$$\text{or } I = 2\pi f C \times E \text{ amperes,}$$

where E and I are R.M.S. values.

Reactance of a Condenser.

It should be remembered that the ratio of E.M.F. to current in a circuit is always expressed in ohms, but whether this ratio gives resistance, reactance or impedance depends entirely on the phase relationship between the current and voltage. If they are in phase their ratio is a resistance, if they are a quarter of a cycle out of step their ratio is a reactance, and if they are out of phase by any odd angle between zero and 90°, i.e., if they are out of step by some fraction of a cycle less than a quarter, their ratio gives the impedance.

Now we have seen that for a condenser the current and voltage are exactly a quarter of a cycle, or 90°, out of step, and hence the ratio $\frac{E}{I}$ is in the nature of a pure reactance. And so the reactance of a condenser is given by $X_C = \frac{E}{I} = \frac{1}{2\pi f C}$ ohms, where C is the capacity in farads and f the frequency.

Comparison of Condensive Reactance with Inductive Reactance.

It is evident that both capacity and inductance in an A.C. circuit produce reactance; each of them introduces a phase displacement of a quarter of a cycle between the current and voltage. But in other respects they are fundamentally opposed: For instance, a condenser takes a current *leading* the voltage by a quarter cycle, whereas a pure inductance passes a current which lags behind the voltage by 90°. Hence if inductance and capacity are present simultaneously in the same circuit, one will have a neutralising effect on the other, and the results of this are to be discussed in the next part. On account of these opposing effects the reactance of a condenser must be considered negative with respect to that of an inductive coil when making calculations. To distinguish between them the one is called *condensive reactance*, and the other *inductive reactance*, denoted by X_C and X_L respectively.

Another aspect in which condensive reactance and inductive reactance are in contrast lies in the manner in which each depends on the frequency, and on the value of capacity and inductance respectively. Whereas inductive reactance is directly proportional to the frequency and inductance, being given by $2\pi f L$, the reactance of a condenser is inversely proportional to the frequency and capacity, being given by $\frac{1}{2\pi f C}$. This means that if an alternating voltage of constant R.M.S. value E is applied to a condenser of capacity C farads, the current "through" the condenser will be directly proportional to the frequency, and if plotted as a graph against frequency will give a straight line passing upwards from the origin O as shown in Fig. 4, where the reactance is also shown plotted against the frequency. These curves should be contrasted with those of Fig. 5 of Part VI (October 30th issue) for a circuit possessing inductance only.

Numerical Calculation.

From the results obtained so far we conclude that a condenser will pass no direct current at all but will allow alternating current to flow to an extent proportional to the frequency. As an example for numerical calculation we can take the case of a by-pass condenser connected between the plate and filament of the detector valve in a receiver. The object of the condenser is to provide an easy path to "earth" for the high-frequency component of the plate current, whilst at the same time preventing as far as possible the escape of the wanted currents of audible frequency.

Suppose that the by-pass condenser has a capacity of 0.0001 microfarad, the radio-frequency current has a frequency of 1,000,000 cycles per second (corresponding to a wavelength of 300 metres) and that the highest note frequency with which we are concerned is 5,000 cycles per second. In calculating the reactance the capacity must be expressed in farads, and is, therefore, $0.0001 \div 10^6$, or 0.0001×10^{-6} farad.

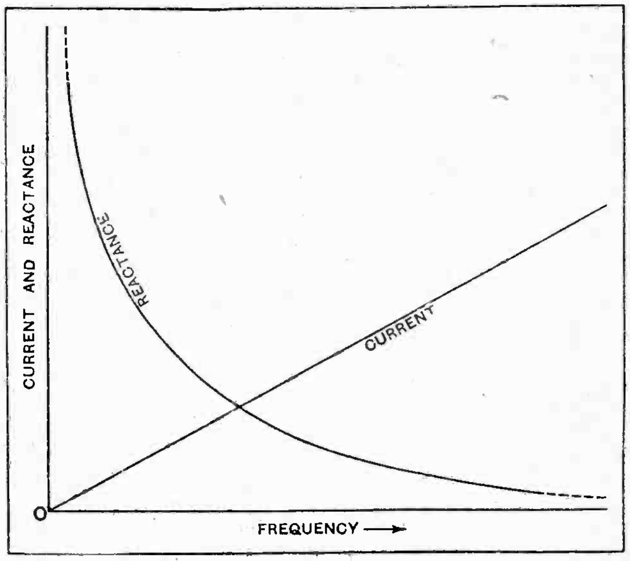


Fig. 4.—Curves showing how current and reactance vary with frequency for a condenser.

At a frequency of one million, or 10^6 cycles per second, the reactance is:

$$\frac{1}{2\pi f C} = \frac{10^6}{2\pi \times 10^6 \times 0.0001} = 1{,}590 \text{ ohms;}$$

and at 5,000 cycles per second the reactance is

$$X_C = \frac{10^6}{2\pi \times 5000 \times 0.0001} = 318{,}000 \text{ ohms.}$$

Thus if there were an anode resistance of 150,000 ohms in the plate circuit, about 99 per cent. of the high-frequency current would be conducted away "through" the condenser, whereas only just over 30 per cent. of the audio-frequency current would be lost in this way.

The next instalment will deal with the effects of capacity in A.C. circuits where resistance and inductance are also present. (*To be continued.*)

MAINS SETS and GRID BIAS

A New Problem and Some Suggested Solutions.

By F. H. HAYNES.

THE chief problem in the design of mains sets is that of providing "free" grid bias. Avoidance of feedback coupling as well as mains hum are the difficulties encountered. This article explains the development of receiver circuits in which bias for all valves is derived from a rectified anode current supply.

TROUBLE is certain to arise in a mains-operated set when the grid bias is produced by the inclusion of dry cells. We can be quite sure that the failure of the grid biasing cells will not be detected until impaired performance is suspected, by which time damage may have been sustained by the valves. Even in the battery-operated set the grid cells are neglected and in the mains set the possible existence of dry cells contained within the cabinet is entirely forgotten.

As an alternative to the use of cells, grid bias is derived by dropping part of the anode voltage across a resistance introduced into the filament (or cathode) side of the H.T. circuit (Fig. 1). This resistance, R, also forms part of the grid circuit, and the voltage set up across it is such that the filament is positive with regard to the grid or, taking the filament as being at zero potential, then the grid is negative. To determine a suitable value for this resistance it is only necessary to multiply the potential required by 1,000 and divide by the average anode current in milliamperes. As a rule only an approximate figure may be thus obtained, yet the result is sufficiently reliable and an error as high as 5 per cent. is not serious in view of the latitude in grid biasing values. It should be noted that the anode voltage is reduced by the amount of the grid bias taken, and for this reason it is not always economical to create in this way biasing potentials of 100 or more volts as required by super-power valves.

A resistance which forms a common path to both the grid and anode circuits of a valve produces a coupling between the output and input and may be responsible or contributory in the bringing about of instability in a high frequency amplifier or oscillation in a detector or low-frequency stage. This undesirable coupling is sufficiently removed by providing a path of low impedance to the signal currents across the biasing resistance by means of a shunt condenser. In a high-frequency circuit, including a screen-grid valve combined with coils of average resistance, a mica condenser of 0.01 mfd. should be regarded as the minimum capacity which can be safely adopted in a set tuning to both wavebands. For a low-frequency stage the shunt condenser will need to have a value of not less than 2 mfds. (Fig. 2). Coupling between grid and anode may be further localised in the case of a transformer-coupled L.F. or output stage by using a filter feed anode circuit. For example, a voltage drop from 300 to 60 as required by a leaky grid detector is produced by an anode resistance of some 60,000 ohms so that it becomes possible to feed the primary of the intervalve transformer through a condenser connected to the anode, thus avoiding incidentally an excessive current being passed by the winding. The earth side of the primary must now be returned, not to the common H.T. –, but to the filament or heater circuit. Similarly, in an output stage, the return lead of a filter-fed loud speaker, instead of connecting to the H.T. –, likewise runs direct to the filament. In this latter case it is advisable to connect condensers in each of the speaker leads, for it will be seen that an earth connection or low insulation occurring on the loud speaker winding would produce a short circuit across the resistance which gives the grid bias.

When dealing with indirectly heated valves it is at once obvious that a resistance connected in the cathode lead will give the required biasing potential (Fig. 3). It will also be noted that a common source of heater current may be connected to the several valves while the biases may differ. While such an arrangement will prove quite satisfactory with certain valves, instances may arise where mains hum is experienced, due to the difference of potential which has been set up between heater and cathode. Considering for a moment the actual circuit of a screen-grid H.F. stage biased in this way, it will be noted that while the dangers of grid-anode coupling across a common resistance are still present, there is in addition, a difference of voltage between heater and emitter, these being in intimate contact within the valve. Many indirectly heated valves may, however, be successfully operated in this way without trouble from A.C. hum, and in arranging the biasing resistance it will be found worth while to make it pass the current of the screen potentiometer as well as the anode current (Figs. 3 and 4). By so doing, the value of the resistance will be reduced owing to the appreciable increase in current which is necessarily passed by the potentiometer and a more constant value of bias will result.

Main Sets and Grid Bias.—

Turning now to alternative circuits designed to avoid differences of potential between heater and cathode, it is pointed out that the use of a separate heater winding for each valve will prove inconvenient. In planning out a circuit one should start by joining the mid-point of the heater winding to a common return lead and to this lead also all the cathodes should be directly connected. As shown in Fig. 5, the grid biasing voltage is now produced across a resistance connected directly in the grid circuit, while no longer is the H.T. – taken to the common lead. Applying this principle to a tuned-grid circuit, it will be necessary to connect the resistance in series with the inductance while the tuning condenser may be taken from grid to earth (Fig. 6). The tuning condenser is shown in this way as in many sets its spindle will be common to other tuning condensers and will therefore be in contact through its bearings with the frame of the set. Further complication by way of the introduction of decoupling resistances has been omitted as it has been found in practice that the other factors present tending towards the setting up of self-oscillation are far greater in their effect than the common resistance with its by-pass condenser. It will be seen that this method can only be applied to two tuned stages when each requires the same bias. This is due to the biasing resistances being connected across common points in the circuit—the H.T. – and frame. Thus the biasing resistances are parallel-connected and the entire anode current of the stages will be distributed between them.

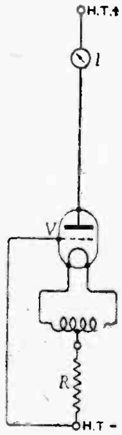
In an endeavour to devise yet another method, attention is turned to the possibility of passing the entire anode current required by the receiver through a resistance connected in the H.T. negative lead and stepping off biasing potentials as may be required by the various stages. Fig. 7 shows such an arrangement. By far the largest demand on the H.T. supply is made by the output stage, so that the omission of the detector and other amplifying stages from the circuit will not complicate a consideration of its principle. A correct grid bias, producing maximum signal, is obtained by the voltage drop across the resistance which, by way of example, has been shown having a value of 20 ohms. In addition to this resistance is a 250-ohm potentiometer from which the bias for an anode-bend detector may be obtained or, alternatively, such a potentiometer may serve as a volume control. By means of this potentiometer, therefore, grid bias applied to the H.F. valves may be steadily increased up to the point of extinction of the signal. A resistance of 0.5 megohm interposed in each lead, carrying the bias to the several stages is effective for decoupling purposes when associated with a fixed condenser of 0.01 mfd. Several bias values are available by making tappings along the resistance connecting the H.T. – to the common return lead, and if the potentiometer prevents the provision of a tapping at a particular voltage, then another resistance may be connected in parallel so as to provide a convenient point of sub-division. Where several chokes are used for smoothing purposes there is no objection to the resistance of one of the chokes being used as a means of producing bias.

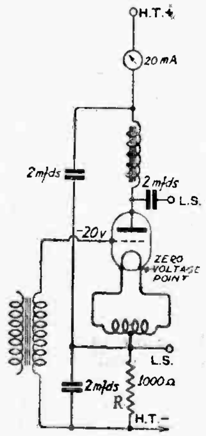
A mains-fed anode-bend detector circuit is shown in Fig. 8, and here again suitable bias is produced by connecting to the point X a lead from the main biasing resistance. Leaky grid detection involves no problems as regards bias. It is only necessary to connect the leak to the cathode. When the grid current characteristic, however, reveals that a definite application of positive bias is necessary it is best produced by a connection to a high-resistance potentiometer running from H.T. + to cathode. Assuming a potential of 250 volts exists between these points, the positive bias of a volt will be obtained at the junction between a 500- and a 125,000-ohm resistance (Fig. 9).

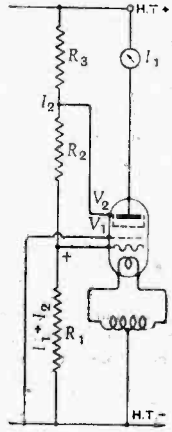
When a gramophone pick-up is to be introduced, a well-insulated two-way switch may be fitted in the grid circuit of the detector, connection to either tuned circuit, or pick-up, while the earthed pick-up lead may be taken to a tapping on the negative biasing resistance. Wire-wound biasing resistances usually possess a safer margin of current-carrying capacity than those consisting of deposited resistance material. The latter type should be rated to dissipate at least 2 watts.

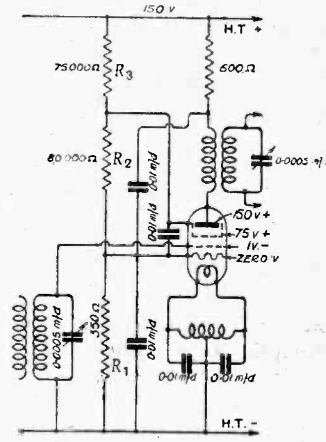
Explanatory Notes on the Circuit Diagrams reproduced on the opposite page.

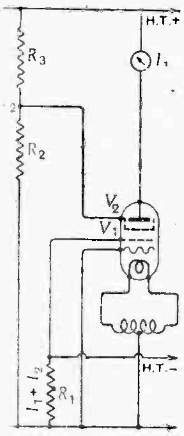
1. When an anode current I traverses the resistance R a bias $V = IR$ is applied to the grid.
2. Output stage in which the grid bias is produced by the voltage drop across a resistance. If the anode current is 20 mA. and the resistance has a value of 1,000 ohms then a bias of 20 volts will be applied to the grid. Note that the anode voltage is reduced by the amount of grid bias.
3. Biasing an H.F. stage. The cathode is connected to the H.T. – through the resistance R_1 and the voltage drop thus produced is applied to the grid. This resistance (R_1) forms part of the screen voltage potentiometer ($R_2 + R_3$). $V_1 = R_1(I_1 + I_2)$. $V_2 = \frac{R_3 \times \text{max. voltage}}{R_1 + R_2 + R_3}$ approximately. In determining V_2 the comparatively low resistance of R_1 may be neglected although it is carrying both the current of the potentiometer and the valve.
4. Practical circuit developed from Fig. 3 showing suggested values for the resistances.
5. Modified schematic circuit of an indirectly heated screen-grid valve in which the potential of the cathode is the same as the mean potential of the heater.
6. The circuit of Fig. 5 shown in practical form. As the ends of the resistance R_1 are connected to the common leads H.T. – and earth, care must be taken when introducing a second similarly biased stage.
7. In this arrangement the total anode current produces a voltage difference across the resistances R_4, R_5 and various voltages as required may be passed to the several valve stages through suitable decoupling resistances (R_6). In this instance R_4 produces the correct grid bias for the H.F. stages, while R_5 arranged as a potentiometer serves as a volume control by increasing the bias. Other resistances may be placed in parallel with R_4, R_5 to produce other biasing potentials such as may be required by an anode bend detector or when amplifying from a gramophone pick-up.
8. Anode bend detector circuit arranged to avoid difference of potential between heater and cathode. The point X is connected through a decoupling resistance to a point on the resistance R_5 of Fig. 7. Only when a reduction of anode voltage is required will the potentiometer R_7, R_8 be necessary.
9. Leaky grid detector with positive bias. A high resistance potential divider is connected between H.T. + and cathode return lead and a small positive potential applied to the grid through the leak resistance. It should be noted that the low voltage end of the potential divider must not connect direct to the H.T. – when negative biasing resistances are interposed.

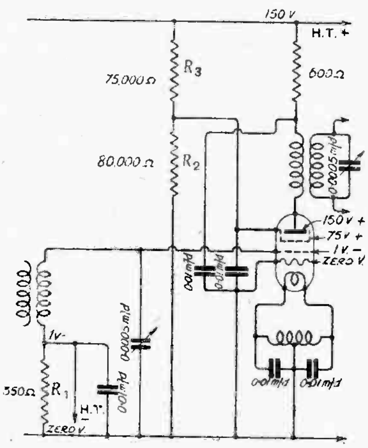

H.T.+
I
V
R
H.T.-
①

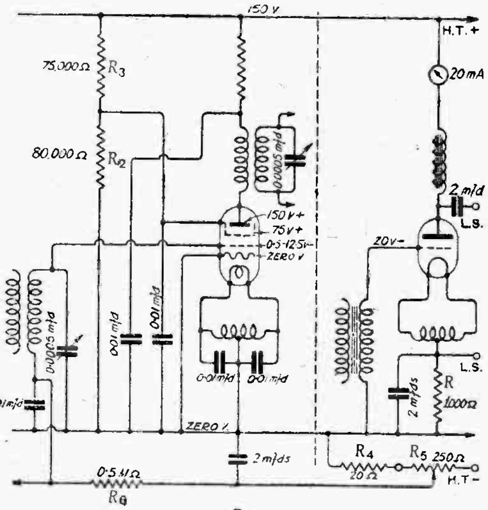

H.T.+
20 mA
2 mfds
2 mfds
L.S.
-20 v
ZERO VOLTAGE POINT
L.S.
2 mfds
1000 Ω
R
H.T.-
②

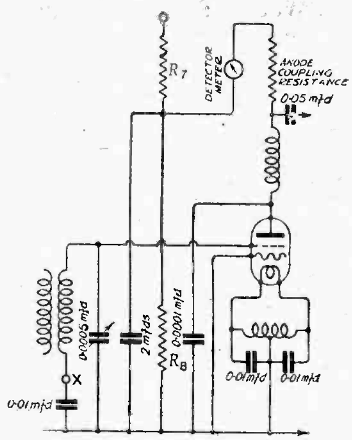

H.T.+
R3
I1
I2
R2
V2
V1
+
I1 + I2
R1
H.T.-
③

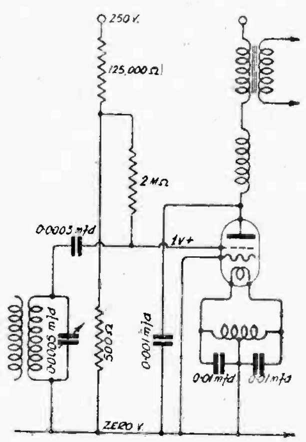

150 v
H.T.+
75000 Ω
R3
600 Ω
80000 Ω
R2
0·01 mfd
0·0005 mfd
0·01 mfd
150 v +
75 v +
1v. -
ZERO v
0·0005 mfd
550 Ω
R1
0·01 mfd
0·01 mfd
0·01 mfd
H.T.-
④


H.T.+
R3
I1
R2
V2
V1
H.T.-
I1 + I2
R1
⑤

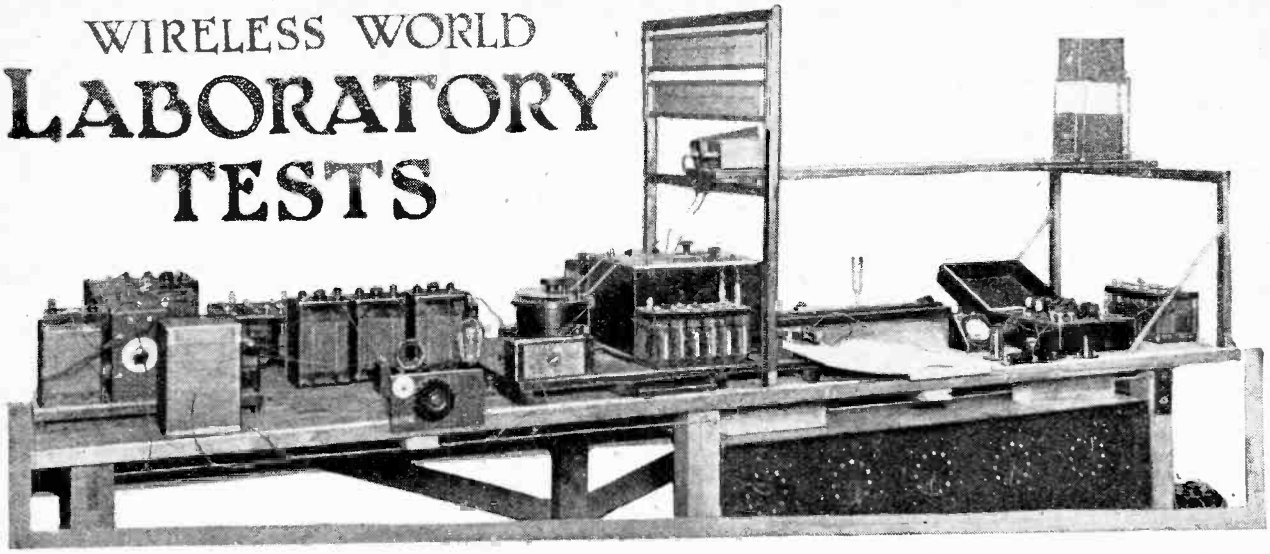

150 v
H.T.+
75,000 Ω
R3
600 Ω
80,000 Ω
R2
0·0005 mfd
150 v +
75 v +
1 v. -
ZERO V.
0·01 mfd
0·01 mfd
1v-
0·0005 mfd
550 Ω
R1
0·01 mfd
H.T.-
ZERO V.
0·01 mfd
0·01 mfd
⑥


150 v
H.T.+
75,000 Ω
R3
20 mA
80,000 Ω
R2
0·0005 mfd
2 mfd
L.S.
150 v +
75 v +
0·5-1·25 v-
ZERO v
20 v-
0·0005 mfd
0·01 mfd
0·01 mfd
0·01 mfd
0·01 mfd
L.S.
2 mfds
R
1000 Ω
0·01 mfd
ZERO V.
2 mfds
R4
R5
250 Ω
20 Ω
H.T.-
0·5 MΩ
R6
⑦


R7
DETECTOR METER
ANODE COUPLING RESISTANCE
0·05 mfd
0·0005 mfd
2 mfds
0·0001 mfd
R8
X
0·01 mfd
0·01 mfd
0·01 mfd
⑧


250 V.
125,000 Ω
2 MΩ
0·0005 mfd
1v+
0·0005 mfd
500 Ω
0·001 mfd
0·01 mfd
0·01 mfd
ZERO V.
⑨

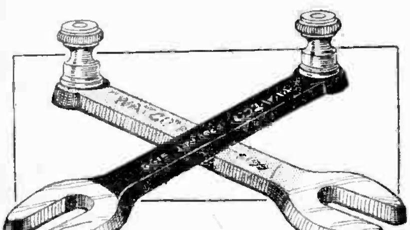
WIRELESS WORLD LABORATORY TESTS



A Review of Manufacturers' Recent Products.

"WATCO" L.T. TERMINAL TAGS.

The restriction of space in portable, and transportable sets often necessitates accommodating the L.T. accumulator in a rather inaccessible position, with the result that one's patience is occasionally seriously taxed in making satisfactory connection between the L.T. leads and the cell. The operation of connecting and disconnecting the cell for recharging purposes can be made delightfully easy by fitting the extension lugs supplied by the Waterloo Tool Co., Ltd., 21 and 23, York Road, Lambeth, London, S.E.1. These are made from soft lead coated with non-corrosive paint and provided with a terminal at one end and shaped lugs at the

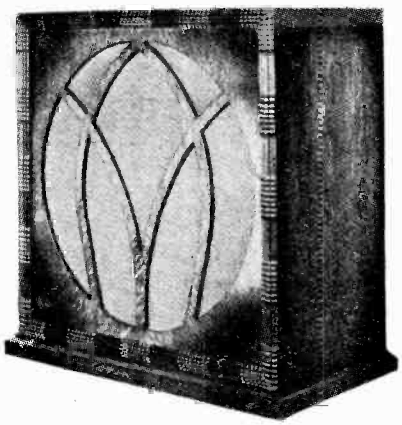


"Watco" extension terminal tags for use in portable sets where the L.T. cell is not readily accessible.

other for gripping under the terminals on the battery. They are supplied in red and black colours as a means of identifying the polarity of the battery. The price has been fixed at 6d. the pair.

AMPLION STANDARD CABINET CONE LOUD SPEAKER.

This new speaker, to be known as Model A.B.6, has been introduced to replace the earlier Models A.C.25 to A.C.29, and is the only balanced armature model loud speaker made by this firm. It occupies an intermediate position between the Amplion Lion and the cheaper "Junior" types. It is housed in a handsome cabinet measuring 14½in. × 14½in. × 8in. deep, with an ornamental front, and is acoustically



Amplion new Standard Cabinet Cone Loud Speaker, Model A.B.6, in polished oak case.

open at the back. Four large-diameter holes provide free egress for the sound-waves emitted from the back of the cone. The confining of these waves often leads to bad cabinet resonance and impairs reproduction.

A feature of special interest is the provision of three input terminals, which gives the choice of three different loud-speaker impedances, and enables that most suited to the particular output valve fitted to be employed. For test purposes the receiver used was fitted with an output valve having an A.C. resistance of 1,600 ohms and an output filter. With this arrangement the medium impedance winding gave the best all-round results. The high impedance winding should be used with valves of between 2,500 and 4,000 ohms A.C. resistance.

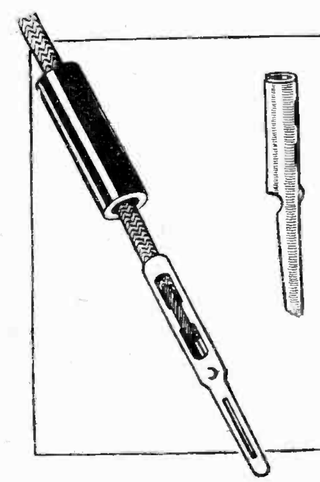
A practical test showed that with normal electrical inputs the frequency band to which the instrument gave good audible response was from about 150 cycles up to 4,500 cycles. The speaker favoured the frequencies below 800 cycles, and showed a noticeable cut-off at 150 cycles.

The instrument is sensitive, and will accept quite large inputs before showing signs of distress.

The makers are Messrs. Graham Amplion, Ltd., 26, Savile Row, Regent Street, London, W.1, and the price of the Model A.B.6 in a polished oak cabinet is £4 10s.

"GOLTONE" SPRING WANDER-PLUG.

Two parts only are used in this wander plug. The prong and wire anchorage are stamped in one piece from hard brass,



"Goltone" spring wander-plug.

and the bared end of the flex is gripped by first threading this through two holes and pushing a sleeve of insulated material over the shank.

The prong is "D" shaped and given a slight taper to enable the plug to accommodate itself to different-sized sockets in the H.T. battery. To differentiate between positive and negative leads, sleeves in red and black coloured material are supplied. The makers are Messrs. Ward and Goldstone, Ltd., Frederick Road Pendleton, Manchester, and the price has been fixed at 1½d. each.

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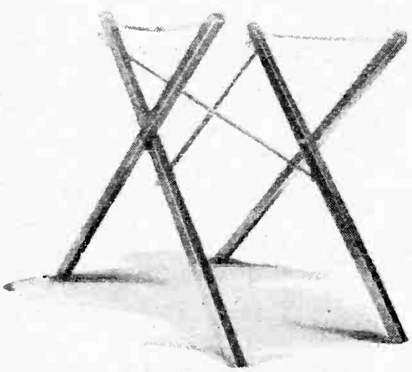
BELLING-LEE "RADIO-LEGS."

A simple but effective device for converting a table type receiver into a pedestal model has been introduced recently by Messrs. Belling-Lee, Ltd., Queensway Works, Ponders End, Middlesex. This consists of a cleverly designed folding leg type table, but without the usual top. Attachment is a very simple matter, and the device is adjustable to accommodate most sizes of cabinets from a small loud speaker to that required to house a five- or six-valve set.



Belling-Lee "Radio-Legs" convert a table model set into a pedestal type and are adjustable to suit any sized cabinet.

The legs are first pulled out to the width of the cabinet and locked by the small nuts provided. Having opened out the cross legs to slightly more than the depth of the set, they are held temporarily in position by a chain at both sides. The set is then placed in the claws on the top of each leg, and two wing nuts tightened until the chains are taut. The set will then be rigidly attached to the legs and can be carried about with ease, at the same time possessing the advantage that it can be placed in any convenient corner.

These legs can be used also to support portable and cabinet type gramophones. They are available in oak or mahogany finish and sell at 15s. 6d. the set.

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RADIO-GRAMOPHONE CABINET.

The Premier Supply Stores, 165, Fleet Street, London, E.C.4, has introduced recently a radio-gramophone cabinet provided with spacious compartments for loud speaker, batteries, receiving apparatus and gramophone equipment. It will accommodate a set measuring 22in. long, 8in. high, and 16in. deep. The overall dimensions of the cabinet are 36in. high, 24in. wide, and 19in. deep. A well is provided to accommodate the gramophone turntable and tone arm. The motor board is made of nine-ply wood.

Handsomely finished radio-gramophone cabinet by The Premier Supply Stores.

The cabinet is handsomely finished in polished oak and the price has been fixed at £4 19s. 6d. An ebonite panel, cut to size, finished and polished in either black or "mahoganite," and measuring 21 × 7in., can be supplied for an additional 3s. 6d.

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"TWIN-CONE" TWENTY.

Linen diaphragms mounted back-to-back, with their apices touching, have been found to give surprisingly good reproduction, the suppleness of the material preventing well-defined diaphragm resonance. Best results are obtained when the two cones are of dissimilar size.

The constructional work involved necessitates access to a well-equipped workshop, but now this need not deter the home constructor, since Messrs. Green and Faulconbridge, Ltd., Coventry, have placed on the market a kit containing all the parts required for the construction of a double-cone linen diaphragm.

The kit consists of 17 packets and contains 149 parts. The main frame is assembled from iron bars, and the sides from stout cardboard finished to resemble grained wood. The finished article measures 20in. square and 8in. deep.

A cabinet is unnecessary, unless particularly desired, since the diaphragm material is not displeasing in appearance and the stout cardboard sides give the impression of a wooden case. Four rubber feet are included to prevent damage (and to absorb vibration) should the loud speaker be rested on a polished cabinet or table.

Provision has been made to enable most of the well-known cone movements to be used. However, the makers offer a special movement for building into the case: this is referred to as the "Twin-Cone" movement, and sells at 15s. The price of the kit is 21s.

A slight modification has been made in recent outfits. Lighter corner-pieces are now included as standard, and, as an alternative to the stout linen for the diaphragm, thinner material can be supplied. This renders the speaker more sensitive and is recommended when small power output valves are used.

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It has been brought to our notice that the price of the Pilot "Resistograd" reviewed in our issue of October 30th last should be 5s. and not 4s. 3d., as stated. The error on the descriptive leaflet was not notified in time to include the correct price.

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In our issue of October 30th last mention was made of the Calton Stewart H.F. choke under "Laboratory Tests." The address of the manufacturers should read 28, St. Enoch Square, Glasgow, and not as stated, the business having been transferred from Edinburgh some time ago.

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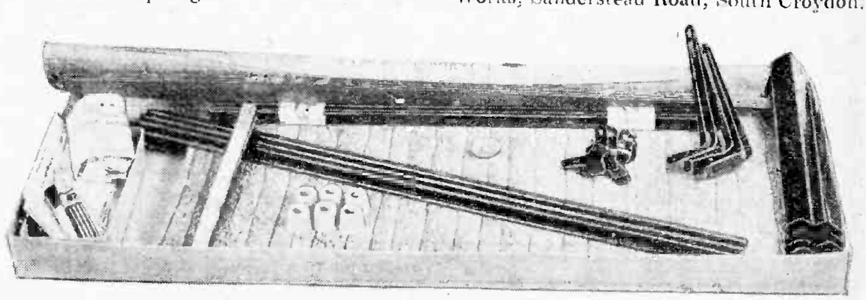
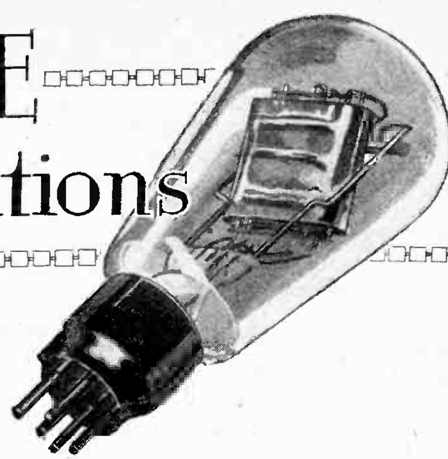
TRADE NOTE.

On November 18th the Carrington Manufacturing Co., Ltd., opened their new showrooms and sales department at 24, Hatton Garden, London, E.C.1. The showrooms are open from 9.30 a.m. to 5.45 p.m. daily, with the exception of Saturdays, when they close at 12.30 p.m. Small stocks are kept for emergency purposes only. Orders should be sent, as hitherto, to the main depot at Cameo Works, Sanderstead Road, South Croydon.



Complete set of parts contained in the kit of the linen diaphragm "Twin-Cone Twenty."

THE PENTODE Under Working Conditions



Calculating the Power Output of Triodes and Pentodes under Correct Load Conditions.

(Contributed by the Research Department of the General Electric Company.)

THE intelligent operation of a loud speaker is dependent upon an understanding of the properties of the output valve. Thought must be given to the correct conditions of load necessary to obtain the maximum undistorted output. Attention is drawn in this article to the excessive voltages developed when using a pentode incorrectly.

IN dealing with three-electrode valves from the point of view of the correct impedance to connect into the anode circuit to obtain the maximum output it is best to use curves in which ordinates are anode current and abscissæ anode volts with curves drawn for constant grid voltages; Fig. 1 shows such a set of curves for an LS5 valve.

Suppose a valve is connected up as in Fig. 2 to a resistance load with an inductance that has a much greater impedance and a condenser that has a much lower impedance than the load resistance.

Suppose now normally the H.T. voltage is 300 and the grid bias is −30. Then with no alternating voltage on the grid the anode current will be 22.5 mA. and the point P on Fig. 3 will represent conditions in the valve as to anode current, anode volts and grid volts (assuming negligible D.C. voltage drop in the choke).

If now an A.C. voltage is applied to the grid, there will be an A.C. component of the anode current—if the anode current increases by δI amps the current through R will be δI amps; the voltage across R will be $R\delta I$, and hence the anode voltage will drop by an amount $R\delta I$. Thus, if on Fig. 3 a straight line is drawn through P such that its slope in

$$\frac{\text{volts change}}{\text{current change (amps)}} = R$$

then whatever voltage is applied to the grid the corresponding anode volts-anode current state will be determined by a point lying on this line.

In Fig. 3 XPY is the line through P corresponding to R = 10,000 ohms; this figure is checked, for by considering the points where the line cuts the axes it is seen that an increase of 520 volts causes a decrease of 52 mA.; hence the corresponding resistance is:

$$\frac{520}{0.052} = 10{,}000 \text{ ohms.}$$

Having our 10,000-ohm line through P we can now study what happens when the grid voltage is varied; when the grid has been swung from 10 volts + from its normal biased condition of −30 volts its voltage will be −20 and the anode

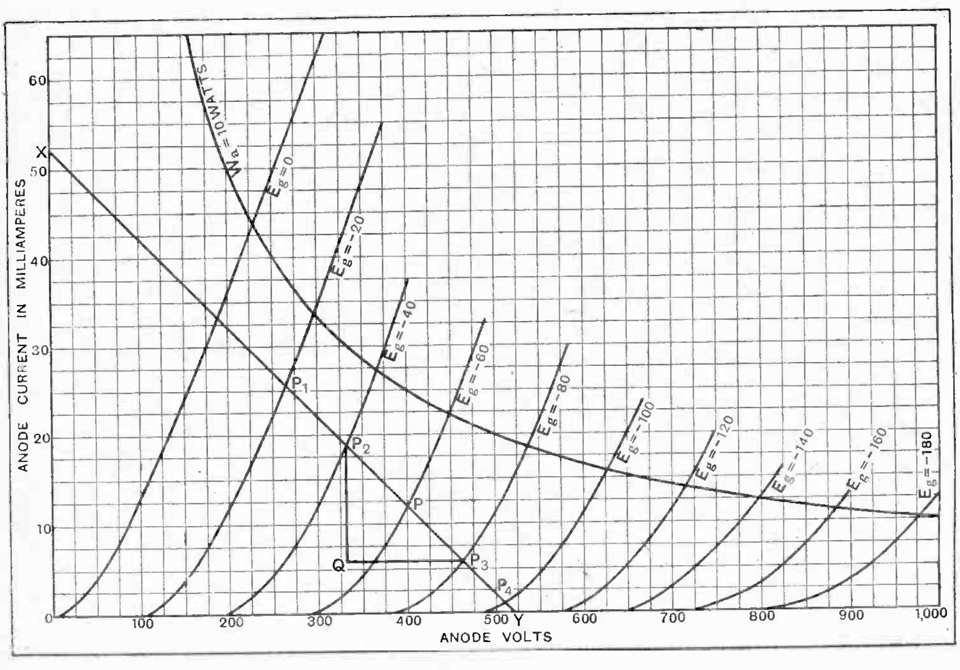


Fig. 1.—Anode current-anode voltage curves for an LS5 valve. The power output triangle P_2 Q P_3 represents only a fraction of the permissible output.

The Pentode Under Working Conditions.—
current and volts will be given by the point where the line XY cuts the −20 volts grid line, i.e., the point marked P_2.

Similarly, when the grid voltage has been increased by 30 volts, the grid voltage will be zero and the point P_1 where XY cuts the Eg=0 line will give the corresponding anode current and voltage.

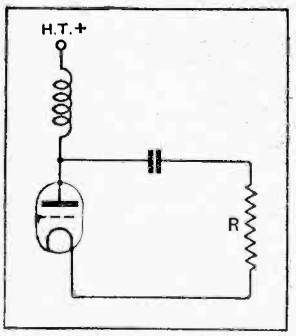


Fig. 2.—Circuit with load R connected to valve output. The inductance has an impedance greater than the load and the condenser impedance is less than the load.

Here we come up to a limitation, for if we swing the grid more positive still we shall have grid current which will cause distortion of the input voltage. Thus the useful portion of the line XY extends upwards from P to P_1; as the voltage applied to the grid will be symmetrical we shall require to swing the grid negative by an equal amount; since we are to swing upward from −30 to 0 we shall have to swing from −30 to −60 volts on the grid arriving at the point P4. Thus with 30 volts bias we can swing the grid from 0 to −60 and our anode current and volts will follow the line P_1P_4. The total change in anode current will be the difference of the currents corresponding to the points P_1 and P_4 and will be 33−12=21 milliamps. This will be twice the peak value of the A.C. component of the anode current so that the R.M.S. A.C. current through R will be $\frac{21}{2\sqrt{2}}=7.5$ mA. approximately. Similarly, the total voltage swing across R is the difference of the voltages corresponding to P_1 and P_4 and is 405−180=225, and here again to get the R.M.S. value we must divide by $2\sqrt{2}$; hence the R.M.S. voltage is $\frac{225}{2\sqrt{2}}=80$ volts approximately. Thus the power delivered to R is $\frac{80\times 7.5}{1000}$ watts=0.6 watt.

We may note that if we draw a right-angled triangle P_1QP_4 the watts are proportional to the area of this triangle, and are in fact equal to one quarter of its area in volt amps. In the present case we note that each volt change on the grid as we pass from P_1 to P_4 along the line P_1P_4 produces equal changes in anode current and voltage, thus the current through R is practically a distortionless replica of the grid volts. This may not be always so, for suppose as in Fig. 1 we had set the anode voltage at 400, the grid bias at −60 and as before take R=10,000 ohms. Then if we proceed as before we might say that we could swing upward from −60 to 0, but it is necessary now to consider the other half of the swing from −60 downwards.

It is seen at once that soon after the grid has swung more than an additional 40 negative volts to point P_4 difficulties arise in that there ceases to be any anode current at all, and further that during the part of the swing −80 to −100 between the points P_3 and P_4 the change in anode current per unit change in grid volts is less than throughout the portion P_1 to P_3 of the curve since the length P_3P_4 is less than P_1P_2, P_2P or PP_3. This will cause distortion and we can say with this setting that we should not swing past P_3. This limits us in the other direction and thus P_2 to P_3 is the extent of the distortionless part of the XY line that we may use.

In practice neither the settings given in Figs. 1 or 3 would be used, but we should by trial and error obtain a line so that the mean bias point P comes in the centre of the usable portion of the line XY, that is the part between the line Eg=0 and the point where distortion occurs due to the curvature of the lower parts of the characteristics.

For example, with a resistance of 10,000 ohms we merely have to draw a number of lines on Fig. 3 parallel to the line XY and pick out the most suitable; this can be done for a number of values of resistance and the maximum watts on each case tabulated; we can then pick out the optimum conditions. When, as is the case with small valves, there is a limitation on the anode

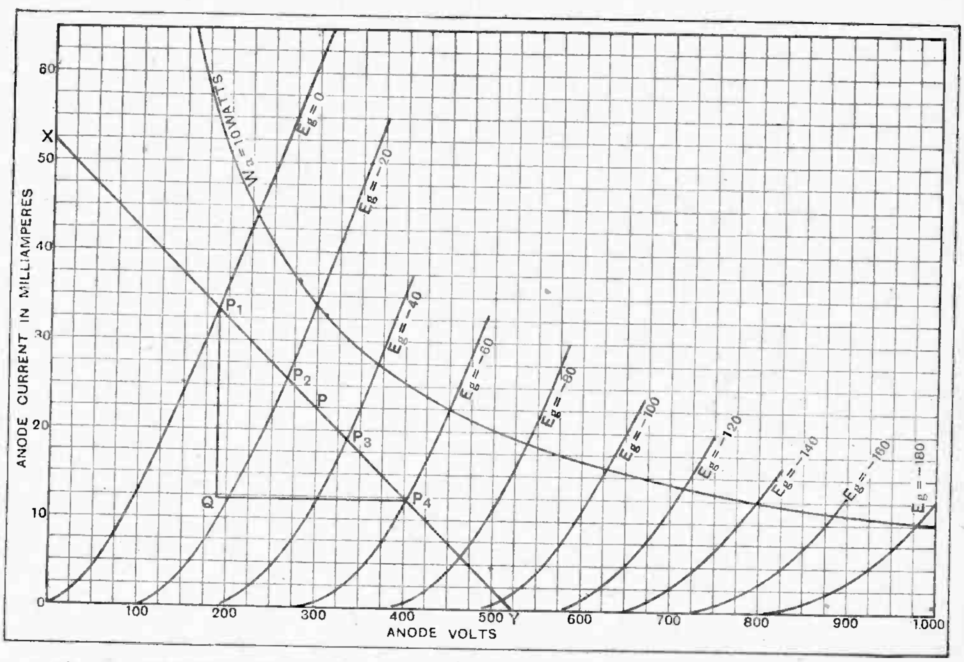


Fig. 3.—Operating conditions for an LS5 valve with 300 volts H.T. and 30 volts bias. Note that the 10 watt dissipation curve is not cut.

The Pentode Under Working Conditions.—

volts usually the optimum resistance is about twice the internal resistance of the valve. With larger power valves and power modulators where there is a limitation on the standing anode watts loss, the optimum resistance may be much more than twice the valve resistance.

Pentodes.

Pentodes, which we shall now examine, however, give quite different results, for we shall find that the optimum load resistance is much less than the internal resistance of the valve.

Curves of a pentode are shown in Fig. 4 and we can proceed in an exactly similar way to determine the optimum condition.

In Fig. 4 the line XY is the line corresponding to a 60,000-ohm load with 150 volts on anode and screen and −9 volts grid bias.

Suppose we swing the grid voltage from −6 to −12, i.e., 3 volts on either side of the bias, then we note that the lengths intercepted on XY on either side of P are very unequal in swing up to −6 on the grid; the anode volt swings down from 150 to 42, a difference of 108 volts, but in swinging down to −12 volts the anode swings up to the point where the e = −12 volt line cuts the XY line; this is off the diagram, but is about 450 volts, so that the increase in anode volts is 450 − 150 = 300, nearly three times these corresponding decreases when the grid swings to −6.

Since the anode current changes are proportional to the anode voltage changes there is corresponding anode current distortion. A further examination shows that

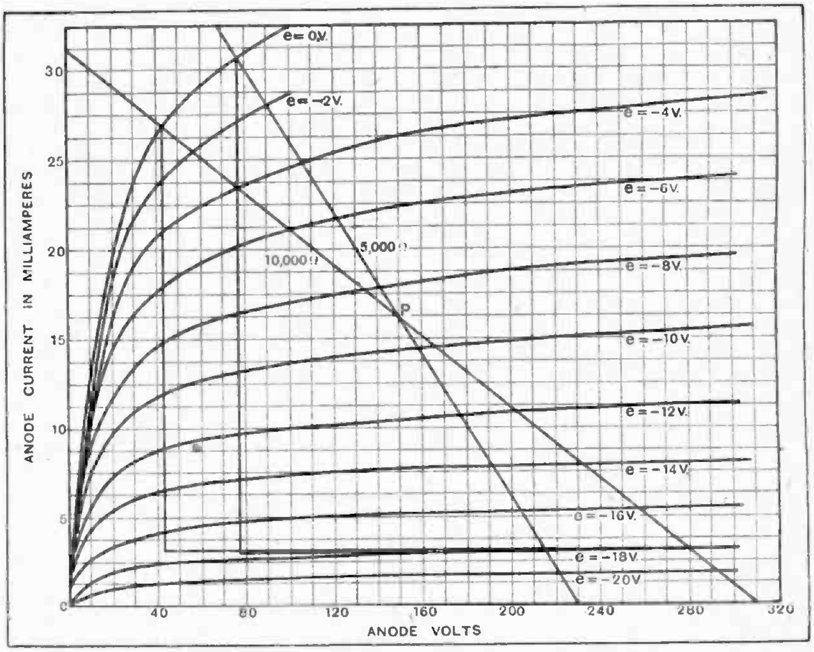


Fig. 5.—Pentode power output triangles for 5,000 and 10,000-ohm loads.

with this loading we ought not to swing the grid more than about $1\frac{1}{2}$ volts above and below −9 volts if we are to avoid serious distortion. If we were to swing the grid from 0 to −18, then the maximum anode voltage would be the point where the Eg = −18 line cuts XY. This is well off the diagram and would be somewhere about 1,100 volts, entailing, of course, great distortion, besides being very dangerous. These high peak voltages can be readily observed by using a peak voltmeter.[1] Let us now draw a 10,000-ohm line as in Fig. 5 with the same initial conditions; we now see that we can swing from 0 to −18 without any very excessive distortion. It is true that the equal changes in grid volts do not cause equal changes in anode current and volts, but the variations are not excessive. Again in Fig. 5 the 5,000-ohm line is drawn, and here again we can swing from 0 to −18 without any very serious distortion.

The triangles giving the full power are drawn and for 10,000 and 5,000 ohms they are about equal areas. If we decrease the load resistance below 5,000 ohms the area of the triangle and consequently the available output decreases. On the other hand, if we increase the

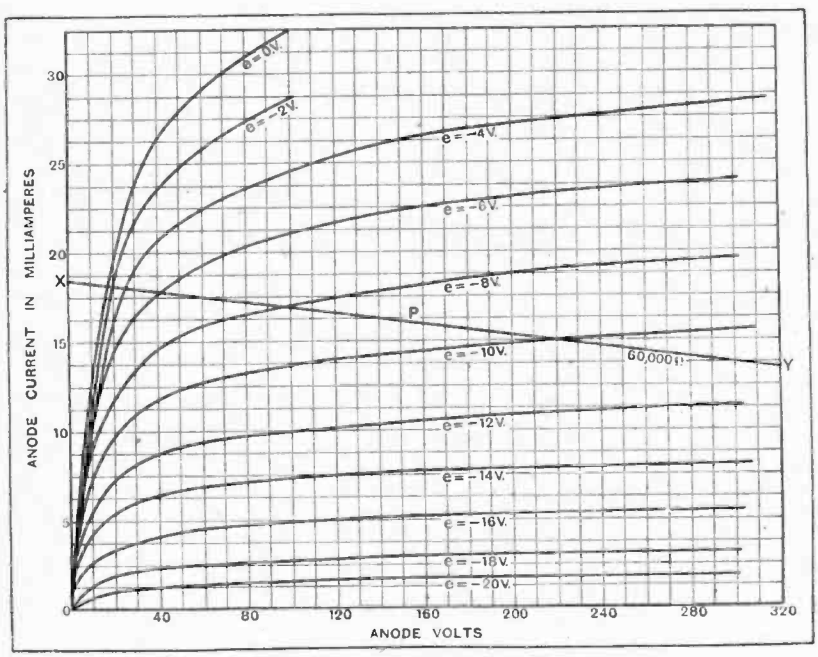


Fig. 4.—If a high resistance load is connected in the anode circuit of a pentode as shown at XY, dangerously high voltages are developed. The line XY would meet the −18 grid voltage line at about 1,100 volts H.T.

[1] *Cf.* Sims, *The Wireless World*, Jan. 16, 1929.

The Pentode Under Working Conditions.—

load much above 10,000 ohms we have to restrict the grid swing, and again the output goes down. Hence for such a pentode the optimum load is roughly between 5,000 and 10,000 ohms.

We have dealt only with resistance loads, whereas in practice the loud speakers are inductive. The treatment of the inductive load is considerably more complicated, but all that has been said about distortion applies equally well. Many loud speakers of the cone or horn type have impedances of 20,000 to 30,000 ohms or more at frequencies of 5,000 cycles, and if used directly with pentodes will give voltage peaks of 5 to 7 times the H.T. battery voltage. These high peak voltages, apart from the unpleasant distortion, are more than the valve or loud speaker can reasonably be expected to withstand.

A suitable transformer in which the winding having the fewer turns connected to the valve and the winding with the larger number of turns to the loud speaker may be of service.

A transformer connected the other way round will, with most loud speakers, of course, give more "noise" for a very small input voltage; but if the signal is increased unpleasant distortion and dangerous overvoltages will occur.

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.

B.B.C. TRANSMISSIONS.

Sir,—One of the most sensible and well-reasoned letters ever published in *The Wireless World* was that by Mr. McCormack on October 23rd last regarding B.B.C. transmissions. Any intelligent listener with a wireless set having a performance curve above the level of the first gramophone would agree with him when he says that the only "first-rate" transmissions are the direct or "local" ones, and that the majority of listeners (outside the London area, at any rate) receive as a rule third to tenth-rate transmissions.

It, therefore, causes me agony of soul to read the letter in your issue of November 13th by "Fair Play," of York, Yorks.

Mr. Fair Play's argument is: "Who are you, Sir, to criticise the B.B.C. unless you can first prove that your set and loud speaker are perfect? How dare a mere cutter, bobber, or shingler of side-bands talk of decent reproduction? Who are we —with our trivial bits of amateur apparatus—to stand up in the market place and deride the omnipotent B.B.C.?"

Now this is very quaint. My taste, hearing, sight, and sense of smell and touch are not what they used to be. I have lived, and smoked, and sat up late, and done many things which I should not have done; consequently, my senses are by no means perfect. We all suffer in this way when we have passed the age of callow youth. And yet . . . do I not know a good, succulent, well-done chop when I bite it? Do I not appreciate a well-sung song when I hear it? Do I not love the original water-colour better than the cheap reproduction? Do I not prefer the odour of real lavender water to the synthetic variety which comes from the penny-in-the-slot machine? Do I not respond to the feel of high-class woollies on a cold day? I do. I and my five senses may not be immaculate, but I flatter myself that I can separate the good from the indifferent and bad.

And so it is with my wireless set. It does not boast perfection. It is a thing, no doubt, of weird curves rather than splendid, manly, straight lines. It cuts off side-bands as ruthlessly as I cut off my own side-whiskers every morning of my life. But—in spite of all its terrible, almost-human imperfections—it can always tell me when a long land-line transmission is torturing a work of art. The Manchester Hallé Concerts, as disgorged by 2LO, cut me to the quick far, far more deeply than my set cuts the side-bands. The Bournemouth Orchestra (as relayed from the glass-and-iron concert hall in that delectable spot) makes me sigh for the melody of the first phonograph and the very, very first Edison-Bell record. And when 2LO gives me a poisonous dose of some remote spot like Plymouth, Cardiff, or Pwll-something-or-other, I feel so despondent that, but for my belief in silver linings, I should drink the acid in the accumulators and waft myself to the place where the music *would* be worth while.

An interesting but very harassing experiment which I sometimes try is to gather together the children (whose appreciation of good reproduction is by no means perfect), give them a few minutes with the 2LO uncles and aunts, and then switch over to the Birmingham-*via*-5GB Children's Hour. They invariably ask me why the second lot of aunts talk with plums in their mouths. I reply, sadly, that this is due to "attenuation of the higher frequencies in the land-line" and *not* to side-band amputation. They are good children. They believe me—because they know from experience that Daddy always speaks the truth. Which he does!

It is a poor set which will not show the lack of brilliance, or the harshness, or the undercurrent of extraneous noise, or the surfeit of plums in female mouths, when a long land-line transmission is in full blast. (Eastbourne, for some peculiar reason, excepted!) And it is a very poor set which cannot make manifest the difference between a good transmission and an indifferent one.

Therefore, I say that Mr. McCormack's letter is sound commonsense, and Mr. Fair Play, of York, Yorks, is talking arrant nonsense. Let us not creep too humbly upon the earth's surface, or we shall get from the self-satisfied B.B.C. precisely what we shall deserve—third- to tenth-rate junk.

Twickenham. BERTRAM MUNN.

Sir,—Surely it speaks well for your broadminded attitude to your readers' views that you should print the letter from "Fair Play." What Mr. McCormack said was perfectly correct and not a bit exaggerated. If "Fair Play's" receiver is not capable of distinguishing between the first-rate transmissions from 5GB and 2LO, especially when the programs are from a local source, and the terrible noises that are sent out when a relay from most of the more distant stations is attempted, either it is very poor indeed or his hearing is at fault. Of course there is some side-band attenuation at the receiving end in most cases, but nothing to compare with the horrible attenuation of even the medium high-frequencies that most land-lines give.

Until the advent of 5GB and the new 2LO, listeners in the Midlands were in the position of having receivers considerably in advance of the transmitters—or some of us had. Perhaps "Fair Play" has never heard a good receiver working on a good transmission?

If a gale puts the normal land-lines to Daventry out of commission we are given speech of a quality which, apparently, satisfies "Fair Play," but which we think horrible.

Birmingham. F. G. SACKETT.

Sir,—The impression which the B.B.C. seems to wish to convey about the quality of their transmissions is that they are well nigh perfect. One is driven to this conclusion: (1) By positive statements to that effect which appear from time to time; (2) by the fact that whilst their official organ contains pages of criticisms, often of a futile kind, about the subject-matter of their programs, criticisms of the *quality* of their transmissions are absent; and (3) by the fact that when anybody is rash enough to comment on the transmissions in your valued journal, or elsewhere, somebody else immediately pops up and tells the critic that he should "look to his set."

That our receiving sets are imperfect, more or less, everybody who has the most elementary knowledge of wireless will be ready to admit. That is not, I would submit, really the point at all. The real point is this: When we hear horrid sounds proceeding from our L.S., are we bound to assume that the fault is always at our end My submission is that most certainly we are not, if only for the reason that, though faults at the transmitting end are commonly discounted, nevertheless, in recent times, rather grudging admissions have appeared which urge difficulties associated with land-lines and "transients."

These admissions raise a number of questions, as, for example: What steps are being taken to get over the land-line trouble? What progress, if any, is being made in dealing with transients? And, thirdly, are land-line troubles and transients the only causes of the horrid sounds? As regards the third of these questions, let us take one or two examples:—

(1) The first few bars of a choral item are emitted by my L.S. They suggest that the singers have been dining on coarse fish and that some of the bones have stuck in their throats. Then there is a kind of rumpling sound from the L.S., and 90 per cent. of the fish-bones seem to have been swallowed. Was this rumpling sound due to the swallowing of the fish-bones or the swallowing of transients, or was it, perchance, due to a switch?

(2) A piano recital from the studio begins in such a way as to suggest that the pianist has, with his opening chords, broken 80 per cent. of the strings of the piano. Suddenly the volume is lowered by 200 per cent. and only about 10 per cent. of the strings appear to have been damaged What is it that has brought about this curious change?

(3) I listen to a piano item from Queen's Hall. It is a remarkably good reproduction of "the real thing." The concert ends, the voice of a giant tells me what the weather has been like to-day. I tone down the giant with my volume control. In due course he finishes and is followed by the usual piano item. I observe that, though I am receiving this piano item at only about one-eighth of the volume of the item from Queen's Hall, nevertheless the studio item produces the broken string effect, whereas the Queen's Hall item did not—or only very slightly. How exactly is this explained in terms of land-lines and transients?

(4) The announcer states that Thir Thamuel Thmith ith about to give one of hith thathinating dithcourtheth. Is the announcer speaking across a land-line from his bedroom, as depicted by Mr. Hammond, p. 334 of the B.B.C. Year Book? Or is it that my set is incapable of dealing with such high frequencies as the ss and ff? Well, I am forced to the conclusion that Mr. Hammond's picture of the announcer is not quite so innocent a joke as might appear at first sight. For when Sir Samuel begins, not only do the ss and fs appear clearly but the ss actually whistle!

Now, sir, criticism is of little use if not constructive. So here are some suggestions: (1) That you continue the good work of publishing letters commenting on the quality of the B.B.C. transmission. (2) That you let us have an article or series of articles showing the *kind* of faults which we may reasonably attribute to faulty transmission and not to our sets. (3) That if the B.B.C. are unwilling to undertake the work themselves and tell us about it, some other public body, equipped with all the necessary and expensive instruments—perhaps the National Physical Laboratory—should carry out periodical and exact tests of transmissions under varying conditions and publish the results. (4) That we amateurs should, somehow or other, get together and evolve a scheme whereby we can compare notes about the transmissions and so help each other to decide whether the faults we notice are to be attributed to our end or to the transmitting end. This last suggestion may be difficult to carry out, but surely it is not impossible. Perhaps some of your readers may be able to make helpful suggestions about it? E. C. RICHARDSON.

Sir,—Such touching faith as that expressed by "Fair Play" in his letter published in your issue of November 13th is, in these days, most refreshing.

Most of your readers will, however, not be prepared to accept "Fair Play" as a competent judge, for he does not appear to be situated in such a position as to be able to take advantage of wireless reception under ideal conditions.

Situated as I am, less than two miles from 2ZY, I can, and do, use "high loss" coils which effectively prevent loss of side-bands, together with an amplifier which follows B.B.C. practice closely and which is admitted to amplify fairly evenly all frequencies between 25 cycles and 6,000-7,000 cycles, and I unhesitatingly endorse Mr. McCormack's comments on land-line transmissions.

One has only to hear a transmission from 2ZY of the Northern Wireless Orchestra (playing in the new studio) and to compare it with any land-line transmission from 2LO (of an orchestra, of course) to realise the enormous difference. In the case of the land-line transmission (whether from the London studio or from the Queen's Hall) the bass lacks "body," the drums are extremely poor, and violins are thin and lack the characteristic timbre of a violin.

But, apart from the technical aspect of the matter, why should London listeners benefit at the expense of that great body of provincial listeners, in numbers many times greater than listeners to 2LO?

Why should not the National Orchestra or B.B.C. Symphony Orchestra be formed in Manchester, where the finest body of orchestral musicians in this country resides and where, in addition, there is the finest broadcast studio in Europe?

Manchester. JAS. HUDSON.

CONCERTS FROM RADIO PARIS.

Sir,—It will no doubt be of interest to your readers to know that we have arranged for a series of weekly recitals to be given each Sunday, broadcast from Radio Paris.

These recitals will last an hour and will consist of varied popular music, the concert for Sunday, Dec. 1st, for instance, was dance music played on Decca records by leading Decca dance bands from 2 to 3 p.m.

We believe that we are the first gramophone company to book an exclusive hour for the entertainment of listeners.

THE DECCA RECORD CO., Ltd.

London, S.W.9.

NON-RADIATING SETS.

Sir,—I would like to express my sympathy with Mr. Henry W. Moss.

I have had the same trouble for the last eighteen months and on all wavelengths covered by the "Everyman Four."

It is very seldom I can listen to a programme without interference of one kind or another, either "howling" or "silent-point" oscillation. (I reported the matter to the B.B.C. in June or July, 1928, and the G.P.O. has been dealing with it for over twelve months and can give me no hopes whatever.)

I also know of a road less than a mile from here where one listener switches off and another says he will give up wireless owing to interference.

I certainly think reaction ought to be prohibited, because I feel sure all this trouble is caused by people "playing" with their sets, and the quality of transmissions must be improved if the ether could be cleared of these "heterodyne howls."

London, S.W.8. A. W. SNARE.

Sir,—Mr. Moss, in your issue of November 6th, proposed that legislation should be introduced prohibiting the use of reaction. I assume, of course, that he meant this to apply only to sets intended for reception on broadcasting wavelengths, since it would render amateur communication on short waves more difficult.

Although anyone who lives in a crowded district will heartily agree to it, this idea is too Utopian to be useful. If, as in France, the larger percentage of sets were commercially built, the legislation could be enforced by limiting manufacturers to circuits without reaction. But in England I think home constructors predominate. It would need an enormous (and incidentally expensive) army of men to go to every house having an aerial and examine the set.

There is another consideration. A man who is an inveterate fiddler will, if he has no reaction control with which to play, adjust some other part of the receiver. The final result of his unskilled efforts will be further oscillation, and the situation will then be as bad as before. "R.N."

Sir,—I read the letter from Henry W. Moss in your issue of November 6th with great sympathy.

My own set has a neutralised H.F. amplifier, and I am quite satisfied causes no interference. I would, however, willingly conform to such legislation as he suggests, and make the necessary alterations to my set, if such legislation would relieve me of the intolerable interference caused by the howls of my neighbours.

I recently sent a complaint to the B.B.C., and a P.O. official has visited the neighbourhood. Conditions were better for a few days, but are again becoming as bad as before.

Grimsby. "FELLOW SUFFERER."

EMPIRE BROADCASTING.

Sir,—One has always understood that the purpose of the Empire Marketing Board was to stimulate the sale of Empire products, not to provide entertainment for Empire listeners.

May one make another suggestion—that Empire broadcasting be regarded as a matter for the Imperial Government, that the B.B.C. do the actual transmission, and that the money be provided by the Post Office; they keep plenty of it!

G. M. PART.

The following extract from a letter from a reader in Singapore was received by Mr. Gerald Marcuse, President of the Radio Society of Great Britain, and is published as of general interest:—

Though I am not personally known to you, you are well known to me through your transmissions in the past, when I had a two-valve set. Now I am armed with a McMichael six-valve short-wave superhet., and I was extremely gratified this morning when I read your letter in *The Wireless World* of the 11.9.29 just to hand, promising us your excellent transmissions in the near future again.

Having no broadcast stations in this country, I went to the expense of getting the present set purely in the hope of getting 5SW in a satisfactory state, but all to no purpose. Twenty-five metres is in the midst of a nest of Morse stations, and its 15 kW. are simply swamped out. I and my family are sending you our grateful thanks for the trouble you, as an amateur, are going to take for the benefit of us amateurs in the outposts of the Empire, devoid of all help. For my part, at least, I have been continually writing to the local papers in the hope that our lamentations may some day reach the local or home authorities. Will it not be possible for you to get someone in Parliament to put the question at one of the meetings as to this Empire Broadcast? The Dutch in North Indies and the Americans in the Philippines are gaining ground, and the British wireless trade is suffering. The other day I went to buy a potentiometer of 400 ohms. I had to come home with a German-made potentiometer of 600 ohms and fix it in my set! And this was the only kind obtainable at any price.

I have again written to the local Press to-day and mentioned also your promise. I shall send a cutting in a couple of days.

Kindly give us some notice before you start and state wavelength. I rather prefer you to stick to about 20, as there is too much atmospheric interference at 40. Of course, you are the best judge.

SUPERHETS.

Sir,—Your correspondent's article on the Paris Radio Show was very interesting. He gives three reasons why the superhet. is as universal over there as straight sets are here. Can anyone give me three reasons for the apparent unpopularity here?

SUPER HET.

TELEVISION.

Sir,—In reply to the last paragraph of your editorial of the 20th inst., I would say that the Television Society is alive to the desirability of a comprehensive survey being made with the object of establishing the reasons for the present situation, and, further, of clarifying the future prospects of television broadcasting. The Society feels, however, that very little can be done in this respect without the whole-hearted co-operation of the trade and commercial interests concerned, who should be prepared to meet in a round-table conference together with representatives of the B.B.C. and representatives of this Society. The Society would, I think, welcome such a conference as being in the very best interests of that branch of applied science for which we all share an interest.

I can say at once that the number of members of the Society who systematically receive the television broadcasts as at present arranged is very limited, and there are probably not more than ten of our members who do so.

The Television Society, London, W.C.2. W. G. W. MITCHELL, Joint Hon. Secretary.

CATALOGUES RECEIVED.

Hobbies, Ltd., Dereham, Norfolk.—Autumn edition of Fretworkers' Weekly Journal (October 5th, 1929), containing a design for a Pedestal Wireless Cabinet.

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Higgs Motors, Witton, Birmingham.—Stock list of 1-, 2- and 3-phase induction motors for 50-cycle supplies; also D.C. dynamos and motors. There is a wide range of small machines of less than one b.h.p.

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Mullard Wireless Service Co., Ltd., "Mullard House," Charing Cross Road, London, W.C.2.—Descriptive leaflets of P.M. Filament Transformer and P.M. H.T. Supply Unit for A.C. mains.

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The D.P. Battery Co., Ltd., Bakewell, Derbyshire.—Illustrated folder of D.P. Kathanode large capacity L.T. accumulators.

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The Varley Co., Kingsway House, 103, Kingsway, London, W.C.2.—Loose-leaf illustrated catalogue of Varley main sets and wireless components; also 15-page instructional book on the use and application of this firm's products.

Messrs. C. A. Vandervell and Co., Ltd., Acton, London, W.3.—Illustrated catalogue of C.A.V. high- and low-tension accumulators for wireless uses; also folder dealing with non-spillable cells for portable sets.

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Messrs. Wingrove and Rogers, Ltd., Arundel Chambers, 188-9, Strand, London, W.C.2.—Illustrated leaflet of "Polar" differential reaction condenser.

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Messrs. J. H. Taylor and Co., Macaulay Street, Huddersfield.—Illustrated price list of proprietary wireless components stocked by this firm.

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Burne-Jones and Co., Ltd., Magnum House, 296, Borough High Street, London, S.E.1.—Descriptive folder of the "Magnum" short-wave converter. This is used in conjunction with the L.F. portion of the broadcast set, and includes short-wave detector and reaction circuit.

Marconi Wireless Telegraph Co., Ltd., Marconi House, Strand, W.C.2. Leaflets Nos. 1082/2, 1101, 1097 and 1103, illustrating and describing their 100-watt and 500-watt fixed wavelength telephone sets XMB1a and XMC2; the 500-watt telegraph transmitter types MC8a and MC8b, and the 1.5 kW. telegraph transmitter MC13.

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A. J. Dew and Co., 32-34, Rathbone Place, Oxford Street, London, W.1.—General wireless catalogue of proprietary receivers, components and accessories stocked for the season 1929-1930.

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Oldham and Sons, Ltd., Denton, Manchester.—32-page handbook entitled "Radio Power Problems," dealing with "Oldham" H.T. and L.T. accumulators and trickle chargers.

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L. McMichael, Ltd., Wexham Road, Slough, Bucks.—Illustrated and descriptive folders dealing with the "Super-Screened Portable Four," "Screened Dimic Three," and mains-operated receivers. Also full constructional details for the "Home Constructors' Screened Three" receiver.

BROADCAST BREVITIES

By Our Special Correspondent.

Progress at Portland Place.—Broadcasting in Parliament.—Christmas Programmes.

Broadcasting House.

The Portland Place site is now ready for the massive building designed by Col. Val Myer to house the B.B.C. headquarters. Tenders have now been invited for the constructional work and should be in the hands of the owning syndicate within the next week.

Building operations will occupy more than a year, and it is doubtful whether the opening ceremony can take place much before April or May, 1931.

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P.M.G. and Brookmans Park.

Seldom does the House of Commons spend so much time on wireless matters as it did on Tuesday of last week—Westminster's wireless day. Besides dubbing himself "the policeman of the ether," the Postmaster-General (Mr. Lees-Smith) had several interesting things to say regarding the activities of the B.B.C., and he made a new disclosure concerning future policy at Brookmans Park. The twin transmitter, which begins tests in a few weeks' time, will commence on low power, gradually increasing its output as the public habituate themselves to the new development. I understand that the first tests will probably not employ more than 5 kW.

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A Ticklish Question.

If the Postmaster-General's proviso is to be strictly observed, I imagine that the power increase of the twin transmitter will be exceedingly slow. Who is to say when the public have habituated themselves to a broadcasting system which calls for uncommonly selective sets and the virtual abolition of the crystal?

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B.B.C. to Borrow Money.

Another disclosure, which was not unexpected by those who have studied the B.B.C.'s present financial position, was contained in the Postmaster-General's remarks concerning the development of the regional scheme. Up to the present the Corporation has financed its stations from its reserves, but it is now anticipated that as the scheme develops it may be necessary for the B.B.C. to utilise its power to raise a loan.

The only alternative is to let the scheme hang fire until sufficient funds have accumulated from licence revenue, by which time the B.B.C. might have learnt too much about twin wave transmission!

Savoy Hill and the Pirates.

With a scarcity of funds looming ahead it is not surprising that Savoy Hill regards the "pirate" question with pathetic interest. Questions in the House evoked the P.M.G.'s statement that licence evasions were being gradually reduced, but Savoy Hill remains sad-eyed, the opinion there being that after seven years of broadcasting there should now be 4,000,000 set owners. Licencees number barely 3,000,000.

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Modulation of B.B.C. Transmitters.

A correspondent in last week's issue of *The Wireless World* pleaded for an equal degree of modulation from all B.B.C. transmitters. An official at Savoy Hill solemnly informs me that uniformity in this direction is always sought by the B.B.C. engineers, and that the degree of modulation never exceeds the boundaries of 2 and 30 per cent.

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A Disappearing Landmark.

The first and second 2LOs are both being dismantled. The Marconi House plant is already in the last stages of dissolution and will not be long survived by the installation in Oxford Street, which will also lose its masts by the end of this month.

Thus Brookmans Park will have no standby.

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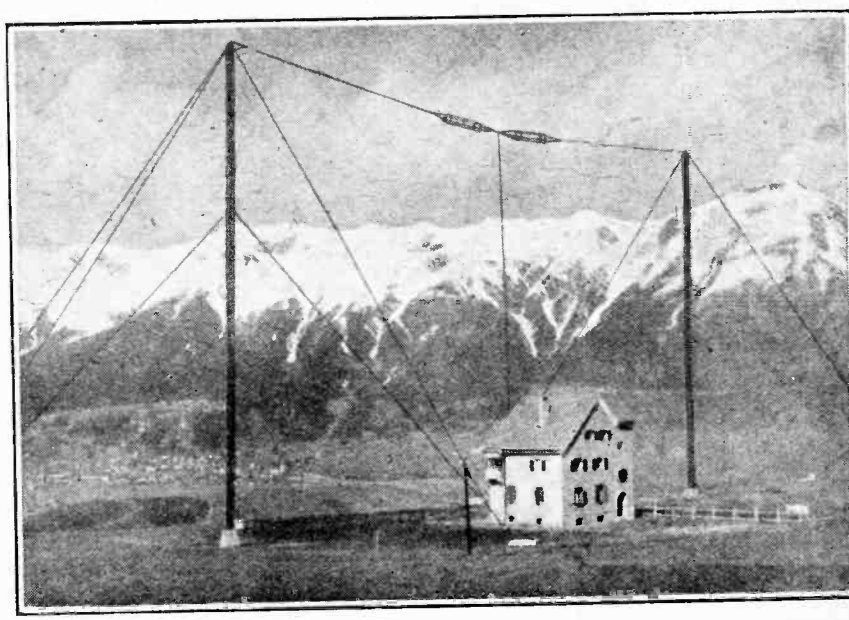
A Broadcast Christmas.

Seven Christmas seasons have been enriched with broadcasting, and now that we are approaching the eighth it needs an effort of memory to recall those prehistoric festivals when we had to make our own music or listen to the waits.

The Christmas element in the transmissions will begin on December 23rd with the broadcasting of the Nativity Play from St. Hilary's Church, Marazion, Cornwall. Two carol programmes will be given on Christmas Eve, while on Christmas morning 2LO and nearly all stations will broadcast the service from York Minster. Miscellaneous Christmas fare will make up the rest of the day's programme. In the afternoon Bransby Williams will give his well-known impression of Scrooge.



BROADCASTING IN THE AUSTRIAN TYROL.—The relay station at Innsbruck which distributes the Vienna programmes to mountain dwellers. The station is without a regular wavelength but is working provisionally on 287.4 metres.

READERS' PROBLEMS ANSWERED

The Service is subject to the rules of the Department, which are printed below; these must be strictly enforced in the interest of readers themselves.

A selection of queries of general interest is dealt with below, in some cases at greater length than would be possible in a letter.

"The Wireless World" Supplies a Free Service of Technical Information.

Designing Tuning Coils.

Have you ever published information for designing inductance coils to specific H.F. resistance values? Inspired by a recent article, I am thinking of trying filter circuits: hence my question. E. B.

Simple graphs for the design of coils of different H.F. resistances were given in our issue of January 11th, 1928. The range dealt with should be sufficient for your purpose.

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"Push-Button Regional Receiver."

With reference to your reply to "T. F. S." under the above heading in your issue of November 13th, I should like to know if it is possible to simplify the arrangement shown by using a tapping on each of the coils, instead of an extra semi-variable condenser for each tuned circuit. T. C. W.

It might be possible to obtain satisfactory results from a simple arrangement of this kind, but it would be found that the operation of tuning by varying a tapping point on an inductance coil would be a very inconvenient procedure; indeed, it would be almost impossible in a set which, by the very nature of the work it is intended for, must have reasonably selective circuits.

Provision for continuous adjustment of inductance over a limited range can be made by winding a few turns of the coil on a rotatable former (variometer fashion), but this would be no simpler and probably no cheaper than a second semi-variable condenser.

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"Pentode Two" Conversion.

My "Pentode Two" receiver gave entirely satisfactory results up to the time when Brookmans Park started operations; now I find that interference is so bad that it is a difficult matter to receive any station except 5GB and one or two other transmissions in the neighbourhood of 500 metres on the normal broadcast band. It is found that spreading of signals can be minimised by fitting a smaller series aerial condenser, but reduction to a value that is really effective renders the set extremely insensitive. Can you suggest a method of altering the receiver? I should not object to rebuilding it in a larger cabinet, but do not care to go to the expense of "scrapping" a number of existing parts, and perhaps adding an H.F. stage. R. F. B.

We suggest that you should rebuild your receiver to the general circuit arrangement of the "Two-Circuit-Two" receiver, described in our issue of February 6th.

The two sets are not widely dissimilar, and you will find that all your present parts can be used, and that little additional apparatus will be required.

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Testing a Variable Condenser.

I have reason to suspect an intermittent short-circuit between the vanes of one of my variable condensers, and, in order to make a test, connected a flash-lamp battery and dry cell across the terminals. The lamp glowed at, apparently, full brilliancy, irrespective of the position of the moving plates. Does this suggest that there is a short-circuit across the frame of the condenser, as the glow was observed when the moving plates were obviously clear of the stator vanes? H. C. F.

It may be that there is, as you say, a complete short-circuit in the frame of the condenser, but this would entirely prevent the reception of signals, and we are more inclined to think that you have forgotten the fact that, in a normal receiver, the variable condenser is bridged by a tuning coil with windings of low ohmic resistance, and, consequently, your test lamp will glow whether the plates are making contact with each other or not.

Before making a test of this sort the tuning coil should be disconnected.

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The "Foreign Listeners' Four."

When an indirectly heated valve is used as a grid detector, with an applied H.T. voltage not exceeding some 60 or 70 volts, I understand that there is no need to provide any positive bias for its grid. It is proposed to take advantage of this in introducing a slight modification to the "Foreign Listeners' Four"; consequently the grid leak will be connected directly to the valve cathode. With this arrangement it would seem that a very simple addition should make the set suitable for gramophone reproduction; will you please give me a circuit diagram showing how the necessary additions may be made, bearing in mind that I wish to get "free" grid bias if possible. W. G. L.

Your proposed scheme is quite sound, and, indeed, there is a good deal in its favour. We suggest the simple method of connection shown in Fig. 1. This necessitates the addition of a biasing resistance in the cathode lead, and also of a grid circuit switch to make the appropriate changes for gramophone or radio reproduction; as usual, it is desirable that this switch should have very good insulation and low self-capacity.

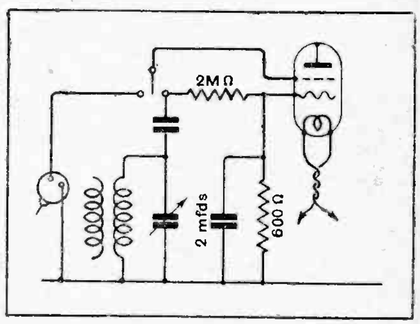

Fig. 1.—Connections of a gramophone pick-up in the detector grid circuit of the "Foreign Listeners' Four."

RULES.

(1.) *Only one question (which must deal with a single specific point) can be answered. Letters must be concisely worded and headed "Information Department."*

(2.) *Queries must be written on one side of the paper, and diagrams drawn on a separate sheet. A self-addressed stamped envelope must be enclosed for postal reply.*

(3.) *Designs or circuit diagrams for complete receivers cannot be given; under present-day conditions justice cannot be done to questions of this kind in the course of a letter.*

(4.) *Practical wiring plans cannot be supplied or considered.*

(5.) *Designs for components such as L.F. chokes, power transformers, etc., cannot be supplied.*

(6.) *Queries arising from the construction or operation of receivers must be confined to constructional sets described in "The Wireless World" or to standard manufacturers' receivers.*

Readers desiring information on matters beyond the scope of the Information Department are invited to submit suggestions regarding subjects to be treated in future articles or paragraphs.

Isolating the Aerial Circuit.

I am about to add a tuned aerial circuit to my receiver and to provide an H.T. feed from my D.C. mains (220 volts with positive earth). Some time ago it was stated in "The Wireless World" that the aerial circuit should, in these conditions, be isolated from the mains, and it has been suggested that a double-wound aerial transformer, with no metallic connection between primary and secondary, is of advantage: is it possible to bring about this isolation when using a two-circuit aerial tuner with capacity coupling? I have studied several circuit diagrams of this arrangement, but it seems to me that they all provide a direct path to earth for the mains. C. R.

So far as isolation of the mains from the normal wireless "earth" is concerned, the capacity-coupled two-circuit aerial tuner does not confer any advantage over any other arrangement, and, if used in the ordinary way, it is necessary to fit the conventional "earth" condenser; to be on the safe side, a second condenser should be inserted in the aerial lead. The need for this can be entirely overcome by fitting a small mica condenser (of about 0.001 mfd.) between the earthed end of the aerial coil and the earth terminal of the set in the manner shown in Fig. 2, where the extra condenser is marked "C."

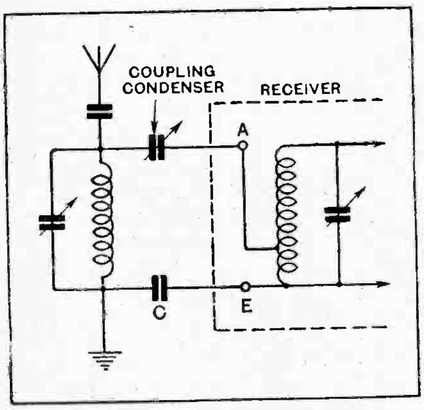

Fig. 2.—A safety precaution for D.C. mains users: a capacity-coupled tuned aerial circuit may be isolated from the supply leads by fitting an extra condenser.

It may be added that this arrangement confers little benefit as compared with the more conventional method, but it does prevent the aerial coil and condenser from becoming "live"—a matter of some importance when these components are mounted outside the receiver cabinet.

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The Best Variable Condenser Capacity.

I am going to buy three high-grade variable condensers, with the idea of using them for experiments connected with H.F. amplification. What value of capacity do you consider to be the most generally useful? C. C. P.

It is rather difficult to dogmatise on this matter, but, on the whole, we think you would be well advised to choose a value slightly over 0.0003 mfd.—say, 0.00035 mfd. This value is highly suitable for use in modern circuits, as it enables one to cover the normal broadcast waveband very satisfactorily, without depending too much on the lower end of the condenser scale.

By choosing condensers of 0.0005 mfd. you would be safe enough, as they would be suitable for use with coils of any reasonable inductance, but scale readings would be unnecessarily close together with the more popular arrangements.

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Mistaken Economy.

It is proposed to use a Mazda 2-volt S.G. valve in the H.F. position in my receiver, with 6-volt valves for detection and L.F. amplification. Instead of inserting a resistance in series with the filament of the H.F. valve, in order to absorb surplus voltage, would it not be more economical to feed it through an extra lead from the positive terminal of the first cell (counting from the negative end) of my 6-volt L.T. battery? S. M. E.

We are sure that it would be a mistake to adopt this plan, as the need for recharging your L.T. battery will be determined by the condition of the cell from which most energy is taken. In your case this will be the first one, from which, with your proposed method of connection, more current will be drawn than from the others. Unless special precautions are taken in recharging, individual cells are likely to be either over-charged or under-charged.

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A Simple Bias Rule.

Is it to be assumed that the correct value of negative grid bias of an amplifying valve is dependent upon impedance, and that an increase in impedance automatically implies a reduction in negative grid bias, all other conditions being unchanged? P. R. R.

Generally speaking, this is a safe rule to follow, both with regard to amplifying valves and anode bend detectors. It should not be applied too hastily when dealing with H.F. amplifiers, which are seldom required to accept any very considerable input voltage. It is usual to take advantage of the improved characteristics resulting from the application of the smallest bias necessary to prevent the flow of grid current.

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A Point of Difference.

There seems to me to be very little difference between filter circuits and loosely coupled separately tuned aerial circuits of the type with which we are all familiar. Possibly, however, there is some difference between the two that I have overlooked; will you please give me a few words of explanation? T. W. M.

Basically there is no real difference, but the term "filter circuit" is conveniently applied to an arrangement of two coupled circuits in which a deliberate attempt is made to avoid loss of high notes (or side-band cutting) by so arranging the coupling between them so that something approaching a "double-humped" resonance curve is produced.

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An Apparent Inconsistency.

After reading a recent article on the subject of H.F. transformer design, I was interested enough to compare the optimum ratios between primary and secondary windings given there with those used in recent receivers described in your journal. I was rather surprised to find that in hardly a single instance are the primaries of these sets as large as theoretical considerations would indicate that they might be; this would suggest that it is considered desirable to sacrifice a certain amount of amplification, but possibly there is some other explanation? C. S. G.

This is another case of compromise, and a good deal depends on the designer's views, although careful consideration will show you that there is something approaching unanimity on this question. The problem of selectivity is at the root of the matter; generally speaking, it is considered best to sacrifice a certain amount of amplification in order to improve the performance of the receiver with regard to the elimination of interference.

In some cases screening enters into the question, and, where complete isolation of the circuits cannot be easily and economically arranged, it is sometimes necessary to forgo amplification to attain complete stability.

FOREIGN BROADCAST GUIDE.

MOSCOW KOMINTERN

(Russia).

Geographical position: 55°42′ N. 37°39′ E.

Approximate air line from London: 1,552 miles

Wavelength: 1,481 m. Frequency: 202.5 kc. Power: 40 kW.

Time: Eastern European (2 hours in advance of G.M.T.).

Standard Daily Transmissions.

G.M.T. 4 a.m. and 5.15 a.m. physical exercises followed by gramophone records; 14.10 gramophone records; 16.15 music lesson; 18.00 main evening concert; 20.00 dance music (Sundays only); 21.55 relay of noises from the Red Square followed at 22.00 by time signal and midnight chimes (to the melody of the *Internationale*) relayed from the Spassky Tower, Kremlin.

Male announcer. Call: *Sloeschaitje! Sloeschaitje! sdie gaworit Moskwa.*

Interval call: Radio Moskwa.

On most evenings after 22.00 G.M.T. news bulletins are broadcast; they are read slowly and repeated, in order to allow of transcription.

Under the heading "Foreign Broadcast Guide," we are arranging to publish a series of panels in this form, giving details regarding foreign broadcast transmissions.

The Wireless World

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.

CONTENTS OF THIS ISSUE.

A RADIO CHRISTMAS.

ONCE again Christmas is approaching, and with it, naturally, come thoughts of entertainment round the fireside. To-day winter evenings round the fireside can scarcely be regarded as up to date unless wireless is present to complete the picture. In the matter of giving presents, wireless offers great attractions by reason of the fact that there is so much that is new from which a choice can be made, whilst the variety of apparatus and sets makes it possible to make a selection to suit every pocket.

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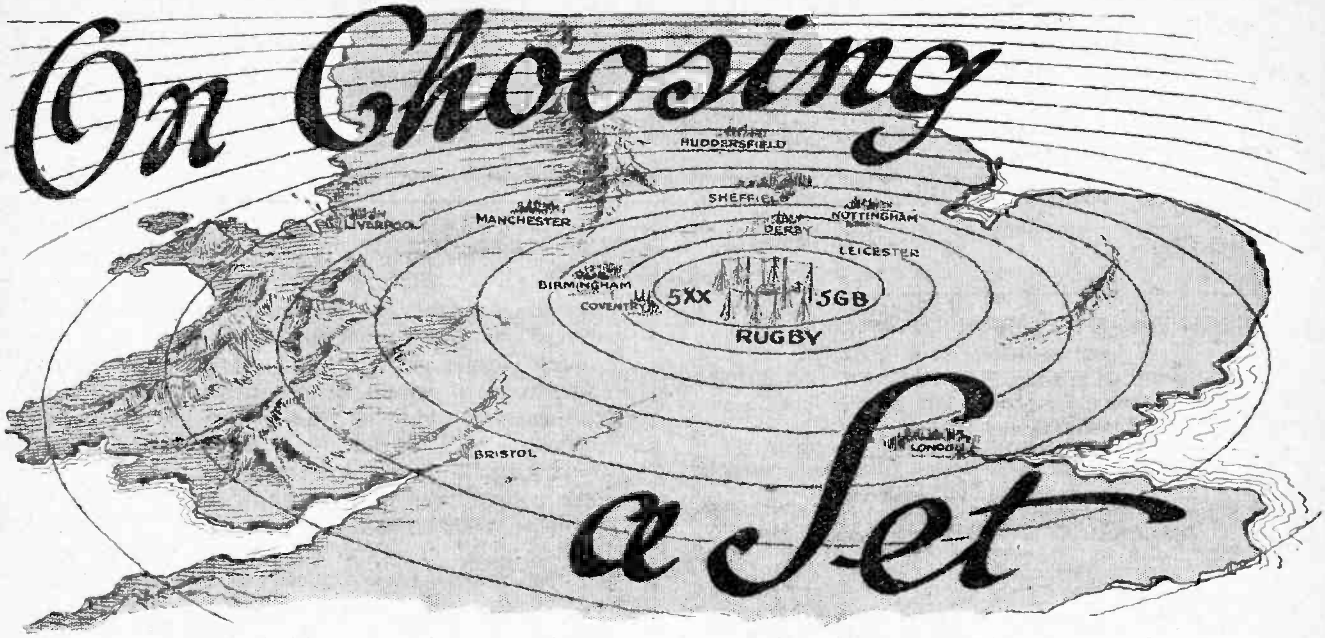
OURSELVES.

WE feel that it would be ungrateful on our part if we neglected to express our very keen appreciation of the way in which our readers have reacted to our decision to increase the price of *The Wireless World* from 3d. to 4d., following the announcement which appeared in our issue of November 27th. We had no reason to expect communications approving of our policy, so that to have received quite a large post conveying expressions of opinion from readers which amount almost to congratulations on our decision is extremely gratifying.

We think it would be of interest to quote from a representative few of the letters which we have received. "I do not think any reasonable person would grumble at the increased price of your journal. Some people have wondered how such a well-produced technical weekly could have been published at 3d.—R. B. Smith, Tyr Pwll, Abergavenny." "Don't, for goodness sake, drop the quality of *The Wireless World*, even at the cost of 6d. It is the only paper worth while in the opinion of really interested people.—R. T. Ashton, Hanley, Staffs." "Regarding the increased price of *The Wireless World*, I believe the great bulk of your subscribers will willingly pay the small addition . . . I feel sure you are taking the right course . . . Those whose sole criterion is cheapness, will always be able to indulge it.—A. F., Southampton." "I have often wondered how much longer we were to have our favourite journal for 3d. Here is one only too pleased to pay 4d. or more if required. More power to your elbow.—L. H. Pepler, Ipswich." "I observe that the price of *The Wireless World* is to be increased to 4d. May I say that if it were treble the amount it would still be the best available value for money? *The Wireless World* caters for a large section of the wireless community for whom other periodicals are valueless.—C. J. Carter, Chalfont St. Giles."

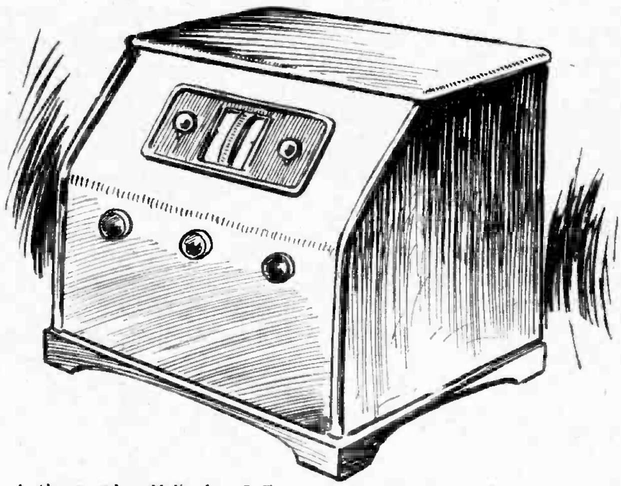
One must find an exception to prove the rule, and up to the time of writing we have received only one letter condemning us for our action. This comes from Mr. E. H. Brown, of South Norwood, who disagrees with our statement as to the time and care required before we are able to give publication to the design of a modern receiver. Our critic states, "If you had, say, a fortnight's work in the experimental workshop with the manufacturers' co-operation, plus the services of a draughtsman to make a drawing of it, it would sound feasible." We are told that in regard to our technical information service we should pass over the bulk of our queries "to component manufacturers, who are only too pleased to give technical information, as I have often proved." This communication concludes with the assurance that "further editions at 4d. per copy can remain on the bookstall so far as I am concerned." We must express regret at the loss of a reader, but we feel, at the same time, that Mr. Brown could never have been warmly attached to a paper of which he appears to have so poor an opinion.



How Decisions are Affected by Changing Conditions.

BROADCASTING technique in this country is passing through a period of transition, and it behoves everyone who is faced with the task of deciding upon the desirable features of a new set, no matter if it is to be bought ready-made or assembled at home, to keep an eye on probable developments of the near future. Naturally, this applies equally to those who, at this season of the year, are giving wireless apparatus as presents, or who are acting in the capacity of adviser to those who are less well informed on the subject.

It is hardly necessary to remind the reader that if present plans come to maturity the whole country will be served, within a couple of years or so, by alternative programmes radiated from powerful twin stations in London (Brookmans Park), at Daventry, on the Lancashire-Yorkshire border, in Scotland, and on the Bristol Channel. These stations are expected to provide signals strong enough to be practically immune from fading difficulties or any ordinary form of interference within a radius of up to 80 miles, and considerably more in the case of 5XX, whose long wavelength is subject to less attenuation.



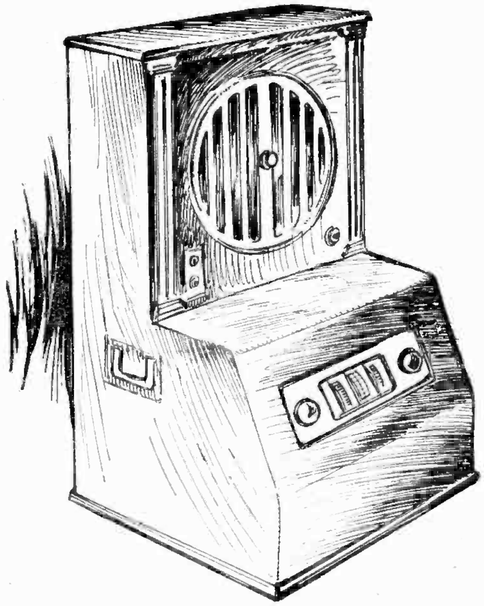
A three-valve H.F.-det.-L.F. set is a safe choice for satisfying average requirements, as it combines reasonable selectivity and sensitivity with enough volume for ordinary needs.

Choice of a suitable set for given requirements is much more a matter of geography than is generally appreciated—at short ranges, a few miles more or less in distance from the local station makes a world of difference in the "spreading" of its signals—and it might seem at first sight that this opportunity might profitably be used to discuss the best circuit arrangement for operation in various areas. Unfortunately, such a course is impossible, for the very good reason that there is still nothing approaching unanimity as to what is best even for the least complex set of conditions imaginable. The writer cannot hope to do more than deal with general considerations that should be taken into account, avoiding as far as possible a superfluity of "ifs" and "buts" that are apt to be so wearisome when one attempts briefly to discuss a number of points.

Before attempting to make a choice it is wise to devote some thought to forming a fairly clear idea of what is required of the apparatus. Many of us, influenced perhaps in the early days of broadcasting by ill-informed and ill-advised pronouncements as to what a wireless set should do, have set an unduly high standard; it is more than ever difficult to combine superlative quality reproduction with long range in one simple piece of apparatus, and

On Choosing a Set.—
there may be a tendency for the popular general-purpose set—jack of all trades and master of none—to give way to more highly specialised circuit combinations.

Be this as it may, it seems likely that a new type of listener will arise, asking for nothing more than the alternative programmes from his local station. Except when he lives on the borderland between the service areas of two regional stations his requirements are easily satisfied. Much has been written on the need



The table portable set—completely self-contained, with built-in loud speaker and frame aerial—is one of this season's innovations, and is proving increasingly popular. Mains-fed models are available.

for selectivity that will manifest itself when the twin stations come into being, but it is always tacitly assumed that other transmissions will be required; if they are not, the problem resolves itself into one of reducing input from the aerial.

Imagine a listener living at a distance of a mile from Brookmans Park; a comparatively crude 2-valve receiver will provide volume only limited by the capabilities of the type of output valve customarily fitted without allowing any mutual interference between the transmissions. All the user has to do is to try various short lengths of aerial until a sufficient, but not excessive, input to the detector is obtained. Of course, similar results may be attained by the use of a fixed aerial and a suitable input volume control.

Disproportionate Cost of an Extra Programme.

Briefly, the position may be summed up by saying that a set with sufficient selectivity to separate the two stations at its maximum range is bound to be capable of separating them at any distance, however short, provided that aerial input can be reduced to simulate conditions existing at a distant point. This proviso implies that the direct pick-up of coils and wiring is negligibly small, or at any rate can be made so by screening.

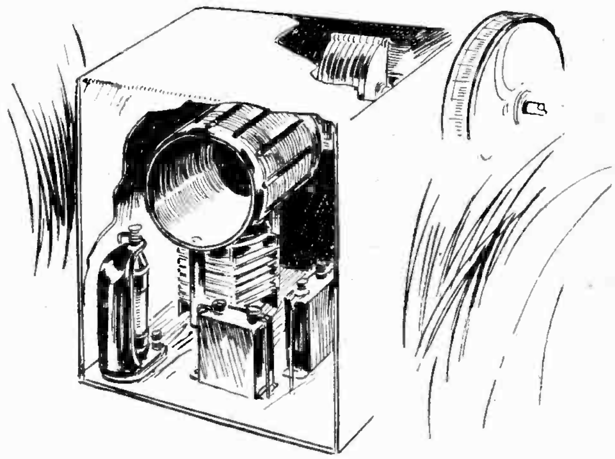
But let our hypothetical listener try for signals from Daventry 5GB, some 60 or 70 miles away—at first sight a modest enough addition to the repertoire of his set. This station may be within its range, but, to obtain sufficient sensitivity, he must increase the dimensions of his aerial—or its coupling, which comes to very much the same thing if a large aerial is normally used—to such an extent that serious interference from the local station will almost certainly make itself felt. This interference can be eliminated only by adding a complicated system of extra tuned circuits, in conjunction with at least one H.F. amplifying valve, and our ideal of a simple and inexpensive receiver is at once shattered in order that a trifling gain may be achieved.

Admittedly this is an extreme case, but it goes to prove that, under anticipated conditions, the reception of anything beyond the local twin transmissions will often be accomplished by considerably increased expense and complexity. In circumstances anything like those envisaged the possibilities of the purely two-station receiver should not be ignored, even if it is used only as an auxiliary to a long-distance outfit which may, of necessity, be rather too elaborate for everyday use.

Laments from Potters Bar.

Influenced no doubt by the minority who loudly voice their complaints regarding interference and the Regional Scheme, one is apt to place undue emphasis on the trials and tribulations of those living in the wipe-out areas surrounding the new stations—existing or projected. No one will grudge them their share of the limelight, and it is only right that their peculiar difficulties should have attention focused on them, although actually they will always be in a minority, and most wireless users will find that the better sets of present design are amply selective. Before attempting to discuss any particular circuit arrangement it is as well to consider one or two general principles about which there has recently been some revision of ideas.

There are still those who profess a distrust of mains-operated receivers, and until quite lately one is bound to admit that there was some justification for their attitude. But now, thanks to a fuller appreciation of



The single highly efficient H.F. stage, with complete metallic screening, scores largely on the grounds of low upkeep cost.

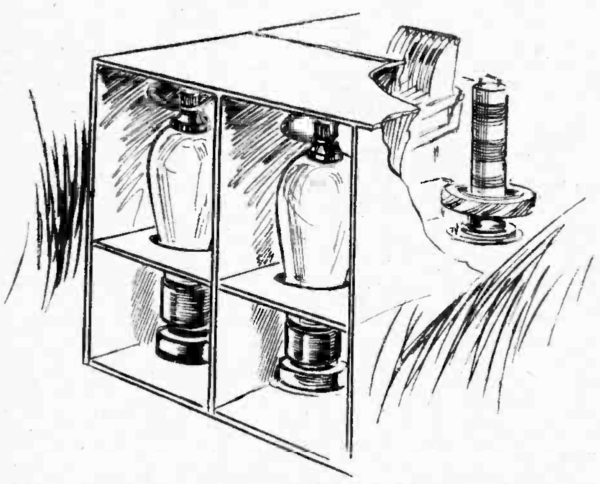
On Choosing a Set.—
the principles underlying power rectification, smoothing, and, most important of all, the "decoupling" of individual circuits, the general performance and reliability of "mains" sets leaves little to be desired; indeed, it is now considered that battery users are almost precluded, by financial and practical limitations, from obtaining the realistic volume that is so readily available to those with access to a mains supply.

The above applies more particularly to alternating current circuits; although very satisfactory D.C. sets have been produced, it is by no means unusual to depend on the mains for H.T. current, and perhaps for grid bias as well, using an accumulator for filament supply. Incidentally, two-volt valves are now so extraordinarily good, as compared with those of a year or two ago, that there is a noticeable tendency to use them even in the case of quite ambitious sets where 6-volt filaments would previously have been chosen. The upkeep of a "D.C." set with no other battery than a single large L.T. cell is a very simple matter.

Some Eliminator Considerations.

The days when a receiver and an eliminator intended to work together were bought separately and more or less at random are almost over; indeed, the tendency of to-day is to combine the two. If the eliminator is not specifically designed to work with the set concerned, the prospective purchaser should assure himself that the necessary interconnections to the various anode circuits can be readily made.

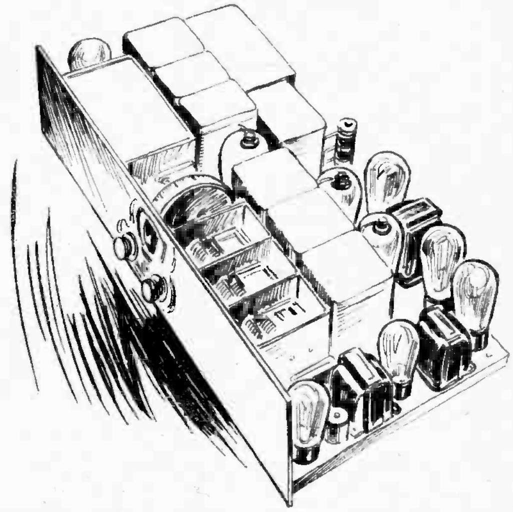
In the matter of price the mains-fed receiver scores



Typical arrangement of components in a multi-stage H.F. amplifier, as included in the most ambitious receivers. Separate screening for the valves is usually provided.

heavily when maintenance expenditure is considered, although its initial cost is apparently disproportionately high until all the factors concerned are properly considered.

This is not the place to discuss the relative merits of "portable" and fixed receivers; the weaknesses of the former are well known, but there is sometimes a tendency to over-emphasise these weaknesses and to ignore the many advantages of a completely self-contained receiver. In any case, the great British public has signified its approval of this type of set in an almost unqualified manner, so it must have a very real appeal. Possibly it will eventually be displaced by the "mains transportable," which, with obvious limitations, has its advantages without its handicap of a limited power output and a rather heavy upkeep cost.



The possibilities of "chassis" receivers, suitable for mounting in existing pieces of furniture, etc., should not be overlooked. Several examples of this type of construction are available commercially.

Recent articles dealing with the trend of modern receiver design show that a three-valve combination of H.F. amplifier, detector, and L.F. valve—very often a pentode is provided in the latter position—is the most popular circuit arrangement of to-day—at any rate for fixed receivers. It will be generally agreed that public taste is thoroughly well justified in this matter, and that for average requirements such a set is a safe choice. It has inherent freedom from serious L.F. instability, is at least reasonably selective, by virtue of its two or sometimes three tuned circuits, and is sufficiently sensitive for use almost anywhere for reception of the nearer stations with a consistent "programme" value, while the better designs can be depended upon for long-distance reception when conditions are reasonably favourable, particularly after dark.

Desirable Points in Design.

A four-valve receiver, with one H.F. amplifier and two L.F. stages, will have a greater reserve of amplification and is consequently to be recommended for more difficult situations and more exacting requirements. It is nowadays considered almost essential that such a set should have a post-detection volume control whereby the very considerable magnification afforded by its two L.F. stages may be reduced. Similarly, it is desirable that specific precautions should be taken to prevent undesirable interaction between the various anode circuits: at the best, such interaction will be productive of more or less serious distortion, and, at the worst, will cause motor-boating or L.F. oscillation. To minimise the possibilities of these troubles there is a tendency to rearrange the valves, and to provide two H.F. amplifiers with a single L.F. stage. Sets of this

On Choosing a Set.—type are rather more difficult to design and operate, but are more sensitive to weak inputs, and also much more selective. On the other hand, the H.F.-det.-2 L.F. combination scores where a very great power output is required. Sets with parallel or push-pull output valves come in this category, as they include the same number of stages.

The "two-H.F." set considered above is quite suitable for use with a frame aerial, and should have ample sensitivity for reception of stations near enough and powerful enough to provide consistently good signals. Due to the comparatively poor pick-up of this type of collector, regular long-distance reception implies either two stages of exceptional efficiency, or, better, of three H.F. valves. This brings us to the luxury class of set, whether for open aerial, frame, or short indoor aerial, with a multi-stage high-frequency amplifier having comparatively flat circuits, and, more often than not, a system of mechanically linked variable condensers. For consistent long-distance reception, this is unquestionably the best type of receiver.

Reverting to the question of selectivity, mention should be made of a point likely to be overlooked in deciding upon a receiver for operation near a twin regional station. This concerns input volume control; it is highly desirable that some means of regulating the signal voltage applied to the first valve should be provided. Detuning may not be permissible, due to the fact that a sufficient variation of the condenser capacity would probably bring in the unwanted alternative station. The ideal input volume control does not seem to exist, but very effective regulation can be arranged by providing variable coupling for the aerial.

TRANSMITTERS' NOTES AND QUERIES

Transmissions on 5 Metres.

Tests on the 5-metre waveband are being carried out from G6XN and G5QB throughout December and January at the following times :—

Each Sunday, 10.00-10.10, 10.30-10.40, 11.00-11.10, 11.30-11.40, 14.00-14.10, and for ten minutes past each subsequent hour and half-hour until 22.40 G.M.T.

Transmissions will take place alternately from G5QB and G6XN, and will consist of series of Vs followed by the call-sign, or of the word "Test" followed by the call-sign, and an announcement of the frequency.

In addition, automatic signals will be sent from G5QB between 9 p.m. and 10 p.m. on each weekday from Monday to Friday inclusive.

Reports should be sent direct to G6XN, 5, Pembroke Mansions, Canfield Gardens, London, N.W.6. or to G5QB, 120, Mill Lane, London, N.W.6.

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Paris Experimental Station.

A French short-wave station which is now being heard in Great Britain is Paris Experimental Radio. Transmissions of gramophone records and speech are made on 31.65 metres (9479kC.) with a power of 1 kilowatt, four days a week at the following times : 10.00-11.30 a.m. G.M.T. Sunday, 21.30 Tuesday, 18.00-19.15 Thursday, and at 19.00 on Friday. The interval signal adopted is that of a metronome with 120 beats per minute. The station closes down with the playing of the well-known French military march, "Entre Sambre et Meuse."

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Federated Malay States.

Mr. G. D. Forbes (VS 2AT), writing from Kinta Kellas Estate, Batu Gajah, tells us that a Radio Society is being formed in the Federated Malay States, and that it is hoped to institute a broadcasting service. We gather from the correspondence which has passed between us that experimenters in the Malay States are few in number and somewhat widely scattered, but that their enthusiasm is almost unbounded.

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South Africa.

With reference to the note on page 417 of our issue of October 9th, we hear that Mr. E. R. Cook (ex G6UO) has been allotted the call-sign ZU1J, and that his present address is 6, Annandale Street Gardens, Cape Town. He generally works on the 21-metre waveband every Wednesday at about 16.00 G.M.T., and would greatly appreciate reports from anyone hearing him in this country.

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French Experimental Transmissions.

The French National Meterological Office, in collaboration with the Administration of Posts and Telegraphs, transmits twice in each month a series of signals on various wavelengths for the purpose of obtaining records of the signal-strength of the respective wavelengths in different parts of the world. The transmitting stations are Lyons FYS, with an aerial output of about 500 watts; Lyons FYR, with 6 to 10 kW., and Paris FLE, with about 1 kW.

The December series is from Paris only; the transmissions on December 12th will comprise only the 1st, 3rd and 6th groups, and that on December 14th the complete series. Each transmission will consist of repetitions of the signal . . — . . interspersed with groups of five figures, continuing for nine minutes, and followed by five minutes of telephony, one of the objects of the test being to discover the regions where distortion of speech occurs.

The series consists of :—

1st group, 11.40-11.54 G.M.T. on 24 metres, 11.55-12.09 on 36 metres, 12.10-12.24 on 56 metres, and 12.25-12.39 on 95 metres.

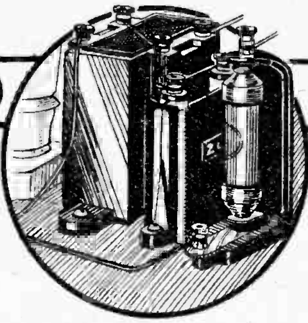
The succeeding groups are similar. The second group will be transmitted from 13.40-14.39, the third from 15.40-16.39, the fourth from 17.40-18.39, the fifth from 19.40-20.39, the sixth from 21.40-22.39, and the seventh from 23.40-00.39.

On January 11th and 18th of next year both the Lyons and Paris stations will transmit, this time on telegraphy only, the signals being repetitions of . . — . . interspersed every two minutes with the call-sign and an indicating group of five figures. The programme for the first group will be :—

12.00-12.10 G.M.T. Lyons FYS on 38 metres 12.10-12.20 Lyons FYR on 38 metres, 12.20-12.30 Paris FLE on 36.7 metres, 12.30-12.40 Lyons FYS on 25.75 metres, 12.40-12.50 Lyons FYR on 25.75 metres, 12.50-13.00 Paris FLE on 73.5 metres, 13.00-13.10 Lyons FYS on 15.1 metres, 13.10-13.20 Lyons FYR on 60 metres.

The succeeding three groups will be similar, and will be transmitted at the following times: 2nd group at 14.00-15.20; 3rd group, 16.00-17.20; 4th group, 17.30-18.50. The 5th group at 19.20 and the 7th at 23.30 will comprise Lyons FYR on 60 metres, Lyons FYS on 38 metres, Lyons FYR on 38 metres, Paris FLE on 36.7 and 73.5 metres, Lyons FYS on 25.75 metres, and Lyons FYR on 25.75 metres, each transmission lasting ten minutes; the 6th group at 21.20 will omit transmissions from Paris. The tests on January 11th will only include groups 1, 3 and 6, but those on January 18th will be in full.

THE PARALLEL-FEED L.F. AMPLIFIER



How Resistance-condenser Coupling Affects the Transformer Characteristic.

By F. AUGHTIE, Ph.D., M.Sc., and W. F. COPE, B.A.

LOW-FREQUENCY intervalve transformers with high permeability cores are becoming increasingly popular, due to good performance combined with small physical dimensions. The steady anode current must, however, be deflected from their primary windings by a suitable resistance capacity filter, the practical study of which forms the subject of this article. The small disadvantages of the arrangement are undoubtedly outweighed by the advantages, not the least of which is freedom from motorboating.

THE modern tendency in the design of receivers is towards simplification of external connections and improvement of the quality of reproduction. The introduction and increasing use of the anode feed resistance scheme has contributed to both of these by eliminating the need for tappings on the H.T. supply and reducing the back coupling caused by its resistance. In the case of high-power receivers, the resistance plays a further part in that it reduces the voltage of the H.T. from the high value required for the last stage, to a value more suitable for the earlier valves.

When a valve is followed by a transformer and the H.T. voltage is such as to permit (or demand) the use of a resistance in series with the H.T. supply, an improvement of the results obtained may be given by rearranging the actual components used, together with a more exact choice of their values.

The actual circuit of the rearrangement is shown in Fig. 2b. Contrasted with Fig. 1, which shows the usual layout, it will be seen that the only wiring changes are as follows:—First, the lead from the resistance to the transformer is transferred from one terminal to the other, giving Fig. 2a; secondly, the order of the condenser and transformer is reversed. This second change has no effect on the electrical constants of the circuit, and is made solely to isolate the transformer from the H.T. supply: it can be omitted if desired. But the change from Fig. 1 to Fig. 2a, while simple on paper, profoundly alters the performance of the assembly in ways which it is the purpose of this article to explain.

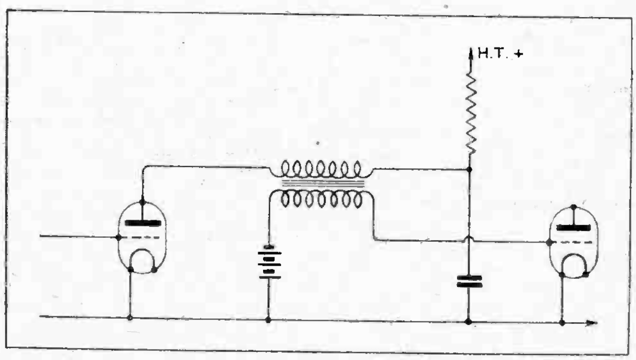


Fig. 1.—The conventional anode-feed resistance or decoupling scheme applied to a L.F. transformer stage to prevent feedback.

First of all, it should be noted that in Fig. 2a the D.C. feed current of the valve flows only through the resistance and *not* through the primary of the transformer as well. The immediate result of this is that the primary self-inductance of the transformer is not reduced from its "open circuit" value, as is the case when the steady current flows through the primary, and as a consequence—quite apart from other effects which will be discussed later—the amplification is maintained down to a lower frequency. In other words, the lower "cut-off" frequency is reduced in value.

With modern transformers tolerating little—if any—polarising current, and modern valves taking larger and larger anode currents, this factor alone is sufficient to warrant serious consideration for the change.

But there is a second effect which even further improves the performance at low frequencies. It is well known that a valve when amplifying may be regarded as a source of (alternating) E.M.F. in series with a resistance equal to its anode slope resistance ("impedance"). This permits us to draw the circuit of Fig. 2 in the form of Fig. 3, where the voltage μe in series with a resistance R_a replaces the valve. Now ignoring for a moment the effect of the resistance R, it will be seen that the transformer primary and the condenser are in series across the valve; the resistance R representing the transformer primary resistance. We see that we have our old friend the tuned circuit once more with all quantities much larger than are encountered in ordinary (R.F.) tuned circuits. The first impression therefore is that the arrangement will be selective, amplifying one frequency very strongly and others weakly. This will be so if the components are wrongly chosen, but by a suitable choice of values (all practicable) quite a different result may be obtained.

The ideal result is that, for a constant input voltage to the grid of the valve, the voltage applied to the grid of the succeeding valve shall be the same at all

The Parallel-fed L.F. Amplifier.—frequencies: this means that (for medium and low frequencies with which we are solely concerned in this treatment) the voltage across the primary must be independent of frequency. This is obtained if the (audio-frequency) current is inversely proportional to the frequency. This occurs with the normal circuit (over the usual frequency range) by letting the current be limited by the impedance of the primary, which, of course, increases with frequency, that is, by making R_a small compared with the impedance of the transformer primary. This is merely a long way of saying that the voltage across R_a must always be small.

The amplification can be maintained at its steady value down to a lower frequency if as the frequency is reduced an extra voltage be applied to the transformer primary additional to that at the output terminals of the valve. Now this is just what the condenser does in the circuit of Fig. 2, since when a condenser and inductance are placed in series across an alternating voltage, this applied voltage is the (arithmetic) difference between the voltage across the condenser and inductance respectively. Hence at least one (and not infrequently both) are greater than the applied voltage.

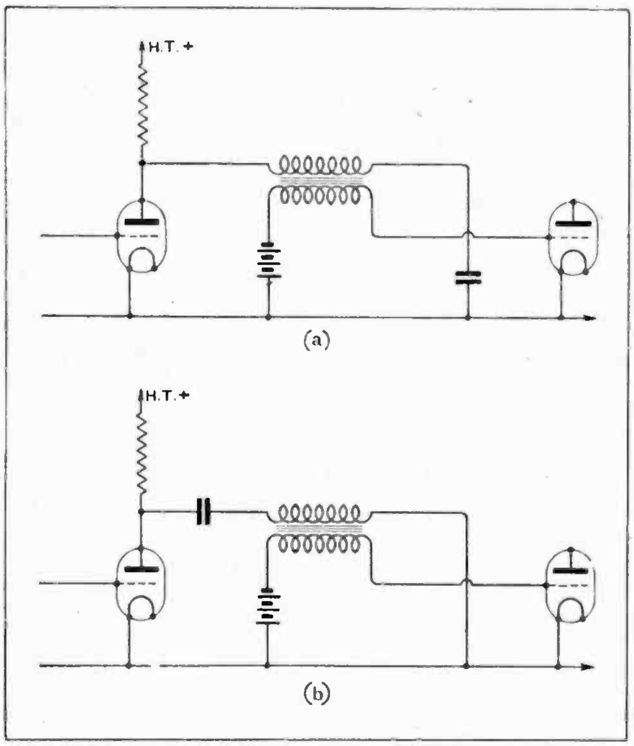


Fig. 2.—(a) The first step in the conversion of the circuit of Fig. 1 to a resistance filter-fed stage where the D.C. is prevented from passing through the transformer primary. (b) The complete conversion.

Looking at the performance from another point of view, the condenser reduces the impedance of the circuit and thereby permits a larger current; this gives an increased voltage across the transformer. The reduction of the impedance given by the condenser increases as the frequency decreases (down to a limiting point), and this can be made to compensate to a considerable extent for the drop of voltage across R_a, which, of course, also increases as the current increases.

This all looks so much like getting something for nothing that the reader is probably wondering "Where is the catch?" The catch is simply that the amplification is slightly reduced—unless an unlimited H.T. voltage is available! This is due to the resistance R now being a shunt with the primary of the transformer. We can see its effect by forgetting for the moment the condenser and transformer primary; re-drawing the circuit (Fig. 4), it is seen to be the usual resistance coupling arrangement, the output voltage of which is known to be $\frac{\mu e R}{R + R_a}$, which is obviously less than μe. Now, looking at the complete diagram once more we see that it is this reduced voltage which is applied to the transformer through the condenser. As the "boosting" effect of the condenser only affects the low frequencies it is clear that at medium frequencies the amplification is reduced.

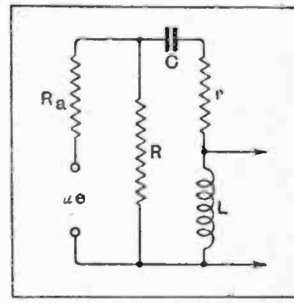


Fig. 3.—A valve when amplifying should be regarded as a source of alternating E.M.F. in series with a resistance equal to its anode A.C. resistance. The equivalent circuit of Fig. 2 is here shown.

The loss of amplification can be made small by making R large, but unfortunately this means using large H.T. voltages, and in practice a compromise has to be made. The average reduction is 20 per cent., an amount which is too small to be detected by the average ear.

Avoiding a Resonant Circuit.

Hanging over our heads all this time is the "tuned circuit" threat mentioned at the commencement. Fortunately the mathematical analysis of the circuit shows how this can be avoided and gives quite a simple formula connecting the constants of the circuit. The full analysis is somewhat beyond the scope of the present paper. The design formula is given in the Appendix.

Note that the steady value of the amplification over the useful range is $\frac{1}{B}$ times that obtained with the usual circuit. When the constants of the circuit satisfy this relation the amplification curve rises smoothly up to the value at medium frequencies without rising above this value, i.e., there is no hump in the curve. It is important to note that the value of L to insert in the formula is the open-circuit inductance of the transformer primary. This is the value usually

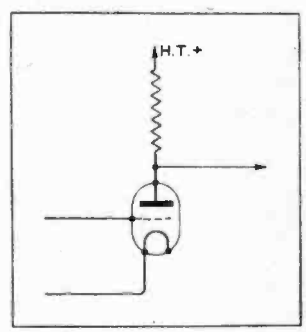


Fig. 4.—The normal resistance coupling arrangement in which the stage amplification must be less than the amplification factor of the valve.

The Parallel-fed L.F. Amplifier.—

given in the maker's specification unless otherwise stated.

In practice the values of the constants will deviate from their "nominal" values given by the makers; fortunately this causes no serious modification of the coupling efficiency-frequency curves, as may be seen from Figs. 5, 6 and 7, which shows the effect of such deviation from the nominal values as are likely to occur in practice.

As the usual tendency is for R*a* to be greater than the rated value, and L to be less, a smaller value of condenser than that given by the formula is often satisfactory. This is cheaper and causes no serious modification of the curve. A value of three-quarters of that given by the formula is suggested as being satisfactory in most cases.

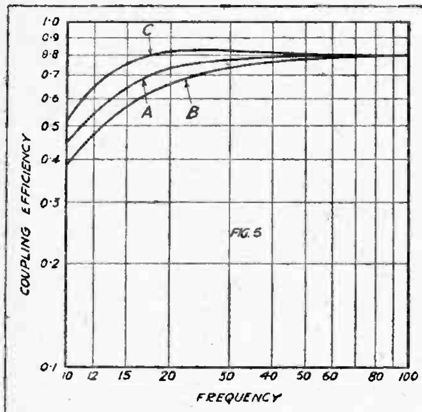


Fig. 5.

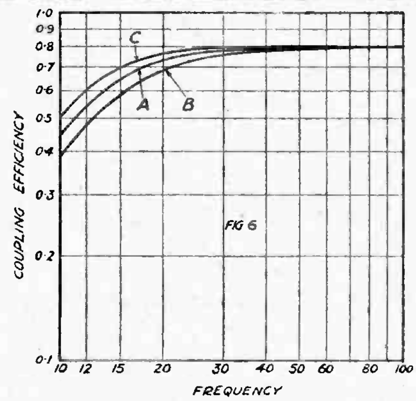


Fig. 6.

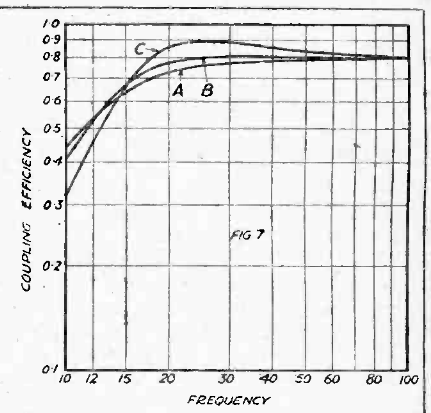


Fig. 7.

Figs. 5, 6 and 7.—Coupling efficiency-frequency characteristics. In Fig. 5 the effect of varying valve resistance is shown. Curve A is for a nominal resistance of 5,000 ohms; curve B for 20 per cent. increase and curve C for 20 per cent. reduction (i.e. 6,000 and 4,000 ohms respectively). C = 4 mfd.; L = 45 henrys; R = 20,000 ohms. Fig. 6.—The effect of varying inductance. Curve A = 45 henrys; B = 11 per cent. reduction = 40 henrys; C = 11 per cent. increase = 50 henrys. R_a = 5,000 ohms; R = 20,000 ohms; C = 4 mfd. Fig. 7.—Varying capacity values. Curve A = 4 mfd.; B = 25 per cent. reduction = 3 mfd.; C = 50 per cent. reduction = 2 mfd. R_a = 5,000 ohms; R = 20,000 ohms; L = 45 henrys.

To facilitate design, in Fig. 8 a number of curves have been prepared showing the correct coupling condenser for various primary inductances and valve resistances.

A further set of curves, Fig. 9, gives the corresponding cut-off frequencies. The cut-off frequency is defined as the frequency at which the amplification has fallen to 70 per cent. $\left(\frac{1}{\sqrt{2}}\right)$ of its value at medium frequencies.

It will be noted that figures are given for low-resistance valves; this is because the circuit is particularly suitable for the penultimate stage of a high-power receiver where considerable grid swing is required for the output stage.

There is one other feature of the circuit to which reference may profitably be made. It can be shown that the magnitude of the audio-frequency current flowing through the H.T. supply falls as the

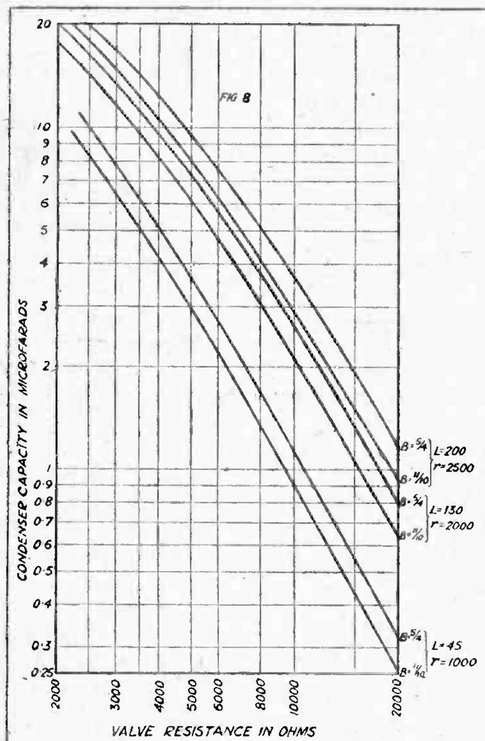


Fig. 8.

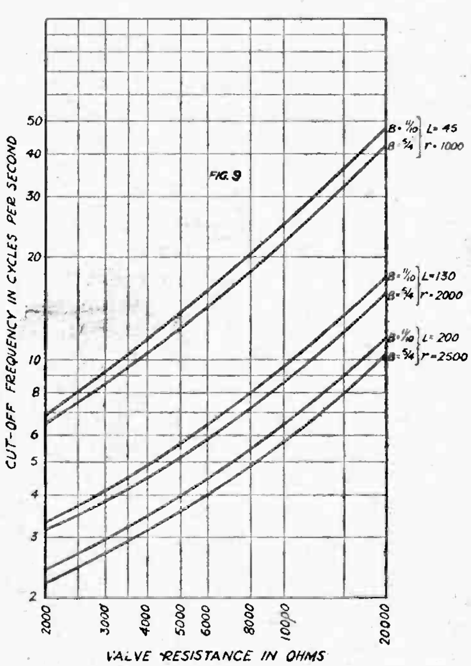


Fig. 9.

Fig. 8.—Showing the correct coupling condensers for various primary inductances and valve resistances. Fig. 9.—How varying valve resistance affects cut-off frequency.

The Parallel-fed L.F. Amplifier.—

frequency is reduced down to the cut-off frequency. This is of importance because the internal impedance of practically all eliminators rises as the frequency is reduced. The circuit shown is therefore free from "motorboating" under ordinary conditions, but the usual choke-filter should be retained in the last stage.

Cut-off Frequency Considerations.

The rise of audio-frequency current through the H.T. supply for frequencies below the cut-off is of little importance because the amplification is very small at these frequencies. There is therefore no tendency to oscillate at a frequency below this value.

APPENDIX.

The design formula is:—

$$C = 2L\left(\frac{B}{A}\right)^2 \qquad \text{Where } A = R_a + r + \frac{R_a}{R}r = R + Br, \quad B = 1 + \frac{R}{R}$$

The amplification at any frequency is given by

$$\mu.\sigma \frac{\omega L}{\sqrt{A^2 + B^2\left(\omega L - \frac{1}{\omega C}\right)^2}}$$

Where in addition to the above:—$\omega = 2\pi \times$ frequency, μ = amplification factor of valve, σ = voltage ratio of transformer.

Except at high frequencies the product $\mu.\sigma$ is constant, and thus we are concerned mainly with the third factor. This is conveniently termed the "Coupling Efficiency."

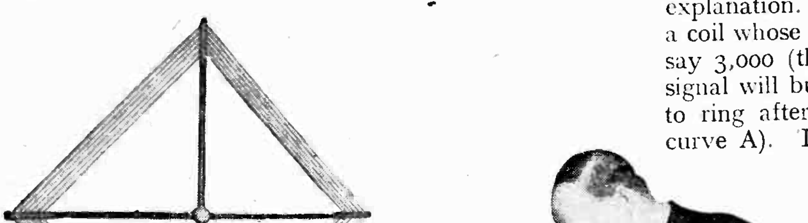
THE ROBINSON "STENODE RADIOSTAT."

A Receiving Set Designed to Separate Two Stations One Kilocycle Apart.

THE WIRELESS WORLD has recently been afforded an opportunity of inspecting a remarkable receiving set designed by J. Robinson, D.Sc., the former head of the Wireless Section of the Royal Air Force, embodying a new circuit system for selective reception known as the "Stenode Radiostat." It is understood that, owing to the patent situation, details cannot be disclosed at present, but the performance of the apparatus seems to show that Dr. Robinson has succeeded in producing a device of unusual selectivity combined with good quality of reproduction.

The set consists of two cabinets, one of which is sealed, while the other is fitted with a variable tuning condenser for coarse adjustment, and a small fine-control air condenser for accurate setting. The maximum variation possible with the latter is only about 6 mmfd., and a change of a fraction of 1 mmfd. brings in 2LO strongly, so that the selectivity is enormous. In spite of the great selectivity, the quality of reproduction is as good as could be desired.

In order to test the effect of an interfering transmitting station, a local oscillator was set up to give a heterodyne note with 2LO. This note could be clearly heard on an ordinary receiver, but no trace of it appeared with Dr. Robinson's set, even when the local oscillator was tuned to a frequency only 1 kilocycle off 2LO. It was not until the heterodyne note dropped to a frequency of 300 or 400 that it began to cut into the broadcast.



The selectivity produced is demonstrated by a superheterodyne provided with a fine-tuning condenser of exceedingly small capacity connected across the oscillator control. An interfering signal from an H.F. oscillator while producing a heterodyne note on a normal receiver is readily removed and a broadcast transmission received with good quality. Dr. Robinson is seen examining the crystal controlled unit.

A Partial Explanation.

Dr. Robinson has supplied a few details, which amount to a hint as to the method which he uses rather than an explanation. If we construct a tuned circuit containing a coil whose ratio of reactance to resistance is very large, say 3,000 (the amateur's usual figure is 150), then the signal will build up slowly, and the circuit will continue to ring after the incoming signal has ceased (Fig. 1, curve A). If, however, we chop the wave into equal sections and reverse the phase in each alternate section, the energy which builds up in the receiving tuned circuit during one section will be completely destroyed during the next, owing to the phase reversal (Fig. 1, curve B). The circuit evidently remains as selective as ever, that is, the shape of the usual resonance curve is unaltered, but the sluggishness has been greatly reduced as curve B shows, while the amplification is smaller.

Fig. 2 shows how the incoming wave is chopped. Two screen-grid valves in parallel receive the incoming signal in opposite phases. This arrangement would, of course, neutralise the signal, and no effect would be transmitted to the detector valve. A device is added which is the essence of the affair. *The*

The Robinson "Stenode Radiostat."—
two screens are wobbled up and down at supersonic frequency, and hence the valves come into action alternately. A train of waves is transmitted by one valve when its screen is up; on the next wobble this valve shuts down, and the waves come through the other valve with a reversal of phase.

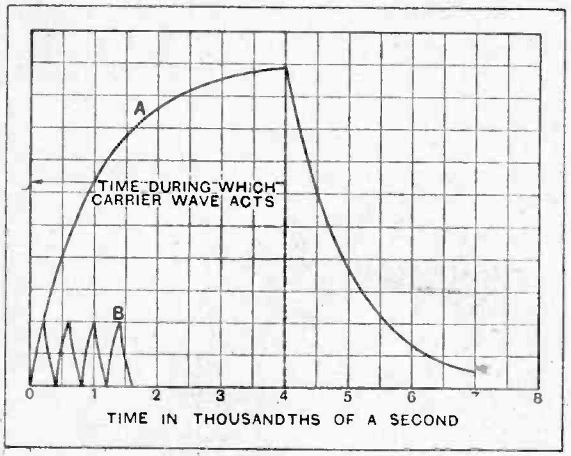


Fig. 1.—(a) Signal given by a tuned circuit of magnification 3,000 when receiving waves on 300 metres. (b) Signal produced by the same circuit when the incoming wave is chopped with reversal of phase at each interruption.

Still a Mystery.

The above explanation certainly discloses an ingenious method by which ringing might be prevented on a set of high selectivity, but it does *not* explain why the sidebands in broadcast transmission get through on such a set. We are still puzzled by the result that an interfering station 1 kc. away is cut out, while the quality of reproduction would suggest that sidebands up to 5 kc. away may be getting through. It is to be hoped that Dr. Robinson will explain this phenomenon at an early date.

While this new circuit system appears to have numerous important applications, Dr. Robinson claims that it is now possible to establish some fifty broadcast stations in an area where only one transmitting station can operate under existing conditions. Broadcast receivers, it is stated, can be constructed at popular prices which will receive existing programmes without mutual interference.

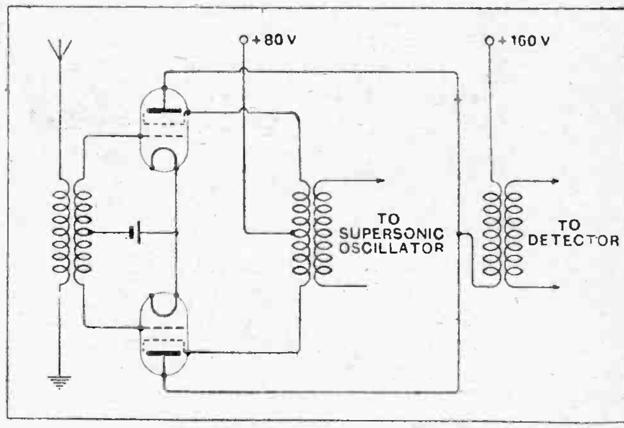


Fig. 2.—The signal is received in opposite phase by two parallel-connected screen-grid valves. A supersonic oscillator connected in the leads to the screen grids upsets the balance and brings the valves alternately into action. In the demonstration apparatus the screen-grid valves follow the intermediate amplifier of a superheterodyne receiver, and the supersonic oscillator is a piezo-electric crystal.

CHRISTMAS RECORDS.

A Good Selection of Seasonable Music.

THE increasing number of readers who employ electrical methods for the reproduction of gramophone music adds special interest at this season to the selection of Christmas records which have just been issued by Columbia. We have had the opportunity of testing a number of these, and consider that they are a most attractive series.

An exceptionally fine record is one entitled "An Organist's Yuletide," which is contributed by Mr. Quentin MacLean, the organist of the Regal Cinema, London. It is a fine example of modern recording, and consists of a delightful Christmas medley, including snatches of carols and traditional tunes.

Savoy Christmas Medleys, a record which has had great popularity in the past, has been remade this season by Debroy Somers' band.

A particularly fine record by the Ketelby Concert Orchestra, with W. G. Webber playing the organ of Westminster Central Hall, and Nellie Walker singing with a full chorus, is "A Dream of Christmas." The theme is that it is Christmas Eve, and the mother has been relating bedtime stories to her little child, who afterwards falls asleep and dreams of the carol singers and fairies.

The Christmas list of new records includes some of the most popular carols and hymns, beautifully rendered by the St. George's Singers. They are six in number, and include "We Three Kings of Orient Are," "Wassail Song," "What Child is This," "The Moon Shines Bright," "I Saw Three Ships," and "The Holly and the Ivy." Three carols are contained on each record. All are sung unaccompanied, and those who have heard the madrigal records of this talented body of singers will not need to be told how beautifully the carols have been performed. The B.B.C. Choir and Wireless Military Band have also contributed to the Christmas vocal list with "Once in Royal David's City" and "While Shepherds Watched," and the fullness of tone produced by choir, band and organ makes an interesting contrast to the simplicity of the St. George's singers.

How we Hear

Can the Principles of Mechanism by which the Ear Detects Sounds of Varied Amplitude and Frequency be Applied in Radio?

By R. T. BEATTY, M.A., B.E., D.Sc.

IF a committee of scientists and engineers were asked to design an instrument which would be sensitive to all audible tones, which would detect a change in pitch of less than a sixtieth of a semitone over most of the range, and register changes in loudness of the order of 10 per cent., which would be capable of operating a relay in response to the chirp of a cricket or the roll of thunder, and, lastly, work day by day for some fifty years without attention, executing its own repairs, keeping itself clean, and costing a penny per day for running expenses, what sort of machine would the committee recommend to satisfy these terrifying demands embracing so many exacting conditions?

No such machine would be produced.

But if thought were taken for the first four conditions only, a solution could be arrived at. One would imagine that it would take a form of long racks carrying some twenty thousand resonators —64 to the semitone over the musical range—with a tiny coil of heated wire in the neck of each resonator to be alternately warmed and chilled by the throb of sound. Each coil would be connected to a valve amplifier, and the output wires would be led through a maze of switches to an inconceivable number of relays.

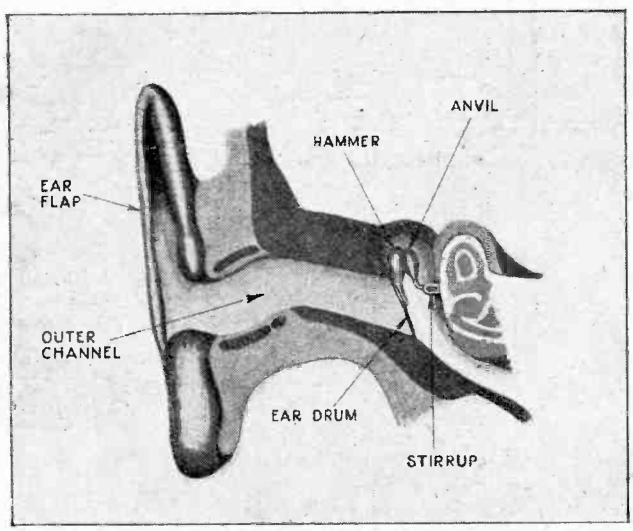


Fig. 1.—Sound is collected by the ear flap, passed along the outer channel, and transmitted via the ear drum and the hammer, anvil, and stirrup, to the oval window shown in Fig. 2.

The whole affair would cost a million pounds; it would be served by thousands of operators, and would fill the great hall at Olympia.

Nature's Curious Device.

Nature, working by her savage formless methods over a space of many million years, advancing by trial and error, with life or death to mark success or failure, has solved the problem. Those who have ears to hear are drawing their royalties on Nature's invention.

What, then, is her solution?

It is the little affair like a snail shell with a bundle of nerve fibres passing from it to the brain; the whole thing could be enclosed within the shell of a hazel nut, and the nerve bundle with its thousands of fibres could be threaded through a tube of macaroni.

It is music's analyser; the brain is its interpreter; and the partnership is one of the sweetest gifts which has been given to man.

The snail shell, or cochlea, consists of a hollow tube of bone coiled into a spiral of $2\frac{3}{4}$ turns and filled with liquid. In all mammals, with but one exception, this spiral shape is found, but if we imagine that man, who is distinguished for the number of convolutions in his

How We Hear.—

brain, is similarly favoured by possessing the greatest number of turns in his cochlea, we are at once humiliated by the fact that pride of place must be given to the common pig, with $3\frac{1}{2}$ turns.

The cochlea if uncoiled would appear as a straight tube 30 mm. long with an average internal diameter of 1.5 mm. This tube is divided lengthwise into two parts by a tightly stretched membrane, the basilar membrane, which runs along its entire length.

One end of the long tube is enlarged and is fitted with two thin membranous windows; one of these, the oval window, carries a piston which conveys the vibrations of sound from the outer ear; the other, the round window, relieves by its motion the pressure set up in the fluid by the motion of the piston.

Man's Miniature Harp.

Under the microscope the basilar membrane is seen to consist of some 24,000 tightly stretched fibres running crosswise, each fibre being held in tension by ligaments. These fibres are connected to each other by a thin membrane, and they increase in length from 0.13 mm. near the piston to 0.4 mm. at the other end of the tube. The whole structure irresistibly suggests a set of tuned

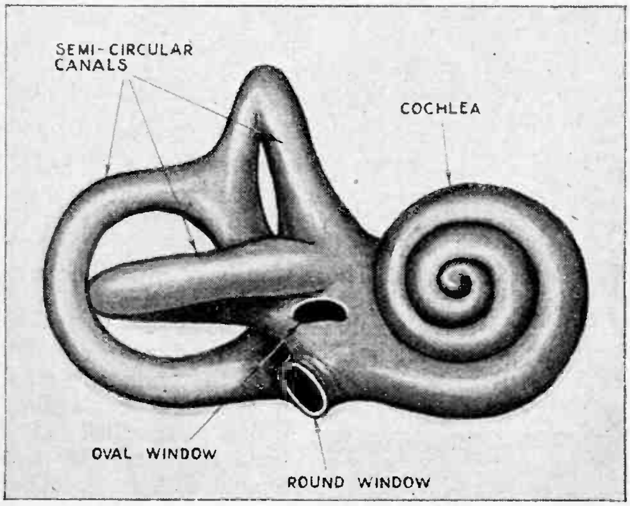


Fig. 2.—The stirrup (Fig. 1), which is attached by a membrane to the oval window, transmits vibrations to the fluid filling the cochlea, across the basilar membrane, and back along the cochlea to the round window.

strings, and all the facts patiently unearthed by anatomists and physicists confirm the conviction that this is indeed Nature's harp which, by the resonance of its strings, analyses the vibrant messages from the external world. Thousands of years before the first savage crouched to evoke rude music from his bowstring, this marvellous instrument lay fully developed in the ears of mankind ready to interpret the rustle of leaves, the song of birds, the roar of the carnivore, to the still lowly brain, deaf as yet to all but material needs.

The Ear as a Whole.

The ear flap (Fig. 1), which is now but a rudimentary collector of sound waves, compared with the large mobile ears of the horse or the dog, passes the sound down the outer channel to the ear drum which actuates a chain of three bones—the hammer, anvil, and stirrup—the three forming a lever system with a reduction in amplitude of $1\frac{1}{2}$ to 1. The end of the stirrup is inserted

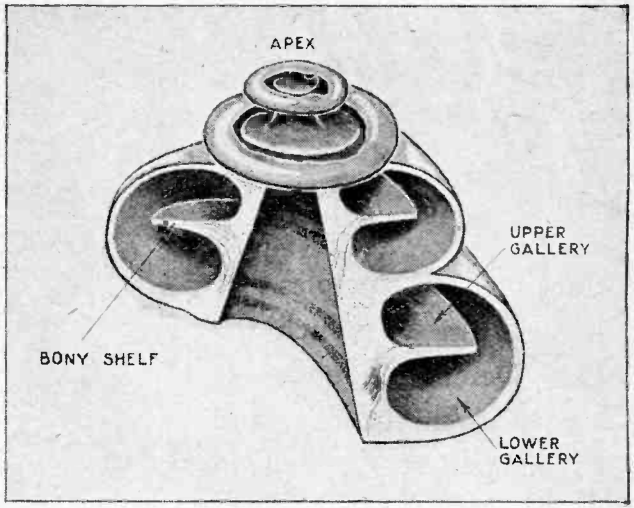


Fig. 3.—Cross-section of the bony cochlea: the basilar membrane is not shown.

into the membrane which closes the oval window (Fig. 2) of the bony labyrinth. In addition to the cochlea three curious formations will be noticed looking like handles. These have nothing to do with hearing, but give us information about our position in space, and guide our movements in turning, leaping, or bending. They form the oldest part of the ear; they are found, but with no cochlea attached, in fishes, which do not need to hear, but whose life depends on their ability to make accurate and well-timed movements.

A cross-section of the bony cochlea is shown in Fig. 3. A spiral tube winds upwards to the apex, and is almost divided in two by a spiral bony shelf; one end of the basilar membrane is attached to the edge of this shelf (Fig. 4), and stretches across to the opposite side where it is held in tension by a strong ligament, so that the spiral tube is actually divided into an upper and a lower gallery.

The Simplified Ear.

A mechanical model, Fig. 5, may be constructed to represent what is generally believed to be the mode of action of the ear. When a puff of air strikes the outer ear the drum and the lever system move forward so that the stirrup transmits pressure to the liquid in the upper gallery; the motion is communicated through the opening at the apex to the lower gallery, and the round window bulges slightly in consequence. In addition, of course, the pressure may be partly relieved by yielding of the basilar membrane, and if a pure tone of given frequency is used we would expect that any portion of the basilar membrane which is tuned to this frequency would be set into resonance, and convey a message to the brain by the nerves which are attached to it. This indeed was the original brilliant suggestion of Helmholtz, and is a remarkable instance of scientific foresight. He recognised that the only known way of analys-

How We Hear.—

ing complex sounds was by the use of resonators, and that the transverse fibres of the basilar membrane, with their progressive variation in length, might act as a system of this kind.

Three Points which Support the Resonator Theory.

As we pass along the spiral tube of the cochlea from base to apex, we find that the fibres of the basilar membrane increase in length from 0.13 mm. at one end to 0.40 mm. at the other. Further, the spiral ligament which holds the membrane taut decreases in bulk from base to apex; near the apex, indeed, it consists of only a few thin fibres. Again, when resonance is set up in any section of the membrane, the mass moved is not only that of the membrane, but also that of the double column of liquid, as shown in Fig. 6, so that the loading of the fibres increases from base to apex.

Now, the formula for the frequency of vibration of a stretched string is:—

$$\text{Frequency} = \frac{1}{\text{twice length}} \sqrt{\frac{\text{tension}}{\text{mass per unit length}}}$$

and we have just seen that in going from base to apex *length* and *mass* increase while *tension* diminishes. It appears, then, that all three factors vary as they should

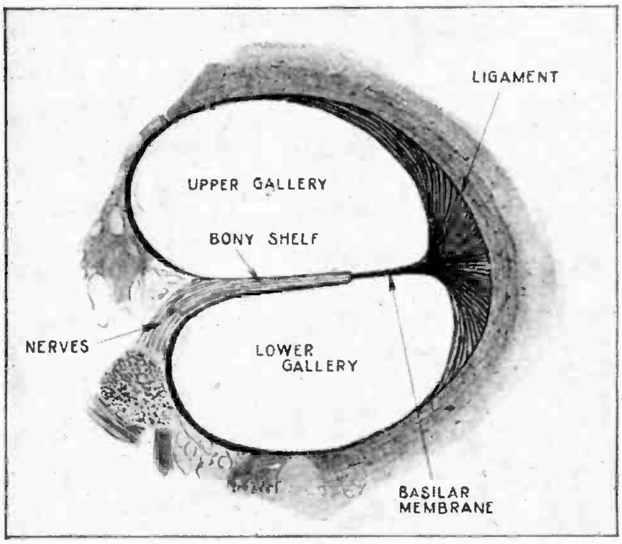


Fig. 4.—Cross-section of the cochlear galleries: the basilar membrane is held in tension by strong ligaments, and nerves run from it through channels in the bony shelf and are led away through the central opening shown in Fig. 3.

if the bass strings are to be located at the basal end and the treble strings at the apical end of the cochlea. Helmholtz was aware of but one of these factors; had the other two been known in his time few can doubt that the resonator theory would have been established so firmly that no rival theories would ever have emerged.

Can the Fibres Stand the Required Tension?

The greatest tension will be needed for the strings tuned to the highest audible frequency, which is about 30,000 cycles per second. Since we can find the length and mass from microscopical observations we can calculate the tension from the formula given above. It works out that we require a tension of 44 milligrammes to tune a single fibre to this note, taking the diameter of a fibre as 0.003 mm.

Now, it is found from experiments on animal tendons and fibres such as human hair or silkworm gut that

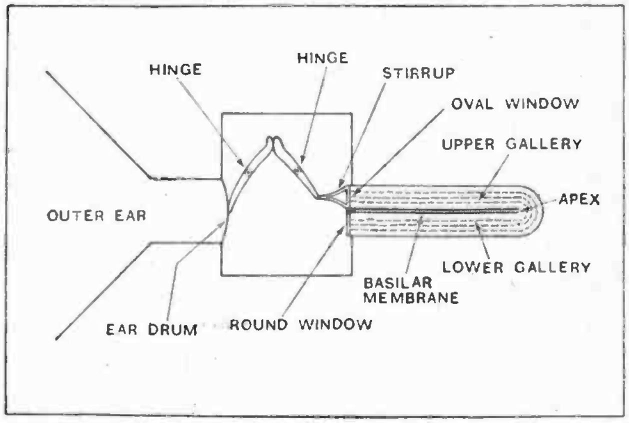


Fig. 5.—The action of the ear demonstrated by means of a mechanical model.

their breaking stress for the same cross-section is from four to eight times the figure just given. It seems, then, that the theory makes no impossible demands on the strength of the resonating elements.

Those who think in terms of the piano or harp may still, however, feel that an instrument on the cochlear scale is unworkable. The deepest string of the piano is several feet long, while the longest string of the cochlea is only 0.4 mm.; how can these ridiculously different lengths be tuned to the same note?

The answer is that the dimensions of the piano are large because the instrument is required to deliver a large volume of sound. The cochlear strings, on the other hand, need only vibrate through a few millionths of a millimetre to excite the nerve endings with which they are connected. Scale has nothing to do with the question of resonance; if we compensate for decreased length and mass by decreased tension we can pass to an instrument whose smallness is only limited by the size of the molecules themselves.

Experimental Evidence for the Resonator Theory.

Twenty years ago a remarkable experiment was carried out on the guinea-pig, which has a well-developed cochlea of four turns. A loud note was sounded close to the animal's hutch and maintained for many hours. The guinea-pig was then killed and its cochlea examined under the microscope, whereupon

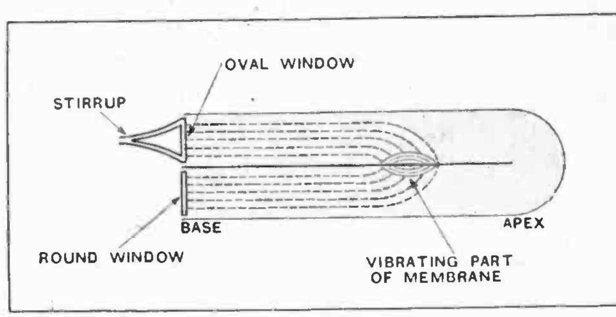


Fig. 6.—From this mechanical model it is seen that not only the membrane vibrates but also a double column of liquid, so that the loading of the fibres increases from base to apex.

How We Hear.—

a portion of the basilar membrane was found to have degenerated, the same being true for the nerves attached to it. Similar experiments were carried out with notes of different pitches, and in all cases the position of the injured part depended only on the pitch of the note which had been used. Fig. 7 represents a section of the cochlea of the guinea-pig, and the positions of the injured areas are marked corresponding to the exciting frequencies. Below are shown the four turns of the basilar membrane uncoiled with the damaged portions shaded.

This experiment, through indicating that the membrane is differentiated for frequency along its length and that low notes affect the region near the apex, is not quite convincing, since in each case a long strip is injured, whereas we should expect the damage to extend over a few fibres only. However, the notes were excessively loud, so that probably a great many fibres were set into forced oscillation in addition to those which vibrated with their own natural frequency.

Last year results of a much more definite nature were obtained in a Leipsic laboratory. A very fine drill, only

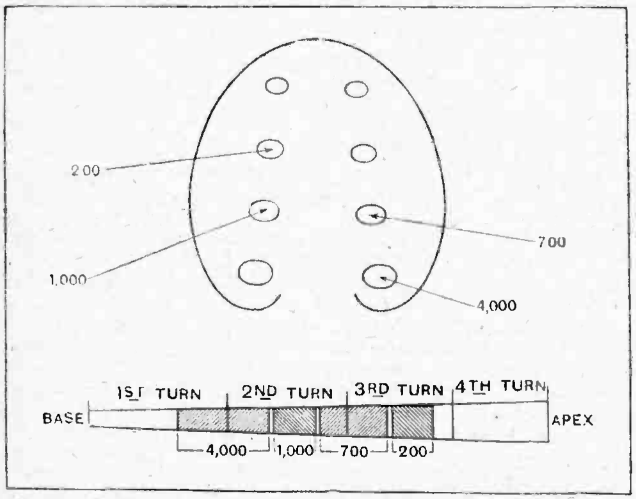


Fig. 7.—Section of a cochlea of a guinea pig, showing how different portions may become damaged by sounding notes of particular frequencies.

$\frac{1}{10}$ mm. in diameter, was used to bore a hole into the wall of the bony cochlea so as to break some threads of the ligament which exerts tension on the basilar membrane (Fig. 8). Subsequent microscopical examination showed that neither the membrane itself had been injured nor the nerves which pass from it and leave the cochlea on the opposite side from the point of entry of the drill. The tension, and consequently the natural frequency of the membrane, must, however, have been decreased.

It has long been known that the guinea-pig responds to any note within its range of hearing by a tremor of its ear muscle. Previous to the operation the animal responded in this way to all the notes of a series of tuning forks spaced a semi-tone apart from a frequency of 1,000 to 40,000 cycles per second.

After the operation a region of deafness was found whose position varied with the location of the drilled hole and which extended over a frequency breadth *not exceeding a single tone.* The positions of the holes in different experiments are shown at the bottom of Fig. 8 with the corresponding frequencies where deafness was noted by the absence of the ear muscle reflex.

It will be seen that the positions agree with the theory that the fibres are tuned to higher and higher frequencies as the base of the cochlea is approached.

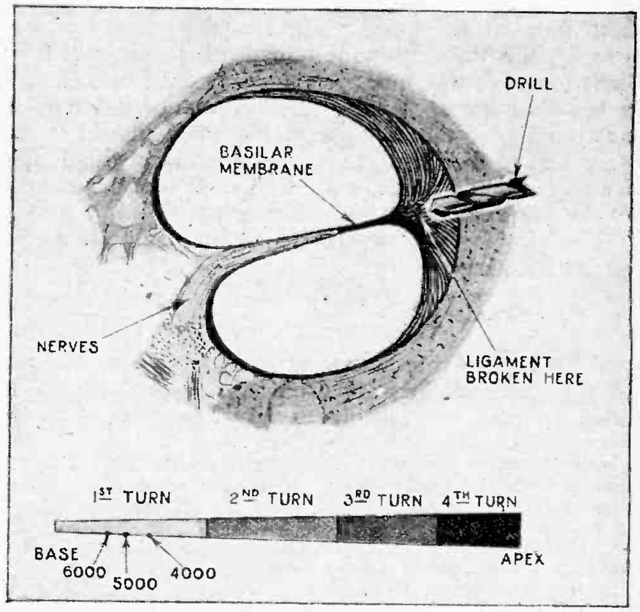


Fig. 8.—Breaking of some of the threads of the ligament which exerts tension on the basilar membrane produces a deafness over narrow bands of frequency.

The most remarkable fact of all is that the narrow band of deafness disappeared after three weeks. The ligament must have recovered its former tension, but that it should have done so, and applied exactly the right amount of pull to the corresponding elements of the membrane, seems to be a marvellous thing.

The Telephone Theory.

Though the resonator theory is so attractive and so powerfully supported by the facts which have been already cited it is not universally accepted. There are some who hold that the basilar membrane has no power of analysis, but that it faithfully follows every change in pressure of the sound waves and by its motion as a whole transmits messages to the thousands of fibrils which make up the auditory nerve. These fibrils accordingly act like telephone wires in parallel, and the onus of analysing the messages is thrown entirely on the brain.

If we accept this theory we must be puzzled by the complex structure of the basilar membrane; a much simpler device would seem to be adequate if no analysis is performed till the brain is reached: a few nerves attached to the ear-drum might suffice.

But a more formidable difficulty arises from the recent discoveries of physiologists as to the response of nerves to rapid impulses.

(To be concluded.)

Broadcast Brevities

By Our Special Correspondent.

Twin Transmission on Trial.—The Modulation Question.—Appeal to Pirates.

Regional Scheme on Trial.

Before these lines appear the behaviour of the Brookmans Park transmitters working in double harness will have been ruthlessly scrutinised by legions of listeners. The B.B.C. is on trial; and I should be surprised if there were any recommendation for mercy if the scheme proved to be beyond the technical resources of the populace.

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Is 261 Metres Too Low?

For one hour and a half daily (Mondays to Fridays) the normal London programme is being broadcast on the wavelength of 261 metres, and many listeners have never yet descended to such a depth. The importance of becoming familiar with this wavelength is realised when one notes that it will be used for the "general interest or national programme"

The B.B.C. are wise in limiting the alternative transmission to speech; and it is also a shrewd move to allow an hour's transmission daily on the shorter wavelength without the encumbrance of the 356 metre signal.

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When to Listen.

The full schedule of tests, until further notice, is as follows:—

MORNING:	
11.30 a.m. to 12 noon (Monday to Friday inclusive).	5XX Programme on 261 metre wavelength.
12.30 p.m. to 1.0 p.m. (Saturday only).	* Special programme on the 261 metre wavelength and 5XX.
12.0 noon to 1.0 p.m. (Monday to Friday inclusive).	The normal published programme on the 261 metre wavelength.
1.0 p.m. to 2 p.m. (Saturdays only).	Special programme on the 356 metre wavelength.
1.0 p.m. onwards (Monday to Friday inclusive). 2.0 p.m. onwards (Saturday only).	The 356 metre wavelength returns to the normal published programme.
EVENING:	
First half-hour of dance music period.	Dance music as published on the 261 metre wavelength only.
Remainder of dance music period.	Dance music as published on the 261 metre wavelength and special programme on the 356 metre wavelength.

* 5XX at all times does its normal published programme, in addition to the special programme on Saturday mornings

There will be no test transmissions on Sundays, Christmas Day and Boxing Day, but the usual programme will be radiated on 356 and 1554 metres.

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A Springtime Service.

The length of the tests is still a matter for debate in B.B.C. engineering circles, but I think that my original prediction, that we shall have the season of spring and portables upon us before regular twin programmes, will not be far wrong.

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Over-modulation.

The question of the modulation of B.B.C. transmitters, recently raised in *The Wireless World*, has excited considerable interest at Savoy Hill. That the B.B.C. stations are models of rectitude in this direction is proved, say the officials, by the news that the Union Internationale de Radiodiffusion is holding up the B.B.C. as an example to transgressors on the Continent. It appears that much of the trouble with the Prague Plan is definitely ascribed to over-modulation by European broadcasters. To those who froth over the Union says: "Look at 5GB and Brookmans Park. Mark the delightful manner in which they are received abroad."

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The Clapham Test.

At its Clapham research station on a recent Saturday, the B.B.C. conducted a little experiment in self-vindication, selecting the transmission of Radio Toulouse for the purpose. Radio Toulouse is an 8 kW station with an estimated aerial power of 5 kW. Signal measurement tests revealed a strength at Clapham of 0.8 millivolts per metre. Now, says the B.B.C., one of our stations operating on the same power would not yield a higher signal strength than 0.25 millivolts at such a distance. Therefore Radio Toulouse is over-modulating. Q.E.D.!

HAVE YOU HEARD THIS ONE? The Czech station at Moravska-Ostrava, which is not difficult to receive in this country. The power is 10 kW and the wavelength 263 metres.

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The Decline of the Oscillator.

That the old breed is slowly dying out is shown by some revealing figures collected by the B.B.C. anent oscillation complaints. In October and November, 1927, complaints of oscillation numbered 2,204. In the corresponding period of 1928 the figure dropped to 1,603. This year it is only 1,551. The figures as they stand tell less than the truth, for in October, 1927, there were only 2,337,733 licenses as compared with 2,852,924 two years later.

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To the Radio Pirates of the World.

Oscillators and pirates are all nuisances, but in most cases there is a chasm of moral difference between the two classes.

The ordinary methods of overcoming piracy being rather slow, the B.B.C. might take a tip from the Polish broadcasting authorities, who are seeking to overwhelm the pirate by an appeal to his better nature. To-morrow (Thursday) the Vilna broadcasting station will broadcast a programme addressed to "the radio pirates of the world." In a special address to this ignoble fraternity, condemnation will be tempered with exhortations to repent. What stony-hearted knob-twiddler could stand this?

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British and German Licence Figures.

The human element asserted itself distressingly in a recent paragraph in which I stated that the increase in British receiving licences amounted to 17,025 in the previous quarter. This figure actually represents the *monthly* increase, so the comparison with the German quarterly advance of 16,941 sheds a yet more glorious light on the popularity of the B.B.C. programmes.

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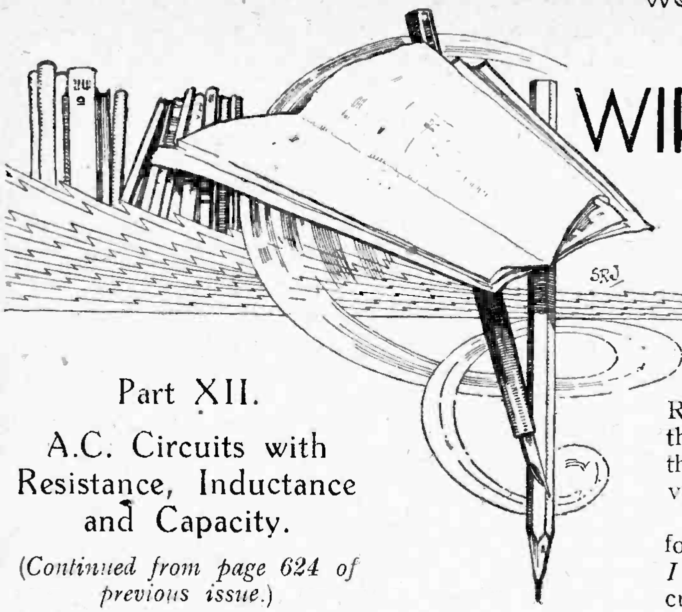
The Microphone in Fleet Street.

Readers who wonder what Fleet Street is like and how a newspaper is produced should listen to the broadcast from 2LO and 5XX on December 16 of a tour of a newspaper office.

The Editor's room, the news room, the composing department, the foundry and the machine room will be visited.



WIRELESS THEORY SIMPLIFIED

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

Part XII.

A.C. Circuits with Resistance, Inductance and Capacity.

(*Continued from page 624 of previous issue.*)

UP to the present we have dealt with resistance, inductance and capacity singly and have discussed the laws applying to each as regards alternating currents. We have also considered the combined effects of inductance and resistance in series, where impedance and power factor introduced themselves. We have now to take into account those circuits in which capacity is present together with one or other, or both, of the constants resistance and inductance. As we have learned all the rules applying to each of the three constants individually, the solving of a circuit where two or all three of them are present merely resolves itself into combining the effects according to the known laws of each. In simple series or parallel circuits this is quite an easy matter, but for circuits where there are both series and parallel portions it is sometimes very difficult. Fortunately we need only concern ourselves with the simpler circuits to enable us to understand and deal in a practical manner with the great majority of circuit arrangements in a modern wireless receiver.

Capacity and Resistance in Series.

In the first place let us consider a circuit consisting of a resistance R in series with a condenser of capacity C as shown in Fig. 1 (*a*). Suppose that it is desired to drive an alternating current whose R.M.S. value is I amperes through the circuit. Then the total voltage required will be made up of two components, namely, that necessary to drive the current through the resistance R and that required to drive the current "through" the condenser C. (N.B.—The same current flows through each element of a series circuit.) Denote these voltages by E_1 and E_2 respectively, as shown in Fig. 1.

We have then $E_1 = IR$ volts, *being in phase with I* (rule for a pure resistance), and $E_2 = IX_c$ volts, *lagging behind I by a quarter of a cycle*, because for a condenser the current *leads* the voltage by 90°. X_c is the reactance of the condenser, its value being $\frac{1}{2\pi fC}$ ohms.

So if we draw a simple vector diagram for the circuit we must draw the lines OE_1 and OE_2 at right-angles to each other, as shown in Fig. 1 (*b*), where OE_1 is in line with the current vector OI. The total voltage required between the ends of the circuit is then given by the length of the diagonal OE. Thus

$$E = \sqrt{E_1^2 + E_2^2} = \sqrt{(IR)^2 + (IX)^2} = I\sqrt{R^2 + X_c^2} \text{ volts.}$$

It will be realised that this is the same expression as used for resistance and inductance in series, except that in the present case we have the condensive reactance in place of the inductive reactance. $\sqrt{R^2 + X_c^2}$ is the impedance Z of the circuit in ohms. A further difference lies in the fact that the current *leads* the applied voltage by an angle ϕ, where $\cos\phi = \frac{R}{Z}$ as before. For the inductive circuit it was a *lagging* angle. The impedance triangle for the circuit is shown at (*c*) in Fig. 1, the reactance line X_c being drawn vertically *downwards* this time because condensive reactance is negative with respect to inductive reactance.

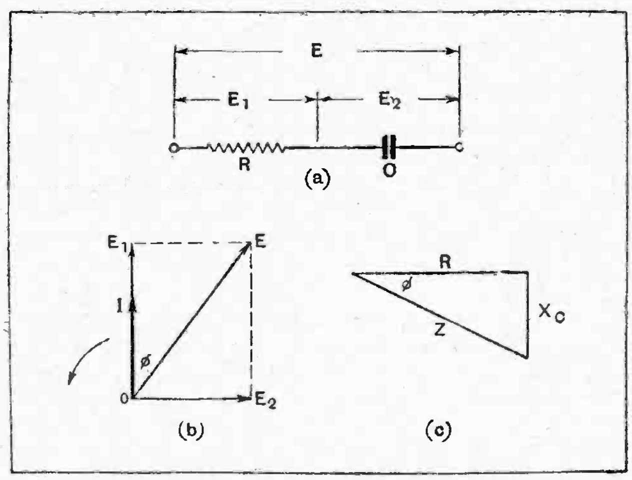


Fig. 1.—(a) Circuit with resistance and capacity in series. (b) Vectors showing the phase angles of the various voltages. (c) The impedance triangle for the circuit.

To illustrate the calculation of such a circuit as that of Fig. 1 (*a*) in practice, suppose that the resistance R has a value of 500 ohms and the condenser C a capacity of 10 microfarads and that we require to know the current taken when 100 volts (R.M.S. value) at 50 cycles per second is applied to the ends of the circuit. The reactance of the condenser

Wireless Theory Simplified.—

is then $X = \frac{1}{2\pi fC} = \frac{10^6}{2\pi \times 50 \times 10} = 318$ ohms. The impedance Z is therefore $\sqrt{500^2 + 318^2} = 583$ ohms, and so the current will be $I = \frac{E}{Z} = \frac{100}{583} = 0.1713$ ampere. This current leads the voltage applied to the circuit by an angle whose cosine is $\frac{R}{Z} = \frac{500}{583} = 0.857$, and this is the power factor of the circuit. Hence the power absorbed is $P = EI \cos\phi = 100 \times 0.1713 \times 0.857 = 14.7$ watts; or by another method: $P = I^2R = 0.1713^2 \times 500 = 14.7$ watts.

Condenser and Resistance in Parallel.

In a circuit where the components are connected in parallel the same voltage is applied to each, and the best way to treat such a circuit if the applied voltage is known is to calculate the current through each branch separately, and find its phase relation to the voltage. The currents can then be added together in the proper manner, taking the phase differences into account. It is perhaps not out of place to remind the reader that currents or voltages must always be added by the parallelogram method when there are phase differences between them. Let us take as an example a circuit consisting of a 500-ohm resistance connected in parallel with a 10-microfarad condenser and assume that 100 volts at 50 cycles per second are applied to the ends of the circuit, as shown in Fig. 2 (*a*). We shall calculate the current and power taken by the circuit as a whole. Let I_1 be the current in the resistance branch, I_2 the current in the condenser branch and I the total current taken by the circuit. Then the current I_1 in the resistance will be $\frac{E}{R} = \frac{100}{500} = 0.2$ ampere, and this will be in phase with the voltage. Similarly the current in the condenser branch will be $I_2 = \frac{E}{X_c}$. But X_c for a 10-mfd. condenser at 50 cycles per second was found to be 318 ohms in the previous calculation: So the current in the condenser branch is $I_2 = \frac{100}{318} = 0.314$ ampere, and this leads the voltage by a quarter of a cycle.

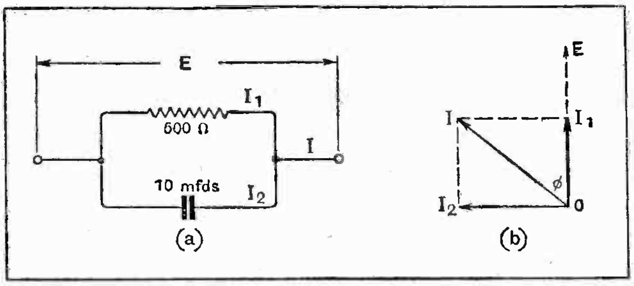


Fig. 2.—(a) Circuit with resistance and capacity in parallel. (b) Vectors giving the currents in the branches and the total current. $OI_1 = 0.2$ amp., $OI_2 = 0.314$ amp., $OI = 0.372$ amp. when $E = 100$ volts at 50 cycles.

How to Use Vectors.

Knowing the value of each current and the phase angle of each with respect to the voltage, we could draw to scale a simple vector diagram as shown at (*b*) in Fig. 2. First draw the voltage vector OE of any convenient length, not necessarily to scale, and in any position. Since there is only one voltage value in a parallel circuit we take the voltage as the starting point. Now draw the current vector $OI_1 = 0.2$ ampere in line with OE and to a suitable scale of, say, 1 inch = 0.1 ampere so that OI_1 would be 2 inches long. Then draw OI_2 at right angles to OE to the *left*, because it is a current *leading* the voltage by 90°. Its length to the same scale will be 3.14 inches. On completing the rectangle, the length of the diagonal OI will give the value of the total current to the same scale. It leads the voltage by the angle ϕ which can be read off in the ordinary way with a protractor.

On the other hand the value of the current can be very easily calculated, since $OI = \sqrt{(OI_1)^2 + (OI_2)^2}$. Hence $I = \sqrt{0.2^2 + 0.314^2} = 0.372$ ampere. The impedance of the circuit is thus $Z = \frac{E}{I} = \frac{100}{0.372} = 269$ ohms, and it should be noted that this is less than either the resistance or the reactance of the respective branches. From the diagram we see that the cosine of the angle of lead of the current is $\cos\phi = \frac{I_1}{I} = \frac{0.2}{0.372} = 0.538$, being the power factor for the circuit as a whole. But the power factor is not given by $\frac{R}{Z}$ as it was for the series circuit. It happens to be $\frac{Z}{R}$ this time, but this must not be taken as a general rule for a parallel circuit.

There are two methods of calculating the power in this particular circuit: (a) By multiplying together the volts, amps. and power factor for the complete circuit in the usual manner, or (b) by calculating the power in each branch separately and adding the values together to get the aggregate. By the former method the power is $E.I \times$ (power factor) $= 100 \times 0.372 \times 0.538 = 20$ watts. Now in employing the second method we know that a condenser takes no power, and therefore that the whole of the power taken by the circuit is absorbed by the resistance, where the current was found to be 0.2 amp. Hence power $= 0.2 \times 100 = 20$ watts as before.

Resistance, Inductance and Capacity.

Next we come to one of the most important circuits as far as wireless is concerned, namely, one in which all three constants, resistance, inductance and capacity are present. Under certain conditions, as every reader knows, such a circuit can be made to respond strongly to one particular frequency whilst giving but feeble response to other frequencies. We shall treat a series circuit first in a general way, and then lead on to the theory of the tuned circuit.

Suppose that a resistance of R ohms, an inductance L henrys, and a capacity C farads are all connected in series as shown in Fig. 3 (a), and that we desire to find what voltage E will be necessary to drive a current of I amperes through the circuit when the frequency is *f* cycles per second. The resistance R and inductance L might very well belong to a single coil, but for the sake of clearness we can imagine them separated.

Wireless Theory Simplified.—

So R stands for the resistance of the whole circuit.

In the first place the same current I flows through each part of the circuit, and so we can write down the value of the voltage required by each portion separately, in terms of the current and the "constant" of that part. For instance, the voltage E_1 required to drive the current I through the resistance R is given by $E_1 = I.R.$ volts, and this is *in phase* with the current. In drawing the diagram of vectors the current vector OI is drawn first, in any position, and the voltage vector OE_1 for the resistance portion of the circuit is drawn in line with OI as these two are in phase. The complete vector diagram for the circuit is given in Fig. 3(b).

The reactance of the inductive portion of the circuit is $X_L = 2\pi fL$ ohms, and the voltage required to drive the current through it is $E_2 = IX_L$ volts. Since the current lags for an inductance it follows that this voltage E_2 must be ahead of the current by a quarter of a cycle. So in the vector diagram the vector OE_2 is drawn at right angles to OI to the *left* (see Fig. 3 (b)).

For the condenser the reactance is $X_C = \frac{1}{2\pi fC}$ ohms, and the voltage required to drive I amperes "through" it will be $E_3 = IX_C$ volts, and this *lags* behind the current by 90° because a condenser takes a leading current. Hence in the vector diagram the vector OE_3 is drawn to the right.

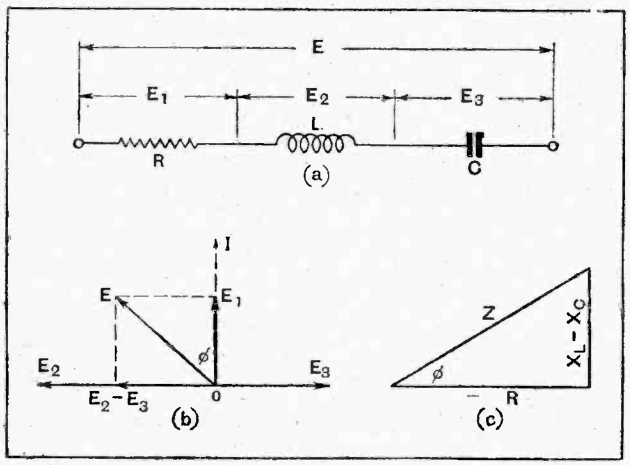


Fig. 3.—(a) Series circuit with resistance, inductance and capacity. (b) Vectors giving the phase angles of the various voltages. (c) Impedance triangle for the circuit.

Now the total voltage E required by the whole circuit will be equal to the sum of the separate voltages E_1, E_2 and E_3. But these three voltages are all at different phase angles, and in adding them the phase angles must be taken into account. However, the addition is a fairly simple one because the two voltages E_2 and E_3 are in direct opposition, one leading the current by 90° and the other lagging by 90°. Hence we can combine these two first, by the simple process of subtraction—the one has its maximum positive value at the same instant that the other has a negative maximum value. So the voltage required to drive the current through the inductance and capacity of the circuit, apart from the resistance, is $E_2 - E_3$ or $E_3 - E_2$ according to which of the voltages is the larger.

Power Factor for Series Circuit.

They might be equal, but for the present we shall assume that E_2 is larger than E_3, and therefore the voltage required by the inductance and capacity together will be $E_2 - E_3$, this voltage still being a quarter of a cycle out of step with respect to the current, as shown by the vector diagram of Fig. 3 (b). $E_2 - E_3$ may be called the total reactive voltage of the circuit.

Now we must add to this the voltage E_1 required by the resistance R. Since E_1 is in phase with I it is out of phase by 90° with respect to the reactive voltage $E_2 - E_3$. Hence the total voltage for the complete circuit is given by the diagonal vector OE, its value being $E = \sqrt{E_1^2 + (E_2 - E_3)^2}$ volts. But $E_1 = IR$, $E_2 = IX_L$ and $E_3 = IX_C$; and so $E = I\sqrt{R^2 + (X_L - X_C)^2}$ volts. From this we get the impedance of the complete circuit, namely, $Z = \frac{E}{I} = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$ ohms.

This is the fundamental equation for a circuit in which all the constants are present in series. The quantity $\left(2\pi fL - \frac{1}{2\pi fC}\right)$ is the resultant reactance due to the combined effects of inductance and capacity in series, and if we denote it by X we arrive back at our original equation $Z = \sqrt{R^2 + X^2}$ ohms. The impedance triangle for the circuit is given in Fig. 3 (c), and by its aid we see that the power of cos ϕ is given by $\frac{R}{Z}$, also in agreement with our previous results. From this we can conclude that the power factor is $\frac{R}{Z}$ *for any series circuit.*

(*To be continued.*)

Catalogues Received.

J. J. Eastick and Sons, 118, Bunhill Row, London, E.C.—"Eelex Radio Bulletin" for October, 1929.

oooo

Keith Prowse and Co., Ltd., 159, New Oxford Street, London, W.1.—Illustrated catalogue of proprietary portable and transportable sets now stocked.

oooo

Igranic Electric Co., Ltd., 149, Queen Victoria Street, London, E.C.4.—Illustrated loose-leaf catalogue of radio components for 1930. Also descriptive folders dealing with the "Neutrosonic Short Wave Receiver," embodying the superheterodyne principle, and particulars of the Igranic "A.C.3," an all-electric broadcast receiver.

oooo

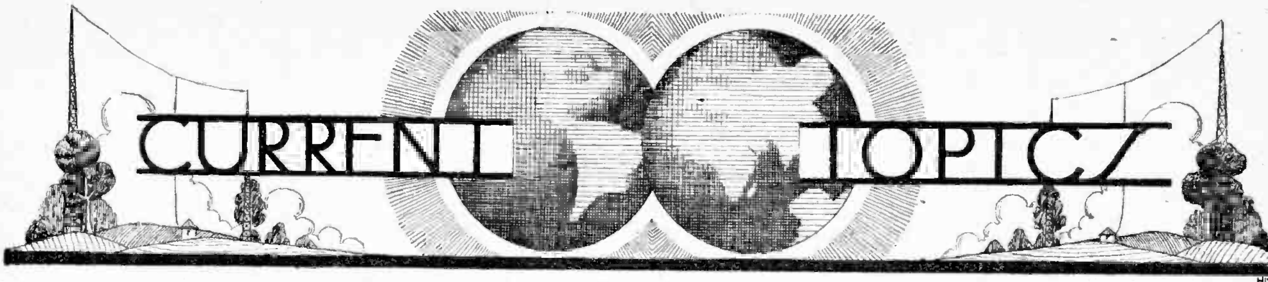
Garnett, Whiteley and Co., Ltd., Lotus Works, Mill Lane, Liverpool.—Illustrated catalogue of "Lotus" components with special reference to their remote control system for mains operated receivers.

oooo

Claude Lyons, Ltd., 76, Old Hall Street, Liverpool.—Descriptive booklet of the "Grassmann" moving coil speaker.

oooo

Standard Wet Battery Co., 184, 188, Shaftesbury Avenue, London, W.C.2.—Illustrated folder dealing with tests that can be made with the Wates Volt-Amp. meter.



Events of the Week in Brief Review.

GWTC.

No known station hears this call-sign, but the letters are a useful memory jogger on shopping expeditions, meaning, of course, "Give Wireless This Christmas."

oooo

THE WIRELESS TREASURE HUNT.

An invitation to participate in a search for "buried treasure" is extended to readers in our advertisement pages this week, prizes amounting in value to £20 being offered to successful entrants. The winners choose their own prizes.

oooo

THIS WIRELESS AGAIN.

"Wireless in Court" was the description applied by several daily newspapers to recent experiments in Bow Street Police Court with a microphone and speech amplifier system.

oooo

CHALLENGE TO DENMARK.

Sweden is now runner-up in the world's race for leadership in the percentage of wireless sets per head of population. According to a Stockholm correspondent, licensed listeners in Sweden on October 1st numbered 416,865, representing 68.3 to every 1,000 inhabitants. Only Denmark exceeds this proportion.

oooo

'PHONE CALLS FROM THE ATLANTIC.

On Sunday last, December 8th, the Atlantic liner *Leviathan* opened a public ship-to-shore telephony service with equipment similar to that which will shortly be installed on the *Berengaria* and *Majestic*. The manufacturers are the Bell Telephone and the American Telephone and Telegraph companies.

oooo

A TWO-METRE CLAIM.

Transmission tests with waves of three metres are referred to in the German amateur periodical, "CQ," which states that success on these high frequencies has been attained by Dr. Karl Stoye by means of a special arrangement of super-regeneration circuits. Transmitters and receivers functioning very efficiently on "the 3-3.40-metre waveband" are reported to be constructed with ordinary commercial apparatus, while a 2-metre wave is said to be attainable with the use of special valves.

oooo

CHEER UP, ETHIOPIA.

Whereas the United States contains 9,640,348 wireless receiving sets, Ethiopia has only two, says the U.S. Department of Commerce. Britain is second in the list with nearly three million, followed by Germany and France. Japan is fifth with 550,000.

Licence fees are highest in Lithuania, where the listener must pay £2 12s. 5d. annually.

oooo

IRISH BROADCASTING DELAYS.

Anxiety is being felt by listeners in the Irish Free State as a result of rumours that the project for a high-power broadcasting station is being shelved by the Government. The scheme aims at the establishment of a station in the centre of the Free State with sufficient power to cover the whole of the country. "Who will pay the piper?" is the question which the Government has to face.

oooo

"ANARCHISTS OF THE ETHER."

Certain French amateurs who are distracted by oscillators and other "anarchists of the ether" are considering the initiation of a campaign similar to that of the Dutch Radio Union, writes our Paris correspondent. The sufferers in Holland are preparing for a systematised "day and night struggle" with all forms of radio disturbance, personal and otherwise. A permanent office has been established where complaints will be received and action taken under legal advice.

oooo

A WIRELESS UTOPIA.

A Utopian dream has been realised by the U.S. Bureau of Standards in the acquisition of Pleasant Valley, Fairfax, Va., as an open-air radio laboratory. The site, covering 100 acres of abandoned pasture land, is flat and relatively free from trees, and is believed to be almost ideal for its purpose, viz., the study of fading.

Ordinary overhead aerials are to be dispensed with, the antenna system being limited to a vertical rod about 55 feet high and a number of direction-finding loops. To obviate "man-made-static," the power line for replenishing batteries from the mains can be disconnected.

The Bureau of Standards is retaining its field laboratory at Kensington, Ind, for investigation into radio echo phenomena.

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PARIS CRITIC OF *THE WIRELESS WORLD*.

In our esteemed French contemporary, *La Parole Libre en T.S.F.*, M. René Sudre makes a spirited reply to the remarks of *The Wireless World* regard-

AN IMPROMPTU WIRELESS STATION. Temporary gear in use at Howden Aerodrome, Yorks, for the collection of weather data in preparation for the flight of the airship R.100 to the mooring mast at Cardington.

ing the Paris Radio Salon and the inextinguishable popularity of the superheterodyne.

"Instead of attributing this to the French desire for good broadcasting," says M. Sudre, "the critic of *The Wireless World* concluded that the patent question is the true cause of the reign of the superheterodyne. . . . On the day that we have a good radio organisation it is possible that we shall go to London for the fashion of our receivers as well as for the cut of our lounge suits. But it is also possible that we shall remain faithful to the frequency changer, reduced to its five, or even four, valves. It is a truly French system which combines elegance of conception with perfection of result."

oooo

"SMALL ADS." AT CHRISTMAS.

Christmas causes delightful havoc to our ordinary printing arrangements, and it is therefore necessary to close for press earlier than usual with our issues of December 25th and January 1st. Miscellaneous advertisements for inclusion in the former can be accepted up to the first post on Wednesday, December 18th; those for January 1st should be in our hands not later than first post on Tuesday, December 24th.

oooo

WIRELESS ON NON-STOP FLIGHT.

In its attempt to beat the world's non-stop record for distance by flying from Britain to South Africa, the Fairey Napier Lion monoplane will carry a small wireless transmitter for sending out messages at hourly intervals indicating its position. Wireless is considered more necessary on this flight than on the Fairey monoplane's non-stop trip to India, which covered a route served by aerodromes at regular intervals.

The transmitter, with the call-sign GEZAA, works on 33.71 metres. Reception reports should be sent to the Signals Branch, Air Ministry, Kingsway. The flight is scheduled to start on any date from December 18th onwards.

oooo

BELGIAN BROADCASTING.

The new Belgian Wireless Bill has passed successfully through the Chamber of Representatives and is now awaiting the approval of the Senate. The Bill gives the postal administration complete control of broadcasting, which will be directed by a National Wireless Institute, operating two high-power stations broadcasting in French and Flemish respectively. The council of control will include a number of independent personages, including four technical authorities, and will be presided over by the Belgian Postmaster-General.

oooo

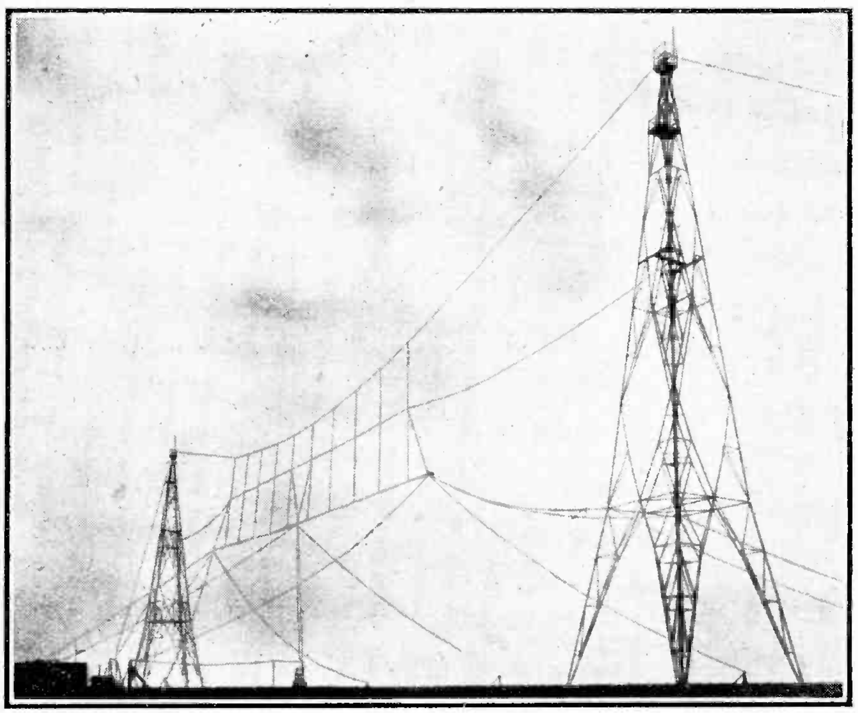
GRAMOPHONE TONE CONTROL.

Dr. N. W. McLachlan will give a lecture-demonstration on "Tone Control for Electric Gramophones" at a meeting of the Incorporated Radio Society of Great Britain on Friday next, December 13th, at 6 p.m., at the Institution of Electrical Engineers.

oooo

STANDARD BATTERY COMPANY.

We hear that the official title of the Standard Wet Battery Company has been changed to "The Standard Battery Company."



HOLLAND'S NEW SHORT-WAVE STATION. The aerial system of PHI at Huizen. The equipment is described in the following pages.

CLUB NEWS.

Invitation to Birmingham Enthusiasts.

A review of the past year's activities of Slade Radio (Birmingham), was given by the chairman, Dr. C. H. Harcourt, at the second annual general meeting held recently. The Society has apparently overcome the difficulties which are often encountered towards the end of the second year, and is entering its third year with confidence.

An appeal is now made for more members, and anyone who is interested in wireless is invited to get in touch with the Hon. Secretary, 110, Hillaries Road, Gravelly Hill, Birmingham, who will gladly forward details of the Society. An open invitation is also given to attend one of the Society's meetings any Thursday at 8 o'clock at the Parochial Hall, Broomfield Road, Slade Road, Erdington, Birmingham.

oooo

An All-electric Receiver.

Mr. A. J. Hall, G2NU, of Philips Lamps, Ltd., has been engaged for some considerable time on research work on all-electric receivers, so his lecture and demonstration before the Muswell Hill and District Radio Society on November 27th were of more than usual interest. To convert the local D.C. supply to A.C. in order to run the A.C. demonstration receiver a special A.C. generator, driven off the D.C. mains, was used, and proved quite satisfactory. The lecturer pointed out the numerous advantages of all-mains sets over battery-driven ones, and gave a demonstration of one of his firm's well-known receivers, upon which a large number of Continental broadcast stations was logged at very good strength, despite the poor antenna system available.

Hon. Secretary, Mr. C. J. Witt, 30, Coniston Road, N.10.

oooo

"Talkie" Secrets Disclosed.

Mr. Hawker, of the Western Electric Company, visited the Wembley Wireless Society recently and gave a lucid description of the method of production and reproduction of "talkie" films.

The lecturer, who has been actively engaged in the preparation of some recent famous talking pictures, let the members of his audience into many secrets of the "talkie" studio.

It was stated that "talkie" films were introduced many years ago but that owing to the reluctance on the part of the film producers the invention was not seriously taken up until quite recently.

At the Society's next meeting on December 13th Messrs. Hart and Perry will continue their "Practical Hints and Tips" demonstration, dealing with the best way to use a soldering iron.

Hon. Secretary, Mr. R. E. Comben, B.Sc., 24, Park Lane, Wembley.

oooo

Varied Fare.

A vigorous debate on the respective merits of the moving-coil and balanced armature types of loud speaker was one of the recent features of the Golders Green and Hendon Radio Society's programme. Mr. Bremner, B.Sc., championed the former, while Mr. Maurice Child upheld the latter.

Programme problems were discussed by a representative of the B.B.C. at a recent meeting, and a lecture of absorbing interest was that given by Mr. H. T. Barton Chapple, B.Sc., on the subject of television.

The Society's future fixtures include lectures on such varied topics as "talkie" films, colour photography, all-mains receivers, and metal rectifiers. The next club dance will be held on December 27th.

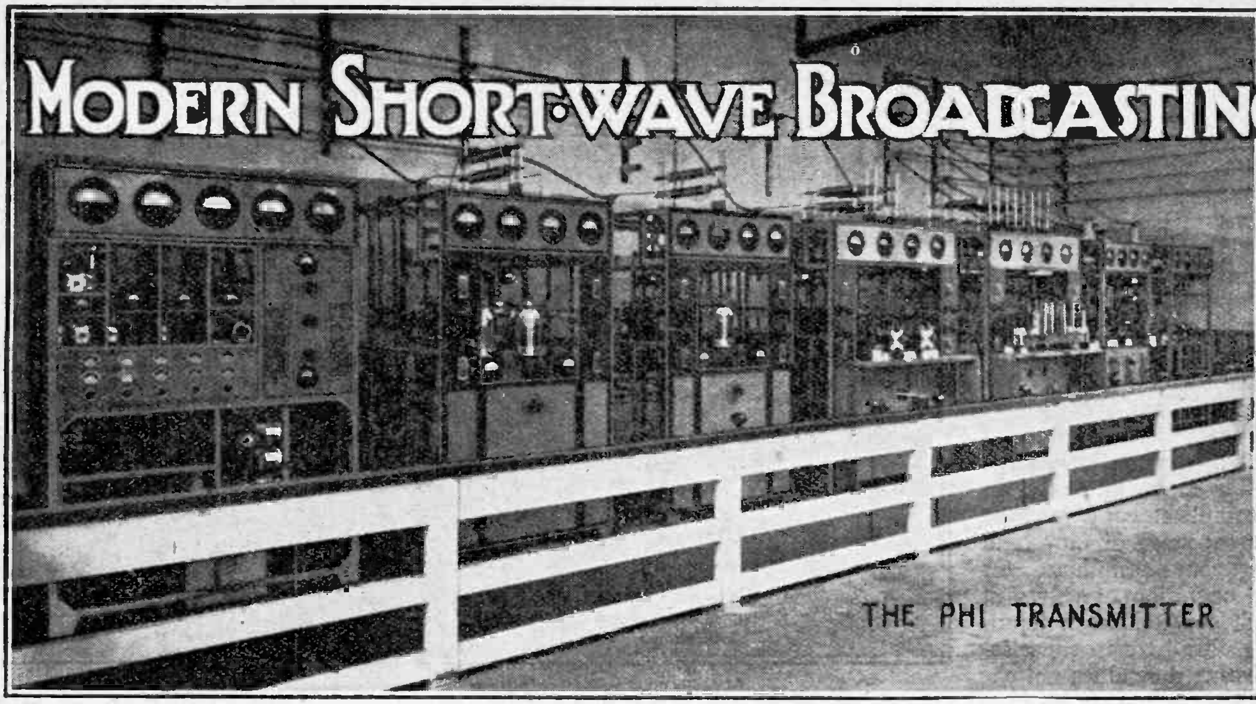
Hon. Secretary, Lt.-Col. H. A. Scarlett, D.S.O., 60, Pattison Road, N.W.2.

oooo

Query Night at Tottenham.

Knotty points of theory in the working of certain portions of a typical radio receiver were explained by Mr. Bodemeaid at the last meeting of the Tottenham Wireless Society. The lecturer had previously obtained from members particulars of points which they had found rather difficult of explanation, and these were worked through one by one. Among the points dealt with were the explanation of the working of a detector valve, the nature of the current before and after detection, and the reason why the rectified current can operate transformers and pass through condensers, etc. The lively discussion which was maintained during the whole of the evening indicated the great interest taken by the members in this type of meeting.

Hon. Secretary, Mr. W. Bodemeaid, 10, Bruce Grove, N.17.



The New Station at Huizen.

By A. J. HALL (*of Philips Radio*).

THE experience gained by the engineers who designed the Philips experimental short-wave station PCJ, has been very liberally drawn upon in the development of the new Dutch short-wave transmitter PHI, located at Huizen.

Even accustomed, as we are, to the very rapid developments in the technique of radio transmission and reception, it can still seem strange that the energy passed to the aerial of this gigantic transmitter is effectively controlled by a piece of quartz comparable in size with a halfpenny!

A glance at the illustration on this page, showing the seven frame-type panels, will indicate the progressive increase in the power handled in succeeding stages of the transmitter.

Commencing with the first panel (stage No. 1)—on the extreme left—the upper portion of this houses the "crystal oscillator." A piezo-electric crystal, ground to oscillate at a frequency of 2,222 kilocycles, is used in conjunction with a 4-volt receiving valve. The purpose of this stage is merely to furnish an output at a dead-constant frequency, to ensure strict adherence of the transmitter to its assigned wavelength. The feeble output of this piezo-electric oscillator is fed to the compartment immediately beneath, which contains two small transmitting valves of 10-watt rating, arranged in push-pull. The constant frequency signal is thus magnified to a suitable value for passing to the next stage.

In the third and fourth positions of this same panel, two operations are performed, viz., frequency doubling and amplifying. Whilst the input to the third position is at a frequency of 2,222 kc., the output circuit is tuned to double this frequency, and a suitably amplified output at 4,444 kc. is available from position number four.

The next operation again doubles the frequency, at the same time amplifying the signal at such frequency, giving a resultant of 8,888 kc., from which it will be seen that a wavelength of 33.75 metres has been reached (positions Nos. 5 and 6). The anode feed to the initial stages, thus far, is at 400 volts. Special precautions are taken with respect to electrical screening, for such a step is found necessary if feed-back trouble in the crystal oscillator stage (the effect of which is promptly to shatter the small quartz crystal) is to be avoided. In the sixth position valves fed at 2,000 volts are used.

The second panel unit incorporates two valves of 1½-kilowatt rating, again connected in push-pull formation, making position No. 7. It is in this stage that the final frequency doubling operation is carried out, resulting in the working frequency of 17,778 kilocycles, corresponding to a 16.88-metre wavelength being produced.

Position No. 8—shown in the photograph as the third panel—performs an amplifying operation in which 1½-kilowatt valves are again used, this time, however, fed at an anode voltage of 4,000. At this juncture, the water-cooled type of valve can be more conveniently used, and succeeding stages, therefore, embody valves of this type, which are capable of taking up to 12,000 volts anode tension.

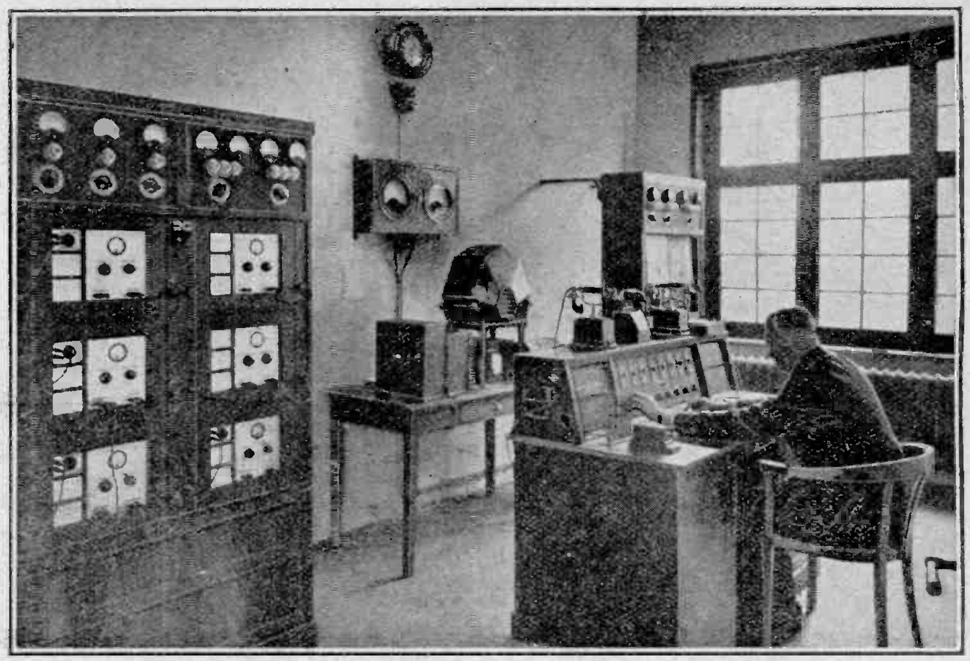
The ninth operation is again amplifying, the stage comprising two water-cooled valves of 10-kilowatt

Modern Short-wave Broadcasting.—

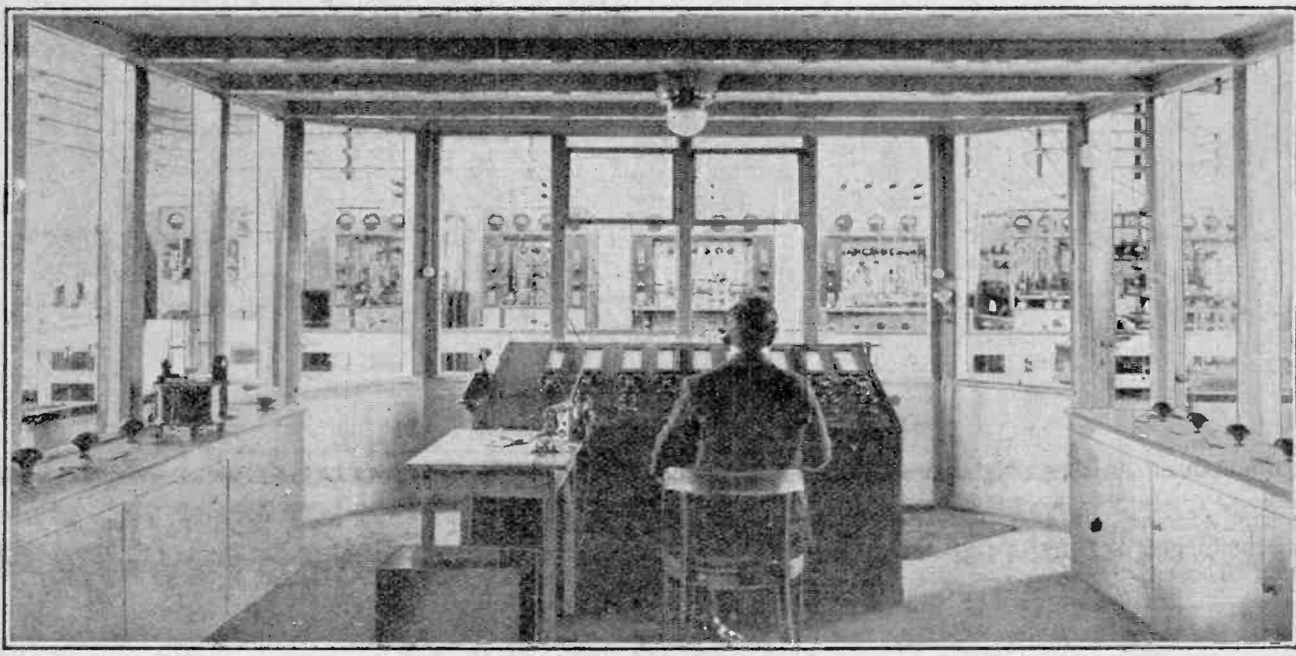
rating. The fourth panel in the illustration depicts this stage. In the tenth operation the power dealt with is no less than forty kilowatts, handled by two valves. Even this does not represent the maximum that can be dealt with, for an anode feed current as large as six amperes at an applied voltage of 10,000 has actually been recorded.

It may here be said that such a comparatively large power input is really an accomplishment in the present stage of ultra-high frequency technique, for the operation of valves at such powers, when handling ultra-high frequencies, presents difficulties not encountered in the generation of frequencies corresponding to the usual broadcast wavelengths. It is known that when dealing with ultra-high frequencies, capacitive currents—which can attain surprisingly large values—flow in certain conductors, and there are necessary precautions to be taken to minimise the effects of such parasitic currents. The signal energy has now reached the stage at which modulation takes place, and in the anode feed circuit of the valves incorporated in this fifth panel unit the necessary modulating transformers are installed.

The modulating unit proper is embodied in the sixth panel, and is equipped with two modulating valves of 15 kw. rating for each of the three transformers. The seventh panel, equipped with four amplifying valves,



The studio control room at Huizen. A special land line connects the station with Amsterdam, enabling the celebrated concerts in that city to be relayed.



From the vantage point of the engineer's control desk, shown above, every portion of the transmitter is under constant observation. The motor generators in the engine room are operated by a remote control device.

Modern Short-wave Broadcasting.—

is the final stage, the output being fed to the aerial. The overall power input is no less than 130 kilowatts, and naturally the supply of this amount of energy at several different voltages presents no small problem.

Reference to the photograph of the high-power rectifier unit will show how the supply is obtained. The main rectifying bank, shown in the picture, furnishes an output of up to 12,000 volts for the higher-powered stages of the equipment, and it will be observed that the water-cooled type of rectifying valve is used.

The medium-power rectifying bank using air-cooled valves operates on an 8,000 volts polyphase supply, whilst the water-cooled bank rectifies a six-phase supply at 14,000 volts.

The smoothing problem is very much simplified by the use of six-phase alternating current.

A comparatively small value of capacity shunted on the output of such a rectifier will yield an output having no trace of ripple, a very necessary feature in a telephony transmitter.

The accompanying photograph shows the Duty Engineer's control position. Necessary indicating meters are conveniently placed, and the operation of the entire transmitter, from the crystal stage to the aerial input, is thus under constant surveillance.

A check on the outgoing signal is maintained by means of the monitor, with its single-turn loop aerial, to be seen on the immediate left of the Duty Engineer. The engine-room is also linked up by remote control with the Duty Engineer's desk.

The filament lighting load, in itself, represents quite a formidable power load, very close regulation of which is essential. Immediately adjacent to the guard rails, in front of the seven panels, can be seen the filament controls which permit adjustments to be made during operation of the transmitter, without necessitating a near approach to any of the apparatus under voltage. The scales of the meters are so disposed as to be visible at a distance of several feet.

The studio microphone is connected to the "A" amplifier rack in the adjoining main control room, the panel incorporating no fewer than six amplifiers equipped with necessary gain controls.

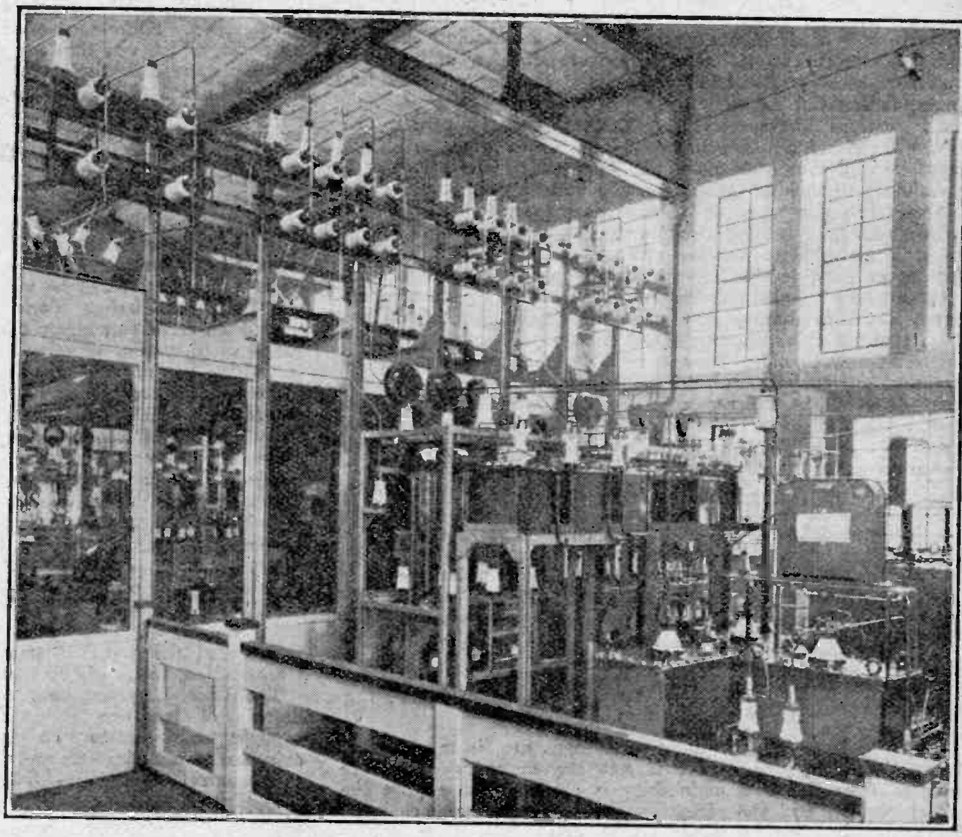
A special land-line connects the control-room with Amsterdam, thus permitting the well-known concerts from that city to be relayed to the far-distant audience of the station.

The aerial used is of the Beam type, and is supported between two masts about 200ft. in height. The orientation of the aerial is such that the strongest signal is placed in territories on a line joining Huizen and the Dutch East Indies.

The choice of wavelengths is governed by several considerations, an important one being the mean noise level from atmospheric disturbances in the location in which the reception is desired. In certain parts of the world there are periods during the year when radio reception on any wave greater in length than about 40 metres—sometimes less—is impossible, due to the severe atmospheric disturbances. With the choice of a wavelength as low as about 17 metres, the atmospheric bugbear will be very much less in evidence, and "all-the-year-round reception" will, therefore, become almost a certainty.

At the present time, the Huizen short-wave transmitter is not operating to standard programme times, but it is expected that the station will go into scheduled operation in the near future.

Reports from many places speak with enthusiasm of the excellent reception and outstanding quality of the transmissions from this new station, which bids fair to establish a name even surpassing that of PCJ.



The high-power rectifying plant at Huizen. The main rectifying bank, seen in the picture, gives an output up to 12,000 volts. Water-cooled valves are used in this stage.

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.

RECEPTION OF CONTINENTAL STATIONS.

Sir,—As I, too, have been a wireless enthusiast since the early days of broadcasting, and take a keen interest in long-distance reception, I was very interested in the letter from Mr. A. W. Scott in your issue of November 27th.

I cannot, however, agree with his assertion that "the 'enjoyment' of foreign transmissions is an absolute myth" and his description of reception from foreign stations as "awful noises—transmission plus mush, atmospherics, heterodynes, fading and morse."

All stations (irrespective of whether they happen to be British or foreign!) are liable to the forms of interference mentioned by your correspondent, and whether the interference is seriously disturbing or not depends very largely on the ratio of interference to strength of received signals.

On a reasonably efficient set incorporating a screen-grid H.F. stage, I am able to receive upwards of twenty Continental stations at good loud-speaker strength on most evenings from dusk onwards. A smaller set (detector and L.F.) enables me to get a similar number of stations on headphones. I do not claim that all these stations afford consistently reliable results, but on any given night I can invariably select, from this wide choice of programmes, several Continental transmissions which, apart from slight fading, are receivable with a volume and quality that compares favourably with reception from Daventry 5GB. It is manifestly absurd to describe these foreign transmissions as "awful noises" merely because they happen to originate on the other side of the Channel or the North Sea!

As the regular reception of foreign wireless programmes by a large number of listeners is calculated, directly and indirectly, to help in bringing about a better understanding between people of different nationalities, it seems rather a pity to discourage it in any way, but of course one appreciates that the B.B.C. cannot be expected to hamper the development of our own broadcasting service on this account. W. OLIVER.

London, S.W.18.

Sir,—The letter over A. W. Scott's signature, in my opinion, voices the feeling of many, if not the majority of licence holders. The B.B.C.'s main duty is obviously to supply the British public, and the reception of foreign programmes is no concern of theirs. I agree that the latter would be worth listening to if they could be received as transmitted, but with the multiplicity of foreign stations this is now a hopeless proposition. Years ago much pleasure could be derived from them, but now it is definitely better to rely on our own programmes, which on the whole are satisfactory.

Mr. Baggs in his letter voices a real grievance in his complaint of London programmes being relayed. My own set, a "Wireless World" screened-grid five, gives excellent reception of 2LO, 5XX, 5GB, and Manchester, but as a general rule this gives only two programmes from four stations, with the inevitable military band from one.

I do hope when the second programme from 2LO is radiated it will give an alternative programme, and that the Northern Regional Station will give a third choice.

This, I understood, was the whole idea underlying the Regional Scheme.

It is up to the ordinary listener to make himself or herself heard on this point, but the apathy of these people is such that it lulls the B.B.C. into a sense of complacency which is definitely to the detriment of all concerned. L. N. GROVER.

Eastwood, Notts.

B.B.C. TRANSMISSIONS.

Sir,—The letter appearing in your issue of November 13th over the pseudonym of "Fair Play" contains a number of errors and misrepresentations of which I ought, perhaps, to take notice.

In my letter in your October 23rd issue I did not imply that *all* distortion occurs in B.B.C. land lines *and/or transmitters.* I implied, on the contrary, that the defects of any one transmitter were not sufficient to impair the satisfactory quality of direct transmission. Sources of error in my set would not prejudice my point, which was that my apparatus, such as it is, gave me satisfactory results with direct but not with other transmissions. Defects in reception would affect all transmissions alike.

A perfect or elaborate set is not needed to make obvious the deficiencies of land-line and wireless-link transmissions. If "Fair Play" can get near enough to a suitable transmitter, a crystal set and a pair of telephones ought to enable him to differentiate for himself between the various transmissions. The problem he sets for my solution, the old problem of obtaining both quality and selectivity, is therefore in this particular connection quite irrelevant. The lines, however, on which it may be satisfactorily solved he will find indicated for him in recent pages of *The Wireless World.*

It is an error to suggest that the human ear is not the final judge as to quality of reproduction. The sole aim of wireless is to give the normal ear a sufficiently approximate duplicate at one end of the process of what it would hear were it at the other. Scientific tests and measurements serve their purpose. They reveal and localise defects and indicate the direction and degree in which improvement is required. They show also that the ear does not demand perfection but will, within limits, tolerate defects. This tolerance, however, far from invalidating an adverse judgment by the ear, only confirms it and puts it beyond question.

It is quite improbable that the B.B.C. would claim that *all* their radiations were as good as *any* set reproducing them. (I use here "Fair Play's" imperfect method of expression.) It is to be observed, too, that "Fair Play" finds it convenient to forget that the B.B.C. themselves, in one of their methods of transmission, make use of a receiving set.

The Chief Engineer does not require proof of the serious defects of land-line transmissions, nor even to have them brought to his notice. In regard to such defects, he has the evidence of his own ears and also, I believe, a certain quantity of technical data. The following passage is taken from a letter from Mr. A. L. Barham published in *The Wireless World* of January 19th, 1927.

> "By great courtesy of B.B.C. engineers I spent a very fascinating afternoon at Savoy Hill a week or so ago and was shown some actual curves of frequencies passed by various land lines lent by the G.P.O. to B.B.C. Most of them were most irregular in the way the sonic frequencies were passed, generally looking more like malarial temperature charts than any instrument response. One comparatively short line had a complete cut-off above 3,000 cycles! As different lines are used at different times the practical difficulties in compensating can be imagined."

Any improvement in land-lines and land-line technique during the past three years has not sufficed to effect any noticeable amelioration in the quality of land-line transmission.

The Chief Engineer is unable completely to rectify land-line errors. He gives us at present the best he is capable of in the way of land-line transmission and he can do no more.

There is no reason why we should not all have, at least occasionally—I mean, of course, in the provinces—concerts of the same merit as those from Queen's Hall by direct transmission from our local stations.

I admitted nowhere in my letter that Daventry 5XX was available as an alternative to Newcastle. Daventry 5XX can be easily heard here, but its reception is too liable to interference by various forms of "mush" for it to be accepted as giving an adequate alternative service.

Newcastle-on-Tyne. K. McCORMACK.

READERS' "THE WIRELESS WORLD" SUPPLIES A FREE SERVICE OF TECHNICAL INFORMATION PROBLEMS

The Service is subject to the rules of the Department, which are printed below; these must be strictly enforced in the interest of readers themselves.

A selection of queries of general interest is dealt with below, in some cases at greater length than would be possible in a letter.

Tracing Power Circuit Interference.

I am occasionally troubled by cracklings and other intermittent noises, which I believe come from the electric power wiring in my neighbourhood, or perhaps from my own house wiring. Can you suggest a simple test which will enable me to determine whether this interference is due to the latter wiring, or to an external source? S. T. A.

This test should be easy to carry out. All you have to do is, at a time when the interference is particularly noticeable, to take out your main switch, which will certainly be of the double-pole type. If, on doing this, there is no appreciable change in the character of the interference, you may justifiably assume that it is entirely from an outside source.

It will be hardly necessary to add that this test should be repeated several times, preferably with the help of an assistant if the set is at some considerable distance from the main switch.

○○○○

Screening S.G. Valves.

I have some well-made copper screening boxes, measuring 8in. × 8in. × 7in. high, and should like, if possible, to use them in the construction of a receiver on the general lines of the "New Kilo-Mag Four." Would there be any harm done if the H.F. valves were mounted vertically in the first and second compartments? W. S. W.

We would strongly dissuade you from adopting this course, unless you are willing to be satisfied with an overall magnification much less than the maximum attainable. If the design of most modern multi-stage H.F. amplifiers is carefully considered, it will be found that it is usual practice to take some pains both to screen individual grid and plate circuits and to isolate the valves themselves from stray fields.

We suggest that you should either mount the valves on "outriggers" behind the screening boxes, as in the original "Kilo-Mag Four," or perhaps better, if the overall width of the receiver is not a matter of great importance, that the boxes should be mounted on the baseboard with a space of some 2in. separating them, thus allowing the valves to be mounted between the screening compartments. This method was exemplified in the "Foreign Listeners' Four."

actually a considerable capacity between the aerial wire and earth; the whole system may be represented as Fig 1 (*a*), where this external capacity is shown by dotted lines.

A similar explanation applies to the series grid condenser (C in Fig 1 (*b*)). It must be remembered that there is a small but definite capacity between grid and filament (denoted by C_g), and that this constitutes a second condenser through which the circuit is completed in the manner shown in Fig. 1 (*c*).

When the plate A of condenser C is given a negative charge, it apparently attracts a positive charge to, but actually drives negative electrons away from, plate B. These are sent across to plate X of condenser C_g, and constitute the counterpart there of those electrons which have been drawn off from plate Y by the

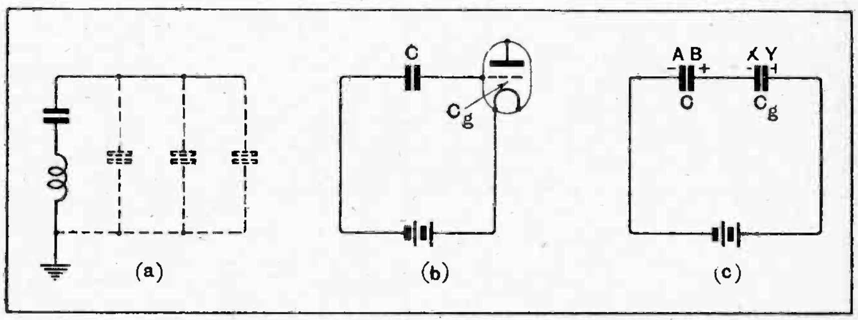


Fig. 1.—The interposing of a condenser in an aerial (a) or grid (b) lead does not constitute a break in the circuit as the condenser is merely connected in series with an existing capacity.

Electrons and Condensers.

With reference to your series of articles, "Wireless Theory Simplified," I have found it quite easy to understand how an electron flow through a condenser is brought about, but cannot quite grasp how this takes place in such practical cases as that of an aerial with a series condenser or of a valve with a condenser in series with its grid. In neither case does there appear to be electrical continuity between the two plates of the condenser.

A few words of explanation would be greatly appreciated. W. T. T.

As you suggest, a condenser cannot be charged unless there is an external circuit, but in both cases instanced this condition obtains, although the circuit is actually completed through another condenser in series with the first.

In the case of the open aerial there is

battery. For further explanation of the subject of condensers in series we would refer you to our issue of November 27th.

Still referring to Fig. 1 (*c*), it should be realised that the voltage applied by the battery is divided between the condensers in the inverse ratio of their capacities, and where the capacity of one of the condensers is very small compared with the other, practically the whole of the voltage is set up across the smaller one. If C has a value of 0.0003 mfd. (or 300 mmfd.) and C_g a value of 10 mmfd., the voltage will be divided in the ratio of 300 to 10 between the condensers. Thus if the E.M.F. of the battery is 10 volts, the voltage across C will be $\frac{10}{310} \times 10 = 0.322$, and that across C_g will be $\frac{300}{310} \times 10 = 9.678$.

Plates B and X are at the same potential, since they are joined: the signs indicate distribution of electrons only.

RULES.

(1.) *Only one question (which must deal with a single specific point) can be answered. Letters must be concisely worded and headed "Information Department."*

(2.) *Queries must be written on one side of the paper, and diagrams drawn on a separate sheet. A self-addressed stamped envelope must be enclosed for postal reply.*

(3.) *Designs or circuit diagrams for complete receivers cannot be given; under present-day conditions justice cannot be done to questions of this kind in the course of a letter.*

(4.) *Practical wiring plans cannot be supplied or considered.*

(5.) *Designs for components such as L.F. chokes, power transformers, etc., cannot be supplied.*

(6.) *Queries arising from the construction or operation of receivers must be confined to constructional sets described in "The Wireless World" or to standard manufacturers' receivers.*

Readers desiring information on matters beyond the scope of the Information Department are invited to submit suggestions regarding subjects to be treated in future articles or paragraphs.

The "Selectivity-Quality" Problem.

In Fig. 1 of the above article in your issue of November 27th, a fixed resistance of 60,000 ohms is shown as being connected between one side of R_1 and the filament of the detector valve. It seems to act more or less as a short-circuit across the H.T. supply leads. Will you please explain its purpose? S. J. E.

This resistance forms one arm of a potentiometer, of which R_1 is the variable element. The voltage applied to the detector anode will be determined largely by the relationship between the values of these two resistances.

In the receiver under discussion there is a very considerable difference between the main H.T. input voltage and that suitable for the detector, and in these circumstances it is desirable to ensure a sensibly constant voltage feed by fitting a potentiometer device instead of a simple series resistance.

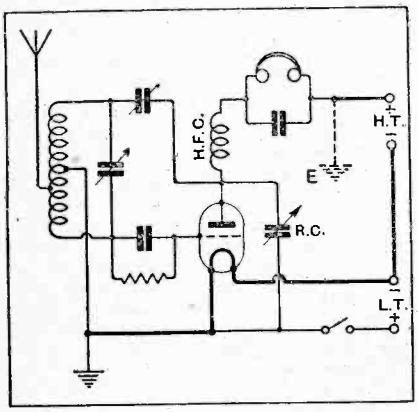


Fig. 2.—When the positive L.T. lead is earth connected there is a possible risk of burning out the valve filament. Short-circuit path is shown in heavy lines.

Still Another Way of Burning Out Valves.

Some little time ago I made up a single-valve detector set with throttle-controlled reaction on the general lines of a circuit shown in your journal, but with one or two minor modifications. As the set was built into a small metal cabinet the positive terminal of the L.T. battery was "earthed" to the case, in order that an existing on-off switch (of which one terminal was in metallic connection with the fixing bush) could be used. Negative terminals of high- and low-tension batteries were connected together, as is always recommended.

In view of the fact that these precautions were taken, I had hoped that the set would be as "safe" as could be expected, but I have actually burnt out the valve on two separate occasions by allowing the high-tension positive lead accidentally to make a momentary contact with the metal container.

Is this particular circuit arrangement especially prone to this trouble, or have I made a mistake in "earthing" the positive side of the low-tension battery? L. H.

Much space has been devoted in this journal to the subject of "safety" valve filament connections; your own arrangement most definitely does *not* come under this category.

We expect that your circuit is that shown in Fig. 2. We have added an earth connection (marked E), which represents what takes place when the H.T. positive lead makes accidental contact with the metal work. If you consider the diagram carefully you will see that this connection provides a "through" circuit, *via* the valve filament, across the H.T. battery, provided that the on-off switch is open.

The throttle control reaction circuit need introduce no more risk of damage to valves than any other, provided that proper precautions are taken in arranging the filament wiring, etc.

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Parallel Feed L.F. Amplifier

In a set on the lines of the 1930 Everyman Four, but with a power valve in the first L.F. position, would it not be preferable to replace the anode resistance by a high-inductance choke? I ask this because it seems that when using a low-impedance valve taking a considerable anode current, there would be an excessive loss of voltage in the resistance. C. B. N.

In a case of this sort we think it would be a mistake to use a choke in place of a resistance, as by doing so there is a risk of upsetting the characteristics of the transformer. In any case, it must be realised both that the inductance of the choke would be considerably reduced were a heavy current to be passed through it, and that there is a tendency for the grid volts/anode current curve of a valve to straighten out when a resistance is connected in its anode circuit. Assuming a fairly conventional arrangement, with reasonable H.T. voltage, we think you need have no fear that the first L.F. stage, if arranged as in the 1930 Everyman Four, will deal with a sufficient input.

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Filter Output as Stabiliser.

I have just replaced a choke filter arrangement by an output transformer, with the result that the set, which was previously quite stable, is now totally unmanageable, and produces violent L.F. oscillation. Is this a usual effect, and, if so, will you please suggest a cure? L. B. G.

An output filter, of the type in which one side of the loud speaker is earthed, acts as a decoupling device by virtue of the fact that speech frequency currents are largely diverted from the common source of H.T. current by the anode choke, which almost invariably has a much higher impedance—at any rate to currents corresponding to the upper range of audible frequencies—than the alternative path.

The fact that you have noticed this effect would point to the need for inserting decoupling resistances in the anode circuits of detector and 1st stage L.F. valves. This should provide a cure, and enable you to use your output transformer with satisfactory results, but if stability is still lacking please send us a circuit diagram of your receiver, with details of the source of H.T. current supply.

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Considerations in Design.

In the design of the Record III, an attempt was avowedly made to attain the maximum possible amplification consistent with the retention of sidebands: I am puzzled as to why a 4in. diameter litz coil, similar to the H.F. transformer secondary, was not used for the H.F. grid coil. Is it not a fact that a high-inductance coil of low H.F. resistance could with advantage be used in this position, providing still greater amplification and less sideband cutting? W. M. T.

Tuned circuits having a large inductance and a small capacity contribute comparatively little to the overall selectivity of a receiver, and on these grounds alone it would probably be injudicious to include a second one of this type in the receiver. Further, a high-inductance coil cannot usefully be employed unless all possible steps are taken to reduce incidental capacity across it, and consequently its use would necessitate "decapping" of the H.F. valve as well as of the detector, which was considered to be undesirable.

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FOREIGN BROADCAST GUIDE.

EIFFEL TOWER

(Paris, France).

Geographical Position: 48° 51′ 30″ N. 2° 17′ 43″ E.

Approximate air line from London: 214 miles.

Wavelength: 1,444 m. Frequency: 205.76 k.c. Power: 12 kW.

Time: Greenwich Mean Time.

Relays main transmissions from the Ecole Supérieure (PTT), Paris.

Standard Daily Transmissions.

8 a.m. news and time (from PTT, Paris); 12.15—13.30 concert interspersed with short news bulletins; 13.30—15.40 news, talks, etc.; 17.45 concert; 19.20 (Sun. 19.50) concert followed by relay of PTT Paris.

Male announcer. Call (when own transmission): *Ici le Poste National de la Tour Eiffel* (repeated). (When relaying PTT Paris): *Ici les emissions de T.S.F. du Reseau Français de Radio-diffusion des stations de l'Ecole Supérieure et de la Tour Eiffel.*

Opening signal: Seconds counted in the French language.

Time signal (when relaying PTT Paris): Carillon de Fontenay (clock with chimes).

Under the heading "Foreign Broadcast Guide," we are arranging to publish a series of panels in this form, giving details regarding foreign broadcast transmissions.

The Wireless World

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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.

CONTENTS OF THIS ISSUE.

THE MARCONI ROYALTY COMPROMISE.

AGREEMENT appears to have at last been reached between the Marconi Company and those manufacturers who were licensees under the Marconi patents. It will be remembered that negotiations for a modified licence agreement began as soon as the appeal of the Marconi Company had succeeded against an order by the Comptroller of the Patent Office under which the amount of royalty payable by licensees to the Marconi Company was reduced from 12s. 6d. per valve stage to 5s. for the first valve and 2s. 6d. on succeeding valves.

The effect of the success of the Marconi appeal against this order was to reinstate the position of the Marconi Company; the judgment deciding that the amount of the royalty could only be reduced by agreement with the Marconi Company, who were entitled to grant or refuse licences under their patents practically on what terms they pleased.

At the time that this judgment was given many months of arrears in royalties on the basis of 12s. 6d. per stage had accrued to the Marconi Company's credit, but so confident were the licensees that the new rate of 5s. and 2s. 6d. would apply that in many instances only this latter amount was taken into account in deciding upon the price at which receivers would be sold.

Had the full royalty of 12s. 6d. been demanded retrospectively by the Marconi Company, it is probable that a number of firms would have been unable to pay, and consequently it seemed highly desirable that some new agreement should be formed which would amount to a compromise to get over the difficulty.

A compromise has now been arrived at by which the royalty is agreed upon as 5s. per valve stage, irrespective of the number of stages, whether or not they utilise patents subject of the licence, with a further 5s. in the case of sets which include a battery eliminator employing any patent. Licensees must accept the agreement for the full period of the licence, which is from August 28th, 1929, to August 28th, 1933.

The licence is granted in respect of past and future patents of the Marconi Company and the Gramophone Company (which recently entered into an agreement to acquire the Marconi Company's interest in broadcast receiving apparatus).

Many of the more important patents held by the Marconi Company at the time of the old agreement have since expired, or will run out well within the new period to August, 1933, so that the Marconi Company benefits very largely by extending the period over which it is assured a substantial revenue from its patents, but the rate of 12s. 6d. over the period during which the question of royalties has been in dispute could legally have been insisted upon by the Marconi Company, so that licensees may well consider that to have avoided this full payment is a fair exchange for being made to continue to pay royalties over a longer period, perhaps, than would otherwise have been required of them. The Marconi Company, by virtue of its associations, is in a strong position to acquire future patents of importance, and these being in future at the disposal of the licensees is undoubtedly another attractive point in the terms of the agreement.

The new agreement is certainly a compromise but, taking into consideration the strong position created for the patent owners as a result of the successful legal appeal, it is satisfactory to the licensees from most points of view. Even an unsatisfactory agreement might have been better than a prolongation of the unsettled situation of the past months.

The Use of Anode Current—Anode Voltage Curves for—

GRID BIAS VALUES

— Determining Input and Output Operating Conditions.

By W. I. G. PAGE, B.Sc.

THE author pleads for the publication by valve manufacturers of anode current—anode voltage curves rather than the more conventional grid voltage—anode current characteristics. It is shown that only with such curves is it possible for the grid potential to be properly adjusted to give the minimum distortion with the greatest possible amplification. There is also considerable information in this article with regard to the effect on grid bias of the early flow of grid current with indirectly heated valves and the alteration from normal bias that has to be made when the filaments of power valves are directly fed with raw A.C.

WHEN we purchase a receiving valve there will probably be contained within the carton a slip reminding us how much we have spent and giving the conventional anode-grid characteristics. These will take the form of the upper part of Fig. 1, which has been traced from the official curves issued for a well-known small output valve. The grid bias recommended by the makers for 150 volts H.T. for amplifying conditions is 6 volts negative, which is marked X in the figure. Since grid current in power valves seldom flows to the left of zero grid volts—and even if it does the affected grid voltage is insignificant in value when compared with the total grid swing—it must be assumed that we are at liberty to allow the signal to swing to zero grid volts on the right (H) and to -12 grid volts on the left (K), for a signal voltage makes equal excursions on either side of the bias point.

Thus the permissible grid swing with an output valve can be safely taken as twice the recommended bias, unless is be expressly stated by the makers that the valve must be overbiased to prevent excessive heating of the anode. When applying the permissible 12-volt swing KH (Fig. 1) to the point X the anode current for the positive half cycle rises to L, or 10.8 mA. from 2.6 mA., and drops from the latter figure to zero at the negative peak of the swing. The two output half-cycles will be extremely asymmetrical, and serious rectification and distortion will apparently take place. Has the valve manufacturer made a mistake or has he over-biased to be able to quote a low average anode current—such an important feature in portable sets?

The Bias Point and the Anode Load.

The answer is that the curves of Fig. 1 are of little use for bias considerations and must be redrawn in another form, taking into account the anode load. As the anode current increases there will be an increasing voltage drop across the load, the anode voltage will drop, and *vice versa*. The dynamic curve can then be found quite easily if it be assumed that the load (loud speaker impedance) is a resistance choke filter-fed in the ordinary way. *Every volt change on the grid means a simultaneous change both of volts and milliamps on the plate,* so that an examination of the working conditions for *a constant plate voltage* as in Fig. 1 gives entirely erroneous results because the anode voltage is changing all the time and is only 150 volts for a fleeting moment when the signal makes the grid potential exactly 6 volts negative. Neither does the positive peak H cause the anode current to be 10.8 mA. (L), nor does the negative peak K mean a drop to zero.

How to Calculate Correct Bias.

By taking the points of intersection of each grid voltage marked and the four constant anode voltage curves (Fig. 1) a new set of characteristics can be drawn as in Fig. 2 giving anode current—anode volts curves for constant grid voltages of equal increment. As an example the $Eg-4$ curve intersections are D E F G in Fig. 1 and are shown again in Fig. 2 with the same lettering. In a similar way the other curves are drawn or in the case of $Eg-12$ and $Eg-14$ are, unfortunately, estimated.

In our early discussion of Fig. 1, in which static conditions were assumed for the plate circuit, no account was taken of the effect of A.C. on the load. We are now concerned with peak voltages which may have an instantaneous value very much greater than the steady voltage of the H.T. battery (or eliminator). If the anode characteristics of Fig. 2 are to give a complete interpretation of working conditions we must ask the valve manufacturers for curves of plate voltages up to at least twice the maximum battery voltage; in the case in question 300 volts.

We can fix the mean working point in Fig. 2 as O, which is the same as X in Fig. 1 (6 volts bias, 150 volts H.T. and 2.6 mA); this point will represent the state of affairs when no signal is being impressed on the grid. When the total permissible grid swing (12 volts) as limited by the 6 volt bias is applied, the working line will start at $Eg=0$, cut O and terminate at $Eg-12$, and the angle of this line will depend on the A.C. resistance R of the load. By Ohm's law R (ohms) $= \frac{\text{change of volts}}{\text{change of amps}}$

Grid Bias Values.—
and we may hazard the guess, since the valve's A.C. resistance under working conditions is some 10,000 ohms, that the best load will be about 20,000 ohms. The line A B has been so pivoted at O that 100 volts anode change is accompanied by 5 mA. (0.005 amp.) change in anode current, making $R = \frac{100}{0.005} = 20{,}000$ ohms. Other angles of A B, that is other values of R, may be tried but it will be found that the greatest output for the minimum distortion will be obtainable with the load value already referred to.

If A O is not more than $\frac{11}{9}$ths of OB, the second harmonic distortion will not exceed 5 per cent., which is unobjectionable. For further details of the 5 per cent. distortion scale which is shown against A B, the reader is referred to an article entitled "Valve Data," which appeared in the issue dated December 4th. Had the bias point been fixed originally at −8 volts, the load line of 20,000 ohms from $Eg=0$ passing through O to $Eg-16$ would not only give serious distortion as checked by the distortion scale, but a region of zero anode current would be entered. If the bias has been fixed at −4 volts as is suggested by the type of curve (Fig. 1) issued by the maker, the valve would be underloaded and the *power output would be more than halved*, although the bias had only been reduced by 2 volts. Thus the manufacturer has gone to some pains to arrive at the optimum bias point for maximum undistorted output, but the curves supplied give no clue to working conditions and are liable to mislead all but those who have taken the trouble to convert them to the type in Fig. 2. Besides giving the bias point for an output valve for minimum distortion with best value of load, these curves show the A.C. milliwatts developed in the load by making A B the hypotenuse of a right-angled triangle and multiplying together A C and C B as milliamps. and volts and dividing by 8 (in this case about 60 milliwatts).

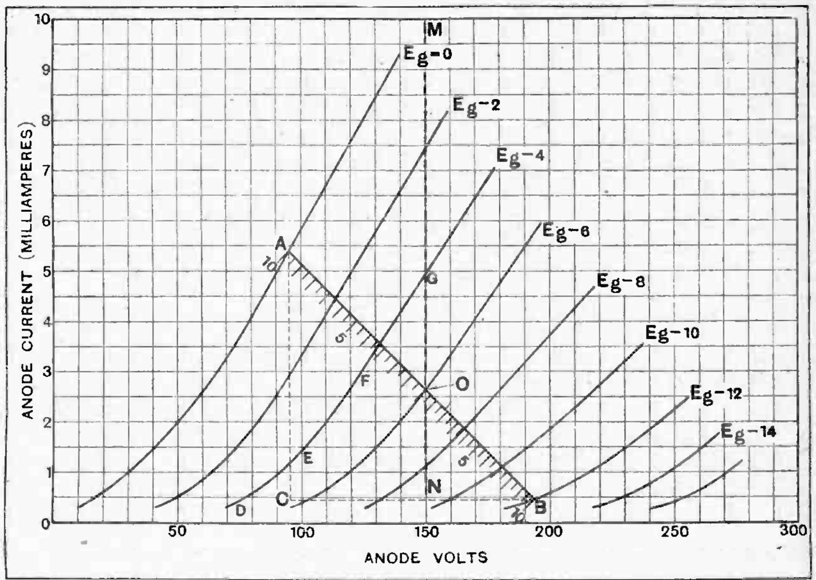


Fig. 2.—Anode current—anode volts curves for equal increments of grid volts (Eg) plotted from Fig. 1. From this family of characteristics the working conditions are easily followed. The bias of 6 volts can be seen to give practically no rectification and the best output load can be calculated from the angle of A B. The actual undistorted A.C. watts developed are measurable from the area of the triangle A B C.

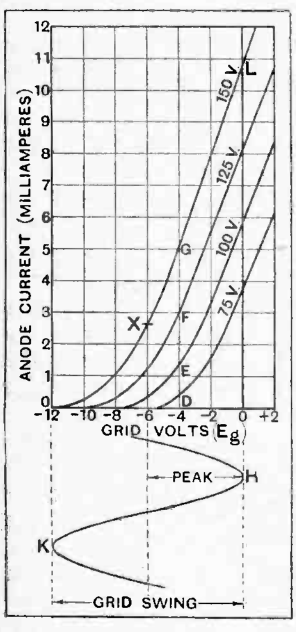


Fig. 1.—Conventional grid voltage—anode current curves for a popular small output valve. Although an optimum bias of 6 volts for 150 anode volts is given by the manufacturers for amplifying conditions, it is seen that a 12-volt grid swing KH would be seriously rectified if operating conditions are viewed from these characteristics.

There appears to be a very urgent need for the publication of anode current—anode volts curves up to high values of H.T., for it is only with their help that many phenomena can be studied both in radio- and audio-frequency circuits. For example, an anode-bend detector when followed by a suitable L.F. transformer provides an extremely small capacitative load to H.F. and the load line can be taken as approximately vertical (R=O when change in volts=O). In Fig. 2 M O N represents such a condition and as the working characteristic swings up and down a constant anode voltage, there would seem to be here an isolated case where the bias can be fixed from the curves of Fig. 1. Even so, the curves of Fig. 2 would be more helpful in determining rectification efficiency and the percentage harmonic distortion with varying depths of modulation. With output valves we have accepted the load as a pure resistance, actually it is usually inductive, and, because the current will lag behind the voltage, the upward swing of the working characteristic will not coincide with the downward swing resulting in an ellipse (see Fig. 3).

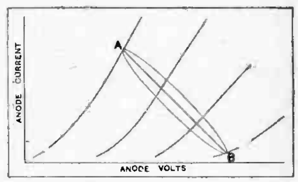


Fig. 3.—With an inductive load the anode current—anode volts characteristic swings up and down in the form of an ellipse A B since the current lags behind the voltage. As an approximation the axis of the ellipse can be taken to represent the load line.

With screen-grid valves it is essential to use the anode volts—anode current curves, for without them the limits of safe anode swing without encroaching upon the negative resistance "kink" cannot be seen. In Fig. 4 curves of one of the new S.G. valves are shown. The working characteristics should apparently be within the dotted rectangle to ensure linear amplification without rectification. An excursion to the left of the rectangle where the $Eg=O$ curve shows the valve to have a comparatively

Grid Bias Values.—

low impedance might affect selectivity. The load line shown represents a coupling with a dynamic resistance of about 40,000 ohms at resonance—indeed a poor inductance with the losses of a bad plug-in coil. If a load of about 250,000 ohms (a good Litz coil) were drawn with its operating point at $Eg-1.5$, the line would be nearly horizontal, suggesting an extremely limited grid swing for 150 anode volts. Further study of such curves might reveal the cause of the mysterious lack of selectivity with S.G. valves when used with H.F. transformers of optimum ratio.

With pentodes the production of dangerous anode voltages up to seven times that of the H.T. battery, and the fact that very low impedance loads must be used, would not have been brought to light without a careful study of the anode characteristics.[1] In brief it may be said that the bias point and general operating conditions for triodes, pentodes and screen-grid valves can only be found by an examination of the anode curves plotted for constant grid volts, and the author feels that his plea for the general publication of such curves is justified.

It has already been stated earlier in this article that with output valves, if there is any flow of grid current to the left of zero grid volts, it affects such a proportionately small amount of the total grid swing that the bias need

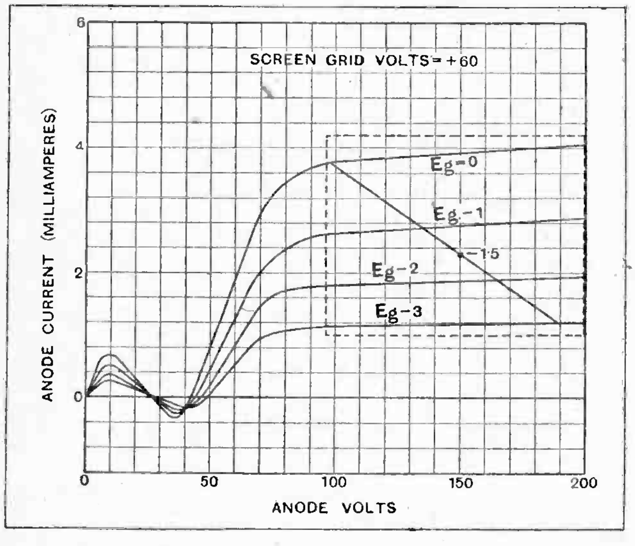


Fig. 4.—Anode characteristics of one of the new screen-grid valves. To avoid rectification the load line should be restricted to the area within the dotted rectangle.

hardly be increased. With H.F. valves and detectors accepting but small inputs the position is different. The increasing popularity of all-mains receivers has led to the widespread use of indirectly heated A.C. valves in which grid current may flow at negative grid voltages. The reason is that electrons are shot off from a cathode or filament just as irregularly as steam is emitted from a saucepan of boiling water. Some electrons start with sufficient velocity to overcome a very small negative voltage on the grid, others have but a small initial velocity and will not form part of the grid current. When there is a voltage drop down the filament, as with the battery-fed type of valve for 2-, 4- and 6-volt accumulators, the positive end of the filament is at a considerably more positive voltage with respect to the grid than the negative end of the filament.

If the grid is connected to the negative end of the filament in a 6-volt valve such as the P.625, the grid is at a potential which is 6 volts negative with respect to the positive end of the filament and only a small portion of the negative end of the filament will produce grid current which will start to flow on the right of zero grid volts (see Fig. 5). In a valve with an indirectly heated cathode there is no potential difference between the ends of the emitter and the whole surface of the latter contributes towards grid current, which will probably start on the left of zero grid volts (see curves on the left in Fig. 5).

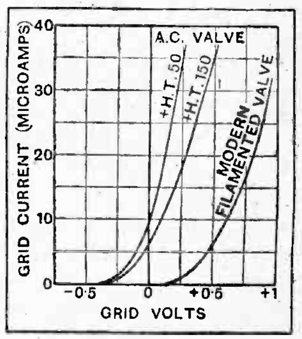


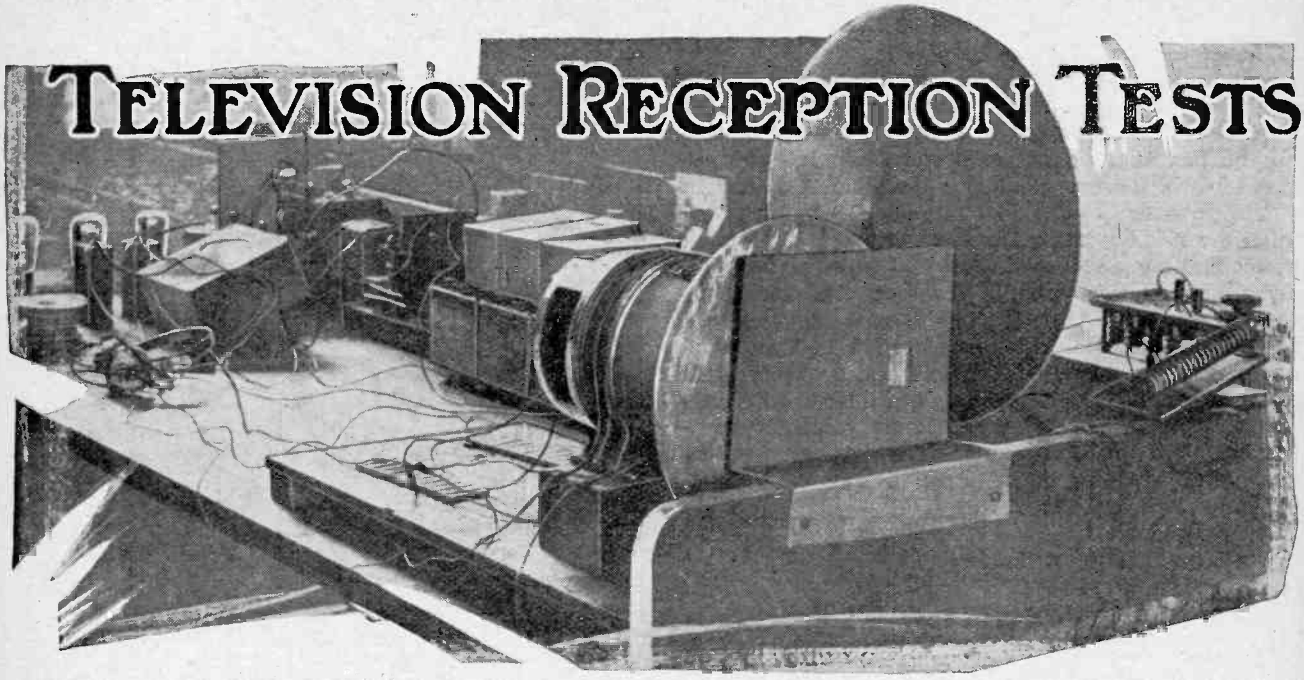
Fig. 5.—Grid current curves for A.C. and ordinary filamented valves.

Grid current curves start at about the same point on the grid base for varying anode voltages, but less current will flow the higher the H.T. pressure, since the plate will begin to rob the grid of the electrons which it has claimed at the lower voltages (Fig. 5). While it is important in the interests of maximum signal strength to bias H.F. valves (neutralised triodes and S.G. valves) as near to zero grid volts as possible, it is desirable to apply a minimum of $1\frac{1}{2}$ volts negative to H.F. valves with independent A.C. cathodes. With an ordinary filamented triode a fraction of a volt is enough. An A.C. valve usually has sufficient grid current flowing at zero grid volts to allow of its use as a leaky grid detector without any applied positive bias, provided the anode volts are kept low (40-60 volts).

The prevailing practice of employing in the last stage of a mains receiver a power valve directly heated with A.C., suggests a few notes on the problems of bias in the circumstances. Assuming that the grid return is taken to the electrical mid-point, we must use a greater bias than is correct for D.C. because (1) we have actually altered the "static bias" on the grid by removing the steady potential drop along the filament and we have also slightly increased the effective anode voltage by the same means; (2) assuming the grid current to start originally at zero grid volts, we have now to take care that the grid does not in effect swing positive, due to the peak value of the A.C. voltage on the filament. The bias which we have to add must compensate for whichever of the above two effects is the greater. The changes in (1) will be taken care of by making the bias more negative by an amount $E_f/2+E_f/2\mu$ where E_f is filament voltage and μ the amplification factor of the valve. The change of bias due to the removal of the steady drop along the filament is compensated for by $E_f/2$, while $E_f/2\mu$ cares for the effective increase of anode voltage. The potential change alluded to in (2) will be $\sqrt{2}\times E_f/2$, i.e., $E_f/\sqrt{2}$. When these two effects are equal we have $\frac{1}{2}+\frac{1}{2}\mu=1/\sqrt{2}$ that is, $\mu=2.4$ approximately. Thus if μ exceeds 2.4 the additional bias is $E_f/\sqrt{2}$.

[1] See *The Wireless World*, December 4th, 1929, page 630.

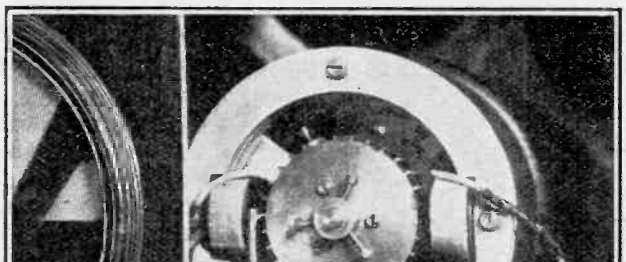
TELEVISION RECEPTION TESTS



An Endeavour to Receive the Television Broadcast, with Details of the Apparatus Used.

By F. H. HAYNES.

BUT for the fact that an experimental television broadcast is being conducted from the London regional station there would have been no justification for this article. So limited is a technical study of the apparatus now used in television that, in reviewing the present situation, a few words must necessarily be devoted to the Baird organisation, which is responsible for the transmissions, and the part played by the Post Office and the B.B.C. As a determined experimenter not to be deterred from his objective by the failure or criticism of others, Mr. John L. Baird has earned for himself the highest praise. His early apparatus was first described in the issues of this journal of May 7th, 1924, and January 21st, 1925, which, while revealing little that was new and an advance on the work of earlier experimenters, showed that he was intensively applying himself to the practical side of the problem. A mechanical analyser was used consisting of a disc carrying a spiral of lenses, the carrier frequency was introduced by a serrated wheel, and the light sensitive device was said to be colloidal. Valve amplification was a new factor, so that it became possible for him to use a neon tube as a source of image-forming light at the receiver. Since that time another contribution of vital importance to television has been the perfecting of the photo-electric cell, and we can say that the valve amplifier, the neon lamp, and the photo cell have made the demonstration of television possible; yet the application of these new devices is but an obvious modification.



The toothed-wheel synchroniser fitted in the Baird television receiver.

Knowing that the real difficulty in television is that of synchronising the revolving mechanism at transmitter and receiver, no inventor can claim success who does not first put forward a solution to this problem. In his earliest apparatus Baird used A.C. synchronising, such as had been adopted previously in several systems, and was described by Campbell Swinton. In this respect the Baird gear represented no advance on the work of others. Synchronising by A.C. consists of feeding a common A.C. current to both transmitter and receiver which, with the aid of a synchronous motors, tuning forks or relays, effectively holds

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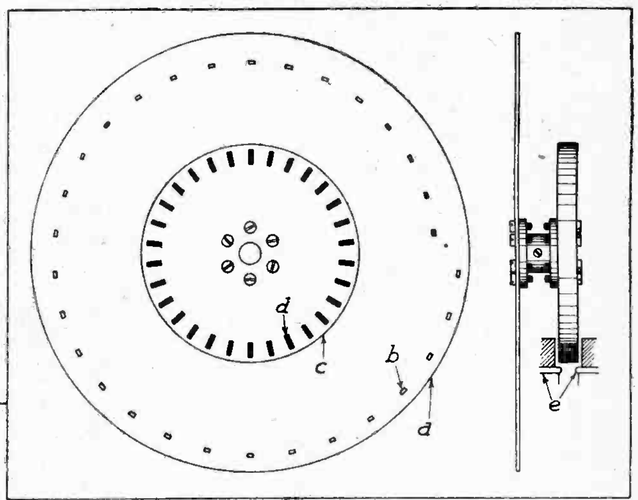
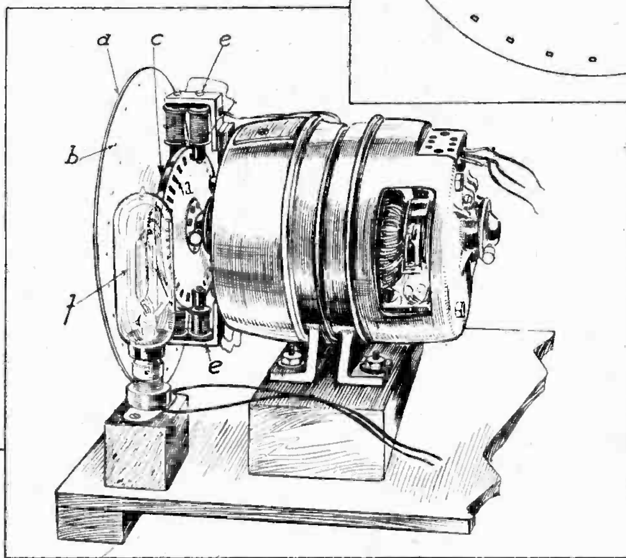
the rotating parts in step. This method demands an additional channel between transmitter and receiver in order that both the picture-forming and synchronising signals may be separately conveyed. In spite of the existence of this all-important problem of synchronising and the fact that no patent specification has yet appeared in which a new solution is disclosed, it is thought in many quarters to-day that television is making vast strides towards becoming an accomplishment as familiar as broadcasting. We now know that Baird had no important contribution to make in solving the synchronising problem. The situation might have remained unchanged following the early experiments of Baird had not financial assistance been sought and a development company formed to convert the Baird apparatus into a marketable article. More recently a larger company acquired the Baird interests in this country, the principal object being that of manufacturing television reception gear for use in conjunction with our broadcasting service. In this connection another almost insurmountable problem presents itself.



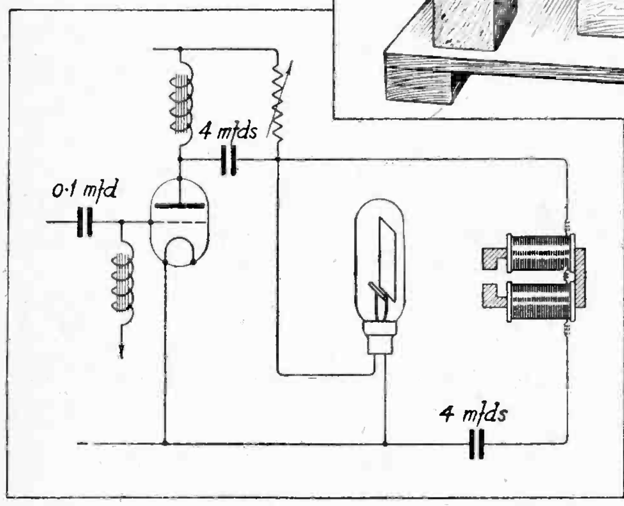
Constructional details of scanning and synchronising discs.



Experimental television receiver. (a) scanning disc, (b) spiral of 30 holes, (c) light fibre synchronising disc, (d) soft iron segments, (e) magnets carrying the picture signals, (f) the neon lamp.

The Frequency Limitation.

When analysing a picture into a number of points of light of varying intensity, an enormous number of individual signals are formed, and we



Circuit arrangement of an output stage in which the picture signals are passed to an electromagnet in order that the current peaks may produce synchronising.

know that the complete image must be transmitted in a period of time not longer than one-tenth of a second if a moving picture effect is to be produced. Unless a very severe limit is imposed, therefore, on the size of the image, and the extent or "fineness" of analysis, the number of signals to be transmitted within a second far exceeds in value the highest audio frequency that can be dealt with in broadcast. So long as the picture is kept small and a coarse degree of analysis used, radio transmission is possible, assuming, of course, that a solution is found to the difficulties of synchronising.

We remember the publicity given to the negotiations between the Baird Company and the broadcasting authorities concerning the inclusion of television transmissions in our broadcast programmes. From the statements issued it appeared that the B.B.C. was opposed to being a partner in such an undertaking, this attitude being based upon technical considerations. Negotiations were pursued, however, and on the intervention of the Post Office we now have the experimental television broadcast service. Transmissions are made from 11 a.m. to 11.30 a.m. daily, Saturdays and Sundays excepted. It is understood that this series of television transmissions is now being extended to include, in addition, two nights a week after broadcasting hours.

Enquiries are being made in many quarters as to the success of these transmissions, which have now been in progress for some eight weeks. Listeners ask where suitable receiving gear can be obtained, and radio enthusiasts seek technical details of experimental apparatus with which to participate in the tests. Can this television broadcast be successfully received, and, if so, what is the quality of the pictures? It was with

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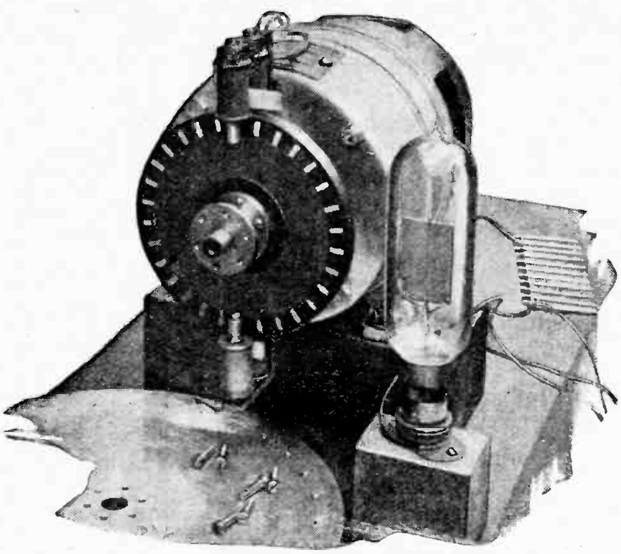
the object of answering these questions that the apparatus to be described came into being.

Details of the Baird method of synchronising were made public last September. The apparatus was shown to be extremely simple, and to consist of a toothed wheel mounted on the shaft of the motor driving the analysing ("scanning") disc. Just clearing the teeth are the poles of an electromagnet, the signal currents being applied to the magnet winding. A very similar arrangement of phonic wheel has already been described in this journal when reviewing the Mihály system of television.[1] Assuming that a break exists between each successive picture, then a similar moment of no signal must likewise occur after the formation of each transverse picture-forming strip. With a number of teeth equal to the number of holes in the disc and the poles of the magnet engaging the teeth during the period of no signal, it is thought possible that the picture signals may be used as a means of synchronising. Thus at a time of no current through the magnet windings the teeth will travel unimpeded past the poles. Should, however, the disc be running slightly too fast the picture-forming current will be energising the magnet pending the interval of no signal being reached. There will thus be a retarding action tending to correctly regulate the speed of running and the precise position of the disc at any interval of time. Whether or not the toothed wheel is controlled by an interval of no signal between each image-forming picture strip or is, in fact, pulled into position by the current representing a bright line across the picture is immaterial. What most probably is the intention is that the bright parts of the picture representing successive peaks of current with each traverse have an accelerating or retarding action upon the rotation.

Unless a generous bank of power valves be used for energising the electromagnet its influence will be inadequate to control the rotation. Whether the power thus available is sufficient to control the disc will depend upon the weight and speed of the revolving parts and the amount of correction required. When one considers that the initial driving power is supplied by a motor running at a speed of over 700 r.p.m., and that the restraining influence of the synchronising current is only applied for a brief interval of time, it will be readily realised that considerable energy will be needed to check even a small variation. Lightness of moving parts and a minimum of friction for the motor to overcome are the aims in setting up the apparatus, while provision must be made to regulate very critically the speed of the motor. A slow-speed motor with ball-race bearing having an armature and commutator of the smallest permissible diameter was selected after making several tests. As to the scanning disc itself, which measured $11\frac{5}{16}$in. in diameter, sheet aluminium was adopted, a little more than $\frac{1}{16}$in. in thickness, after tests had been made with another and much lighter material.



View showing the method of mounting the synchronising disc and its associated electromagnets. The critical speed-adjusting field rheostat can be seen on the right.

IS it possible to receive in the average home the television broadcasts now taking place from 2LO? The test apparatus made up with a view to answering this question is here described together with details of the results obtained. Unlike most scientific achievements uncertainty exists as to whether the claims of success have been substantiated.

The recent announcement that 1,000 receiving sets will shortly be available, and that the television transmissions are being extended has created a demand for precise technical information concerning the apparatus and its performance.

Instead of the iron-toothed wheel, as recommended by Baird, one of fibre was constructed slightly larger in diameter than was indicated, so as to provide a more critical control and yet possessing quite moderate weight. To avoid the windage of projecting teeth, which it was quickly realised was appreciable at the normal running speed, small iron bars were pressed into a fibre disc, and their ends turned down flush with the faces. Precise details of the disc can be gleaned from the illustrations. Every care was taken to ensure correct spacing between the bars and that they passed through the disc at exact right angles to the faces. Maximum magnetic flux for the watts available was thus produced by the short magnetic circuit when these bars passed between the poles of an electromagnet. Two magnets were actually used in order to get the strongest magnetising effect without saturating the iron. As there was no end play on the motor shaft, exceedingly small clearances were possible between the poles and the disc, and this is, of course, an important condition, seeing that the watts used to produce a given magnetic flux increase approximately as the square of the width of the gap increases. So small were the clearances, in fact, that when the signal currents were applied a slight pulling in of the poles occurred, and, in order to prevent rubbing, it was necessary to insert wooden wedges between the end cheeks of the bobbins.

[1] Television by the Mihály System, July 3rd, 1929.

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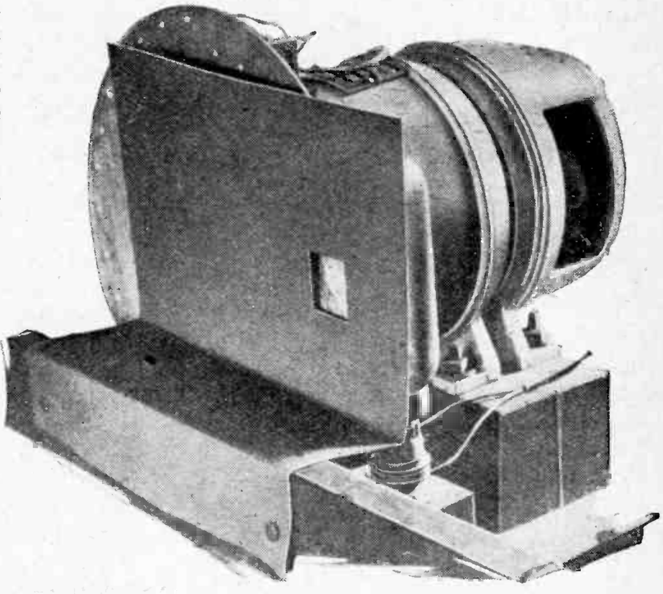
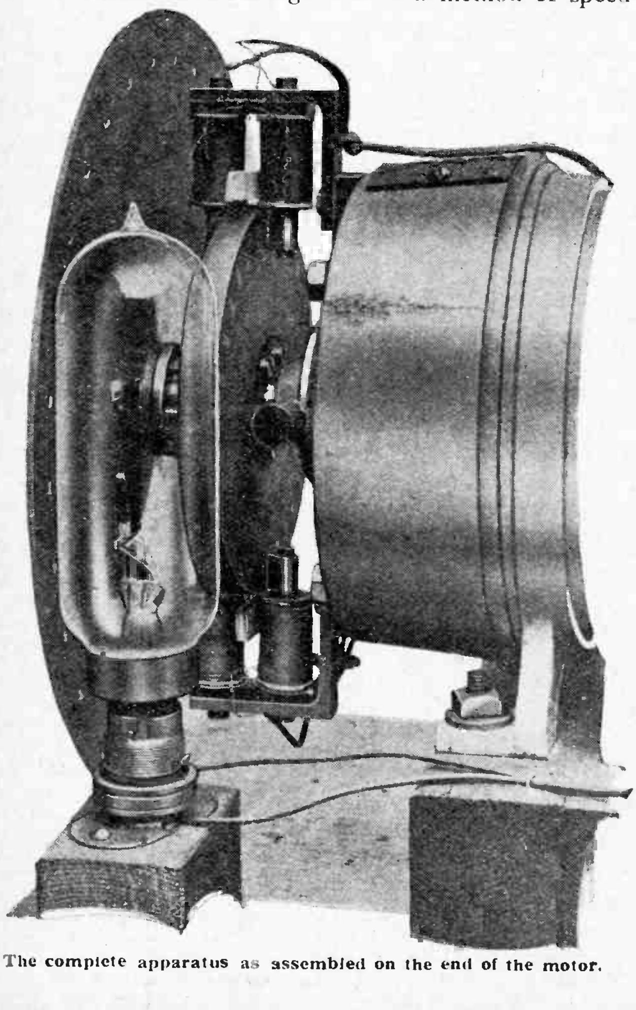
A brass bush coupled the synchronising and scanning discs. In the absence of published information it became necessary to conduct some preliminary tests in order to discover the direction of the spiral of holes in the scanning disc, the pitch of the spiral, together with the size and position of the image. Quickly it was realised that reasonable precision was necessary in the positioning of the holes, and that a small error in the setting out of any one hole produced a dark strip when the disc was rotated before a source of light. It was noted also that for uniformity of illumination when receiving a picture that the holes should not be precisely round, and that their exact shape, which more probably approaches a rectangle, can, no doubt, be readily calculated, bearing in mind also the hole-shape used in the scanning disc at the transmitter.

Speed Regulation.

Critical speed control was arranged by variable resistances in the field and armature circuits of the motor, so that an almost correct running speed was maintained with a minimum of current. Part of the resistance controlling the field was brought out to a short-circuiting switch in accordance with popular American practice, so that the speed could be critically checked while watching the formation of the image. Such a method of speed control, while being crude and entirely unsatisfactory in a commercial product, is as helpful as anything in the hands of the experimenter. Attention was particularly turned to an endeavour to successfully operate the synchronising device. With a power output valve such as the P.625, which can be run from a normal source of H.T. supply, it cannot be seen how sufficient control of the disc can be obtained. By fully loading its grid with an alternating current, and experimentally adjusting the impedance of the magnet so as to obtain a maximum power output at the given frequency, the control provided by a valve of this class proved entirely inadequate. In making this observation it must be borne in mind that the magnets are only acting at brief intervals.



A card is used to "frame" the image while a magnifying lens was improvised so that the details could be more carefully examined.



The complete apparatus as assembled on the end of the motor.

Tests with Generous Output Stage.

The next step was to arrange a generous output power stage, and the arrangement finally set up consisted of no fewer than three of the new LS6A valves with fully loaded grids, as revealed by microammeter and milliammeter, and working with the maximum rated anode voltage of 400. Even so generous an output stage as this proved insufficient to produce stable and automatic synchronising. When the grids of the output valves, however, were fed with alternating current, the effect was different, and, in spite of the comparatively high speed of rotation, synchronising with the A.C. voltage was at once possible, as was to be expected from previous experience with a phonic wheel. Owing probably to the irregular wave-shape of the picture-forming signal this type of synchronising, as suggested by Baird, cannot be regarded as satisfactory. Maybe by mere coincidence the regional scheme will provide an acceptable solution to the problem, in that while one transmitter will convey the picture signals, the other can provide an alternating current controlled by the analysing disc at the transmitter. Such a proposal differs vastly from the existing claims as to the possibilities of a television broadcast

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service, and would entail the use of a twin receiving equipment.

As to the results obtained it may be stated that pictures were received within the first ten minutes of using the apparatus, but the synchronising was not automatic and success depended upon the very careful manipulation of the field regulating switch, combined with frequent frictioning of the disc. For the most part the successive pictures appeared as parallelograms rising and falling before the aperture. With the rising or falling string of pictures one soon learns how to speed up or retard the disc, yet an apparatus demanding such a procedure possesses no commercial merit. The neon tube functioned well, and after critically adjusting the threshold and signal voltages the contrast of the image was brought down from the harshness which it possessed at the commencement of the tests. Detail was poor, due, perhaps, in some measure to small inaccuracies in the location of the holes and to the continuously changing position of the picture. Two types of tube were tested, with equal success, one a product of the General Electric Company and the other a Raytheon Kino-lamp (Rothermel).

It is probable that the scanning disc used was incorrectly divided in that the pitch of the spiral was excessive as compared with the mean circumference. In the absence of information it is suggested that some 50 per cent. of the signal is taken up by the synchronising mechanism so that the height of the picture is only about one-half the distance between successive holes. This reduction in the height of the image demands a smaller pitch for the spiral in order to maintain the correct height to width ratio. Actually the holes in the disc were very much smaller than they appear in the illustrations, the apparent large size being due to countersinking. Assuming that nearly half the signal energy is thus applied to the windings of the magnets, and this would seem to be the case from these tests, the successful working of the apparatus can be anticipated. A bright margin observed between successive pictures indicates the inclusion in the transmission of a definite synchronising signal.

In addition to the apparatus referred to here other forms of gear were tested. An attempt was made to rotate a light paxolin disc with a powerful audio-frequency oscillator adjusted closely to the picture frequency and to which the picture signals were coupled. It was the hope that the peaks in the signals would drag the oscillator precisely into step. Insufficient power, however, was produced to maintain the high speed of rotation, while practical difficulties in combining an incoming signal with the local oscillator made the arrangement unworkable.

Transmission but no Reception.

Against the observations recorded here may be quoted the fact that successful public demonstrations have been claimed. Other than at the Olympia demonstration and that which is frequently given at the Baird studios, where in both instances the transmitting and receiving equipments are set up in adjoining rooms, no details can be gleaned of successful television reception possessing commercial possibilities and operating under conditions similar to those existing in the home of the broadcast listener. While much is being written on the obscure electrical and light problems involved in television the writer is unaware of any single instance of an experimenter coming forward claiming successful results and inviting investigation. We will be better able to judge the fulfilment of the claims made when Baird receiving equipments become available, and one cannot but draw attention to the extraordinary position which exists under which the transmissions have come into being without even the standards of transmission being disclosed to the public or a single specimen instrument being procurable. Television receiving sets are to be available shortly, and, according to a statement by the Baird Company, one thousand instruments will be completed during the month of January, and whilst one must assume that machines already exist it has not been the good fortune of the writer to be favoured with an early specimen in order that its successful working might be endorsed. "Television is here" has so long been the cry that failure in its fulfilment is sufficient contradiction of its truth. It has long been hoped that in television the amateur will find a new field of experiment, and with the introduction of receiving equipments in the course of the next few weeks an opportunity will be afforded to judge its potentialities. In the meatime a statement from the B.B.C. as to the nature of the reception, which, one must assume, they are investigating, would be welcomed.

BOOKS RECEIVED.

Elements of Radio Communication, by J. H. Morecroft. A text-book for students giving the general principles of wireless telegraphy and telephony in a concise form and without the use of advanced mathematics, comprising the simple laws of the electric circuit; special laws for radio circuits; general idea of radio communication; the valve and its uses; telegraphy; telephony; and typical receiving sets. Pp. 269+x, with 170 illustrations and diagrams. Published by J. Wiley and Sons, Inc., New York, and Chapman and Hall, Ltd., London. Price 15s. net.

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The Fundamentals of Radio, by Prof. R. R. Ramsey, Ph.D. of Indiana University, U.S.A.

A text-book for students, comprising the general theory of electricity and the principles and practice of radio telegraphy and telephony. Pp. 372+xi, with numerous illustrations and diagrams.

Published by the Ramsey Publishing Co., Bloomington, Indiana, U.S.A., price $3.50.

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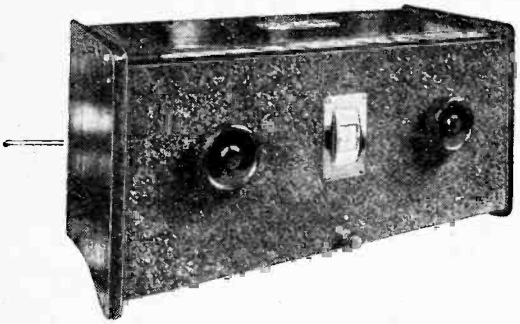
A.T.I. (Annuaire Téléphonique International).—The first edition of the International Telephone Directory in English, French and German. Containing the charges for long-distance telephone conversations between Continental towns and a list of 12.120 names, addresses and telephone numbers of manufacturers, hotels, traders, etc., in 1,485 towns of 27 different European countries. These are classified under their trades, but a further alphabetical index of their names is provided in which they are grouped according to their respective countries. The directory is published in Copenhagen, and the editors, while admitting that this first edition naturally falls far short of the objects they have in view, hope that its utility will be so universally recognised by firms doing foreign business that subsequent editions will become more and more complete. The sole agents for Great Britain are Messrs. Rassey Bros., 28, Basinghall Street, London, E.C.2.



KIT CONSTRUCTORS' NOTES

The New Osram Music Magnet.

THAT the basic essential features of the original Osram Music Magnet have been found suitable to be included in their entirety in this season's model must surely be a matter for justifiable self-congratulation on the part of those responsible for it. In a rapidly developing art such as ours, no better proof of excellence exists than that a design—particularly one of an ambitious and unconventional kind—should not only survive, but actually flourish, after the acid test of a year's trial.

It must be a pleasant task—it is certainly still a comparatively unusual one—for a wireless set designer to be relieved of the necessity for producing something entirely new, and to be able to concentrate all his energies on improving his original conception in detail. However carefully the job may have been done in the first place, experience nearly always shows minor crudities or imperfections to be smoothed away, and desirable additions to be made.

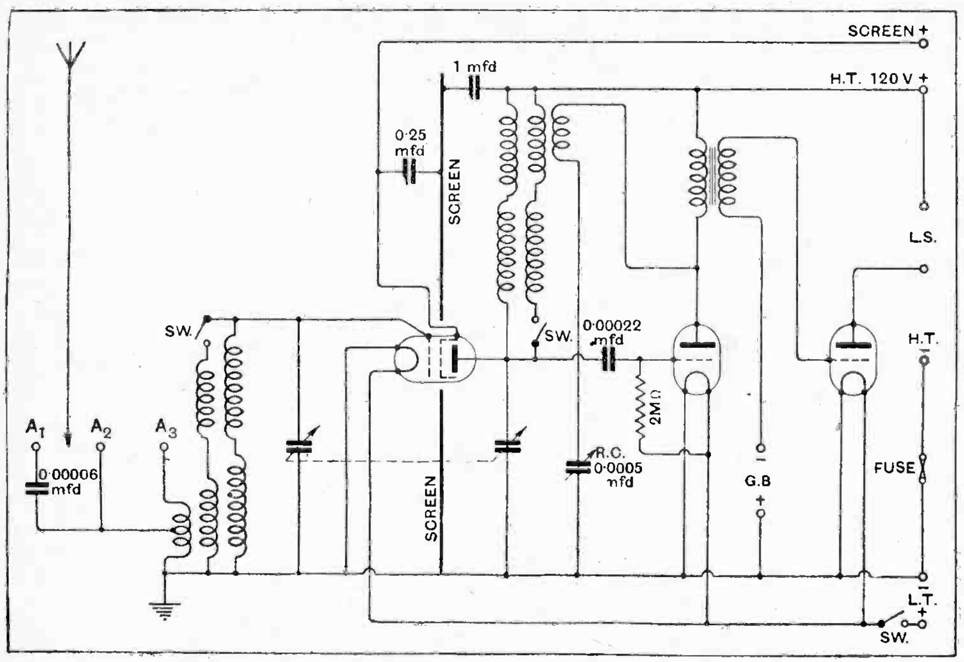
The set under review provides an example of what can be done when working on these lines. Although it is externally similar to its prototype, critical examination shows that hardly a single detail remains unchanged. Alterations are found in the arrangement of the filament wiring; originally, there was considerable risk of burning out valves by an accidental short-circuit, but, by connecting H.T. negative to L.T. negative and fitting an on-off switch (insulated from the metal panel) in the positive L.T. lead, the receiver is rendered as safe, and even fool-proof, as is possible. As an extra precaution, a safety fuse is inserted in the H.T. negative lead.

An improved mounting for the H.F. valve is provided; although it is still carried in a spring holder, a fairly rigid metal spring is used for making connection with the anode terminal.

The coil assemblies have been simplified, and now consist of two concentric formers, the inner carrying the medium-wave inductance and the outer the long-wave coil; there is also a third section which, as the coils are interchangeable in grid or anode circuits, functions as either "aperiodic" aerial or reaction winding. The coils have a very limited external field, as each of the tuned inductances comprise two windings in opposite direction. For working on the long waves, one section only is used, while for the medium band, both are placed in parallel by the action of built-in roller switches. One is apt to criticise the position of these switches on the score of inaccessibility—the lid of the box must be opened to change wavebands—but any other plan would introduce undesirable complications.

Complete ganging of the two tuned circuits is, of course, still a leading feature of the design, and an important innovation this year is the provision of direct wavelength calibration; indications are marked on the dial every 50 and 200 metres for the medium and long wavebands respectively. This is a most attractive and valuable feature.

It will be unnecessary to enumerate all the details in which the present set differs from the original, but mention should be made of the improved condenser friction drive, which operates well and is quite easy to set up, and of the



Circuit diagram, showing details of waveband switching.

Kit Constructors' Notes.—
fact that a good-looking polished oak cabinet, supplied in sections ready for easy assembly, is now included in the set of parts. The efficient L.F. transformer is of a new type, with high-permeability core.

The diagram given shows that the circuit is a fairly conventional arrangement of H.F. amplifier, detector, and one L.F. stage. Aerial coupling is through a double-wound transformer with three optional connections for varying selectivity. By joining the aerial to A_3, the complete primary winding is in circuit and signal strength is (almost invariably) at a maximum; greater selectivity but generally less sensitivity is afforded by changing to A_2; in this position the number of aerial coupling turns is reduced. The third terminal, A_1, is joined internally to the tapping point on the coupling coil through a very small condenser, and provides high selectivity with considerably weaker signals.

H.F. coupling is through a tuned anode arrangement, and the detector operates on the grid principle. For reaction control, a commendably large value of variable condenser is used, and it should be noted that the primary winding of the L.F. transformer is relied upon to deflect sufficient energy through the feed-back circuit, the usual choke being omitted.

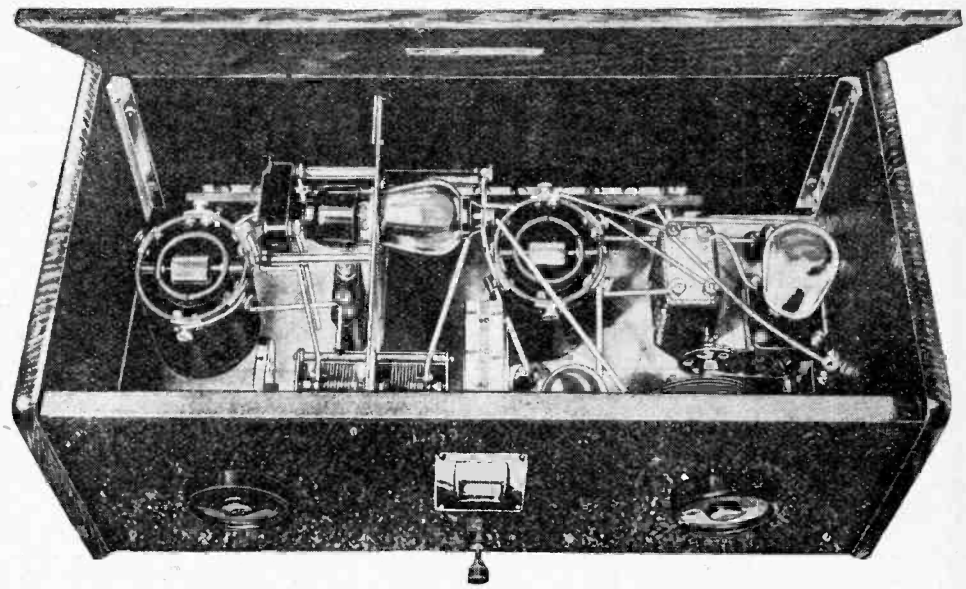
Assembly and wiring of the "kit" submitted for test took precisely 2 hours 55 minutes; this allowed sufficient time to make connections neatly and properly. Prospective constructors may be interested to know that it is wise implicitly to follow the sequence of operations as laid down in the instructional pamphlet, and that apparent short cuts may involve the risk of having to remove parts already assembled. In general, accessibility of the components is excellent, and all the holding down holes register accurately with their counterparts on the sheet aluminium chassis. Care should be taken to see that the lead between terminal No. 4 of the anode coil assembly and the reaction condenser is led well clear of the roller switch in such a way that it does not interfere with its operation. A small spanner is useful for tightening up the various nuts, particularly those on the terminals; the condenser spanner supplied might with advantage be made double ended so as to serve for this purpose.

Satisfactory Ganging.

One's initial impression that the design of the set is particularly well balanced is confirmed on testing it. The H.F. resistance of the coils seems to be just high enough to ensure entirely satisfactory operation of the single-knob tuning control and low enough to afford reasonable sensitivity; with regard to this latter quality, the set behaves every bit as well as many popular receivers with independent tuning condensers.

To obtain high selectivity it is necessary to make full use of the variable coupling provided by the three aerial terminals, and it would be more convenient if these were replaced by sockets. Over most of the tuning scale, there is naturally a considerable drop in volume as coupling is loosened, but this is not so marked when receiving the lower wavelengths on either band. Operated on an indifferent aerial in central London, Brookmans Park was just audible on the setting corresponding to the proposed twin station (261 metres) with the aerial connected to A_3 (least selective adjustment). This slight interference was entirely removed by applying reaction. There was very little spreading of local signals with the weaker coupling provided by connection to A_1 or A_2.

On the medium band, reaction control was found to be smooth, progressive, and almost free from overlap; on the longer waves it was not quite so good, but still satisfactory. Thanks largely to the new L.F. transformer, quality of reproduction is distinctly superior to that of the original model, and, with a super-power L.F. valve in place of the Osram P.215 normally supplied, a still greater undistorted output is obtainable—but, of course, at the expense of an increased H.T. consumption.



Interior view, showing dual astatic coils and positions of the more important components.

Two years ago it would have been considered almost impossible to produce an inexpensive 3-valve set with H.F. amplification, ganged tuning, and wavelength calibration, even under factory conditions, where tests can be applied at various stages of manufacture. It is something of an achievement to have devised means whereby these advantages can be offered to the home constructor in such a way that he is virtually assured of success, provided he applies reasonable care and common sense in assembly and wiring. The complete kit, including valves and cabinet, costs £9, and may fairly be considered as good value for money.

CURRENT TOPICS.

U.S. FOOTHOLD IN CANADIAN ETHER.

While Britain continues to dally with the project for an Empire broadcasting service, the United States has secured a new mouthpiece for national and commercial propaganda in Canada by the inclusion of station CKGW, Toronto, in the National Broadcasting Company's network. CKGW broadcast its first N.B.C. programme on the American Thanksgiving Day (November 28th), and will in future relay to Canadian listeners regular programmes from New York, Washington, and other cities of the United States.

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WORLD TALKS FROM THE VATICAN.

Work has now begun on the erection of the Papal wireless station in the Vatican City. The apparatus is being built by the Marconi Company.

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RAIN-MADE "STATIC."

During the rainy spell many listeners have imagined that atmospherics have been on the increase. In most cases it has been found that the supposed static has been due to faults in aerial insulation disclosed by the damp.

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FRANCO-TURKISH WIRELESS SERVICE.

A public radio service to Turkey has been opened by the French Post Office. Private and commercial telegrams marked "Voie T.S.F." are sent by this route at the ordinary rates.

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POLICE WIRELESS IN FRANCE.

A network of fifty-one police wireless stations distributed throughout France is provided for in the Budget of the Ministry of the Interior for 1930. The central transmitter will be the Eiffel Tower, says *The Daily Telegraph*, and the calls will be made at an hour's interval during a certain part of the day. Photographs and finger-prints will be included in the transmissions. The receiving stations will be specially equipped for short-wave reception, and their duties will include watching foreign transmissions and searching for illicit stations.

OUR CHRISTMAS-DAY ISSUE.

Special arrangements have been made whereby the issue of *The Wireless World* dated December 25th, will be on sale on Saturday, December 21st.

PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

Sir Ambrose Fleming, M.A., D.Sc., F.R.S., lecturing on "Television, Present and Future," will provide one of the attractions of the twentieth annual exhibition of the Physical and Optical Societies.

The exhibition is to be held on Tuesday, Wednesday, and Thursday, January 7th, 8th and 9th, 1930, at the Imperial College of Science, Imperial Institute Road, South Kensington, and will be open in the afternoon from 3 to 6, and in the evening from 7 to 10 p.m.

Over eighty firms have accepted the invitation to exhibit in the trade section at this exhibition, and in addition a group of research and experimental exhibits is being arranged, which will be shown by Fellows of the societies and others, and a number of research laboratories and other institutions. Some interesting historical exhibits will also be included.

Sir Ambrose Fleming's lecture will be given at 8 p.m. on January 9th.

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TREE RENT.

Listeners who have used trees in Enfield Town Park Estate, Middlesex, to support their aerials, are to pay a shilling a year to the Town Council as "rent."

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NEW YEAR "SMALL ADS."

Special holiday printing arrangements make it necessary to close for press earlier than usual with our issue of January 1st. Miscellaneous advertisements for inclusion in that issue should be in our hands not later than first post on Tuesday, December 24th.

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MAZDA VALVES.

In our issue of December 4th we drew attention to the special arrangement of the Edison Swan Electric Co., Ltd., whereby customers who were unable to obtain valves of the new Mazda series from their local dealers could be supplied direct on application to the company. Owing to the large response, the Edison Swan Electric Co., Ltd., regret that this offer must now be withdrawn. Every effort is being made to overtake the demand.

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"WIRELESS FOR THE BLIND" FUND.

With the object of providing every blind person in the United Kingdom and Northern Ireland with a wireless set a Fund has been established, with H.R.H. The Prince of Wales as President. Wholehearted support is being given by the B.B.C., and one of the first moves in the broadcast campaign will be a microphone appeal, to be made by the Rt. Hon. Winston Churchill, M.P., at 9.20 p.m. on Christmas Day from all B.B.C. stations.

It is estimated that 15,000 blind people throughout the country need sets.

All donations to this Fund should be sent to the Rt. Hon. Reginald McKenna, Hon. Treasurer, British "Wireless for the Blind" Fund, 226, Great Portland Street, London, W.1.

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MAN'S INGRATITUDE TO MAN.

That broadcasting for love is a thankless task is the discovery of the Radio Club of Burma, which has received numerous complaints from Rangoon that its programmes do not come up to the expected standard. More in sorrow than in anger, the president of the club is asking the Government to erect a powerful station which can be heard all over the province. The Radio Club's transmitter has a power of only 750 watts, and funds are scarce owing to the fact that the club, unlike the broadcasting companies, draws no revenue from the wireless import duties.

FOR THE WORLD'S FASTEST LIFEBOAT.—The totally enclosed wireless telephony transmitter and receiver installed by the Marconi Company in the new Dover lifeboat, the fastest in existence. Known as the type XMB.1., the set uses a transmitting power of 100 watts on a wavelength of 900 metres, and is designed for work under the roughest conditions. The lifeboat is specially equipped for aircraft rescue work,

HOW WE HEAR

The Ear Corrects certain Loud Speaker Defects and Acts as an Amplifier, Rectifier and Frequency Analyser.

By R. T. BEATTY, M.A., B.E., D.Sc.

(*Continued from page 652 of previous issue.*)

PHYSIOLOGISTS find that both motor nerves (those which transmit orders *from* the brain) and sensory nerves (those which transmit messages *to* the brain) behave exactly alike. Messages pass along both kinds of nerve at an average speed of 100 metres per second, or 220 miles per hour—a rate which is too slow to be of an electrical nature and which is ascribed to chemical action; this action is, however, accompanied by an electrical effect, which can be amplified and recorded by a string galvanometer. These records reveal a most curious result; the amplitude of the disturbance is always the same (Fig. 9). The only difference between the effects of a strong or a weak stimulus applied to the nerve is that in the former case more pulses are produced in the nerve per second than in the latter. Further, it is found that the passage of a pulse leaves the nerve in a refractory condition for about 0.003 second, during which time no further pulse can pass, so that the nerve can transmit no more than 300 pulses per second. If the nerve passes through a ganglion (a swelling on the nerve which acts as an amplifier of the pulse) the number is still further reduced.

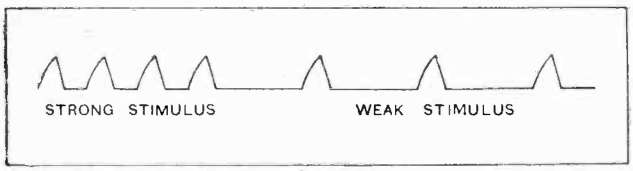

Fig. 9.—A strong or weak stimulus is conveyed by a nerve as a variation in the frequency of the impulses. The amplitude of the disturbance is always the same.

Here, then, a fatal objection arises to the telephone theory: how can a nerve convey the sensation of a note of 20,000 cycles per second when it can transmit but a few hundred pulses per second?

How Our Ears Deceive Us.

When the tuned strings in our ears respond to the throb and pulse of sounds which reach them they may play strange tricks at times: they may actually generate tones, phantom tones, which do not exist save in the ear itself: out of two sounds they may create a third; out of a single sound they may create a multitude.

When a tuning fork gives out its single pure tone we should expect the strings of the basilar membrane to vibrate most strongly near the resonance point, with neighbouring strings affected in rather smaller measure.

The Ear Makes Its Own Overtones.

If in addition we sound a feebler note of different pitch it may be drowned by the louder tone unless its strength is sufficient to cause a subsidiary peak on the main resonance curve (Fig. 13). This drowning, or *masking*, effect might be expected to be greater when the two notes are close together than when they are far apart. Fig. 14 shows results on masking obtained by Fletcher in 1923. He measured the strength of a just audible tone when sounding alone; then he ascertained how many times that strength required to be multiplied for audibility in presence of a second stronger tone. In curve A, Fig. 14, a tone of 800 cycles/sec. was sounded continuously. The ordinates give the multiplying factor required to make any weaker tone audible: the factor is seen to be symmetrical on either side of 800 cycles/sec. with a kink at the maximum due to complications arising from beats when the tones are nearly equal in pitch, and we may conclude that the ear strings vibrate symmetrically on either side of the resonance point as imagined in Fig. 12. But the story changes when the continuous tone is made 4 times as strong (as in curve B), or 8 times as in C. The curve becomes unsymmetrical, the masking is greater on the

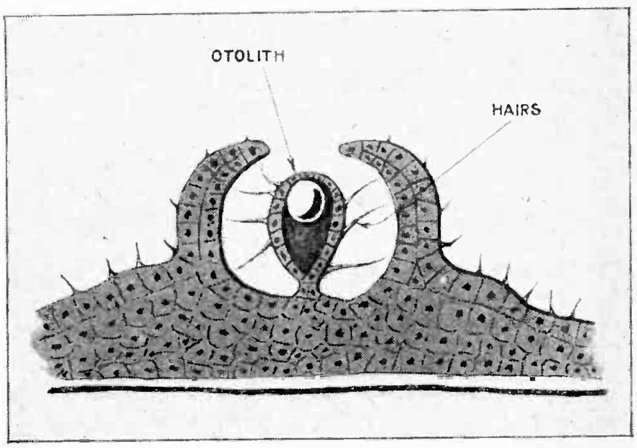

Fig. 10.—While a fish has no powers of hearing, it is equipped with a device that detects violent vibration. It takes the form of a tiny stone which is carried in a sensitive cavity.

How We Hear.—

high frequency side, and new kinks show the presence of *overtones*, which are harmonics of the 800-cycle note, as is evident since their relative frequencies are as 2, 3, 4, etc.

The Ear is an Unsymmetrical Receiver.

How come these overtones? It is idle to say that they arise in our consciousness or that they are figments of the brain incapable of analysis: science has taught us little if we cannot better such explanations.

A hint is given by the behaviour of vibrating bodies when the amplitude is so large that the strain exceeds the elastic limit or when the load is unsymmetrical, as when a diaphragm is loaded with a wax pellet on one side. Theory shows and experiment agrees that in such cases overtones will appear and will become relatively stronger as the amplitude is increased. Now many unsymmetrical structures occur in the ear: for example, in the arrangement of the muscles which bear on the ear drum, in the ear bones, and in the structures connected to the strings themselves. Hence we have good reason to expect the overtones which Fig. 14 shows to be present. *The ear has the faults of the early microphones used in broadcasting or of a badly designed loud speaker.*

Difference Tones.

But theory goes farther and predicts that when *two* pure tones excite an unsymmetrical receiver a *third* tone will be generated with a frequency equal to the difference between the first two. When the middle C of a piano and the G above, whose frequencies are as 2 : 3,

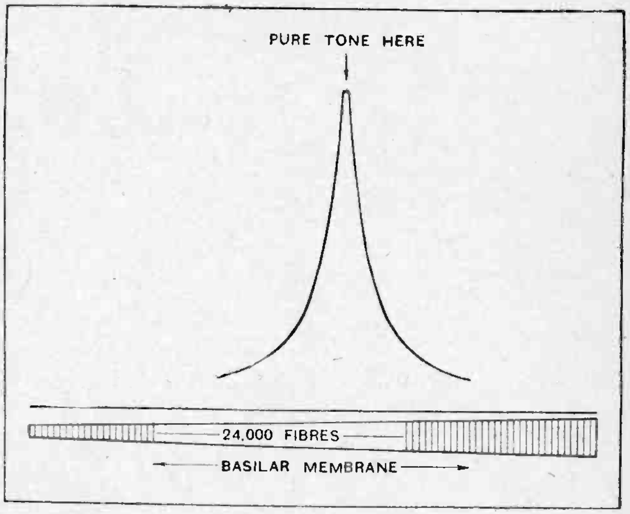

Fig. 12.—Hypothetical amplitude of vibration of the ear strings when a pure tone is sounded.

are sounded together, using the loud pedal, the C an octave below, whose relative frequency is 1, will be heard. We cannot say, however, that this tone is generated only in the ear, for on opening up the piano it will be found that a lower C string is vibrating strongly: the difference tone has been produced by the unsymmetrical frame of the piano. But when the experiment is repeated with tuning forks placed on separate tables with no connection save air, the same difference tone is heard and can be made to give beats with a third fork of nearly the pitch of the difference tone. This tone cannot be picked up by a resonator and so has no existence outside the ear.

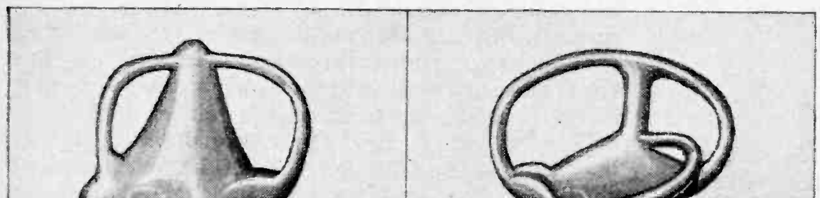

Fig. 11.—The evolution of the cochlea from fish to mammal. A, fish, no cochlea; B, frog, a slight swelling on the right indicates the beginning of the cochlea. C, bird, slightly curved cochlea; D, mammal, spiral cochlea with several turns.

Fundamental Tone Suppressed—No Change in Pitch.

When a vowel is sung, and a record taken on an oscillograph and analysed, the constituents of the complex sound are as shown in Fig. 16: the vowel can be faithfully reproduced by using a series of valve oscillators and loud speakers, one for each partial tone. Now comes a truly remarkable result: if the fundamental tone be suppressed the vowel will sound exactly the same: if in addition the first overtone be silenced the *pitch* on which the vowel is sung will seem unaltered though a very slight change of *quality* will appear, as if the same note had been taken up by a different voice. With

How We Hear.—
so many overtones present the ear has manufactured the difference tone corresponding to the fundamental with an intensity so great that the presence or absence of that tone in the air makes practically no change, the same being true to a smaller extent of the first overtone.

Does the Loud Speaker Cut-off Matter?

Those who use loud speakers which fail to reproduce below 250 cycles/sec. must have been astonished to hear bass voices, cellos, and bass viols coming through almost unimpaired. The reason is now evident: the low notes, though lost in reception, have been re-created in the ear. We must not conclude that the fundamental tone of *any* sound will reappear, for if the overtones are not harmonic, the difference tone will not coincide with the fundamental: thus drums, cymbals, and xylophones sound unnatural when the lower tones are cut off.

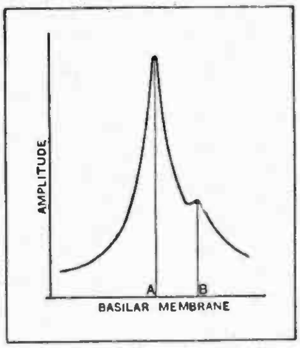

Fig. 13.—A second tone at B is audible if it causes an extra peak on the main resonance curve due to a tone at A.

The Ear is a Rectifier.

The author well remembers how difficult it was fifteen years ago to get the theory of difference tones across the lecture table to second-year students. To-day it is only necessary to give the analogy of the anode bend rectifier and the explanation becomes clear and unforgettable.

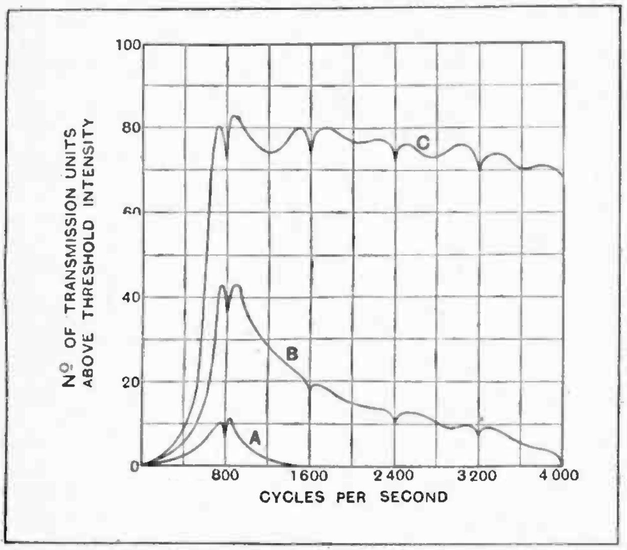

Fig. 14.—Masking of one tone by another: the ear introduces overtones when a note is loud.

For the anode bend rectifier is an unsymmetrical structure. Though the grid voltage may swing up and down by equal amounts the anode current will show unequal changes. When two carrier waves act on the rectifier a heterodyne note (difference tone) is produced: without the rectifier the compound note could only be resolved into its two H.F. constituents and no difference tone would appear. As the carrier waves are made stronger the heterodyne note becomes *relatively* stronger.

The ear gives precisely these results, and the analogy is made closer by the experimental fact that when two notes above the audible range are produced by two bird calls an audible difference tone can be heard, as was shown many years ago by Lord Rayleigh.

Do Beats Merge into a Difference Tone?

Beats are the periodic waxing and waning of sound heard when two pure tones of nearly the same pitch are produced. If the pitch of the higher tone be gradually raised the beats become more rapid and finally pass into a new tone—the difference tone. Whether the beats and the new tone are identical has been a controversial question for fifty years, but on the resonator theory of the ear's action we should say that they are entirely different. Our explanation would be that when, as in Fig. 18, the two tones are close together, the two resonating strings suffer fluctuations of amplitude twenty times per second and that the corresponding nerves carry to the brain information that each string is vibrating with a varying amplitude: at the same time a vibration of twenty cycles per second is produced, but is inaudible because no ear string is tuned to such a low frequency. On raising the pitch of the upper note to 2,100 c.p.s. beats are still heard, but the difference tone of 100 c.p.s. is now picked up by a string and becomes audible as a *tone*: if this string were absent we should hear the beats but not the tone; if the two upper strings were absent we should hear the difference tone but not the beats. Finally if the upper note is raised to 2,500 c.p.s. the beats are so rapid that the nerves cannot convey news of the fluctuations: the beats disappear and the difference tone of 500 c.p.s. is heard alone.


Fig. 15.—Overtones generated in the ear as the bass C is sounded more and more loudly. The sizes of the notes indicate roughly their intensity.

The Sense of Direction.

Familiar sounds like voices, footsteps, or the barking of dogs, can be located without effort: it is easy to say whether they come from front or rear, from right or left. In trying to account for this sense we naturally enquire what happens in the simpler case when the sounds are pure tones such as those produced by a tuning fork.

Suppose a tuning-fork sounding in the middle of a large meadow on a dark night. It is found that if one ear is stopped up an observer has no idea of the position of the fork: if he uses both ears he can easily tell when the fork is on his right or on his left, but he is unable to distinguish a fork in front from one in rear.

How We Hear.—Thus we have a clue to the cause of our sense of direction. Sound waves from the fork are diffracted by the head and reach one ear in advance of the other, and so differences of phase and intensity are set up. If the direction of the waves makes an angle A with the fore and aft line of the head we can calculate the phase difference P between the waves arriving at the two ears; in Fig. 19 this relation is shown for tones of different frequencies; thus when we face north and a tone of frequency 310 c.p.s. comes from the north-east the phase will lead by 65° at the right ear.

An Experiment with Headphones.

Now we can try the following experiment: Two telephone magnets are set up, as in Fig. 20, with wires leading from their coils to two ear-phones, and a toothed iron wheel rotates rapidly as shown. A phase difference will be set up between the alternating currents which circulate in the two coils and consequently in the ear-phones; if the phase difference is zero the sound seems to come from a point in front, but if the current leads in the right ear-phone the apparent source is displaced to the right through an angle which agrees with that given in Fig. 19. This is a striking confirmation of the theory and so we conclude that the string affected in the right ear leads its opposite number in the left ear in phase, that this lead is preserved in the pulses set up in the pair of corresponding nerve fibres, and that the brain translates this lead into a judgment that the sound is coming from a point to the right of the line of sight.

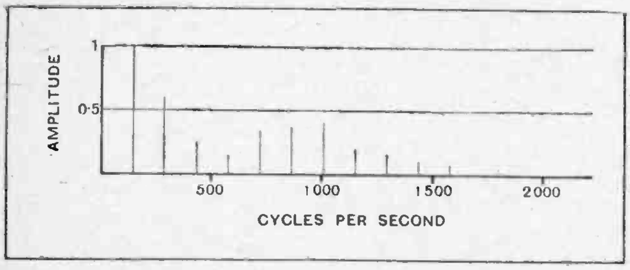

Fig. 16.—Showing the vowel "ah" sung on d.

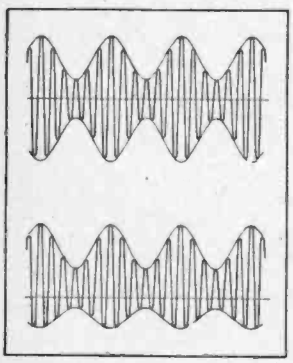

Fig. 17.—Any unsymmetrical receiver will produce partial rectification of a wave: the unsymmetrical structure of the ear must cause a similar effect.

So much for relative phase, but what about the relative intensity at the ears? Experiment shows that relative intensity is comparatively ineffective in helping to form a judgment as to direction. This result leads us into difficulties, for a strong stimulus causes more pulses to travel per second along a nerve, and if the pulse frequencies are unequal in two corresponding nerves no permanent phase difference can be set up.

How, then, do we keep a sense of direction? No doubt the physiologists will eventually supply the answer, but in the meantime we may hazard the guess that the nerve pulses are not continuous but form intermittent trains, the leading pair of pulses in each train maintaining a constant phase difference; thus the required lead would exist at the beginning of each train, though it would rapidly disappear after a few pulses have passed (Fig. 21).

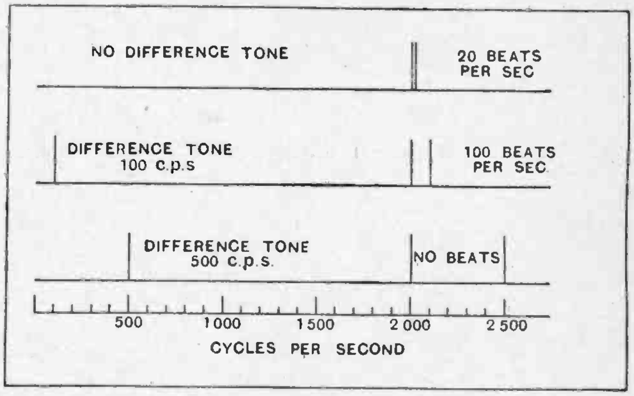

Fig. 18.—How beats merge into a difference tone.

Multiple Images.

For sounds of high frequency the sound may appear to be in two or more positions at the same time. Thus at 930 c.p.s. let the phase be made to lead by 150° at the right ear; this is the same thing as if the phase were to lead by 360° − 150° = 210° at the left ear. From Fig. 19 we see from the curve corresponding to 930 c.p.s. that phase differences of 150° and 210° corre-

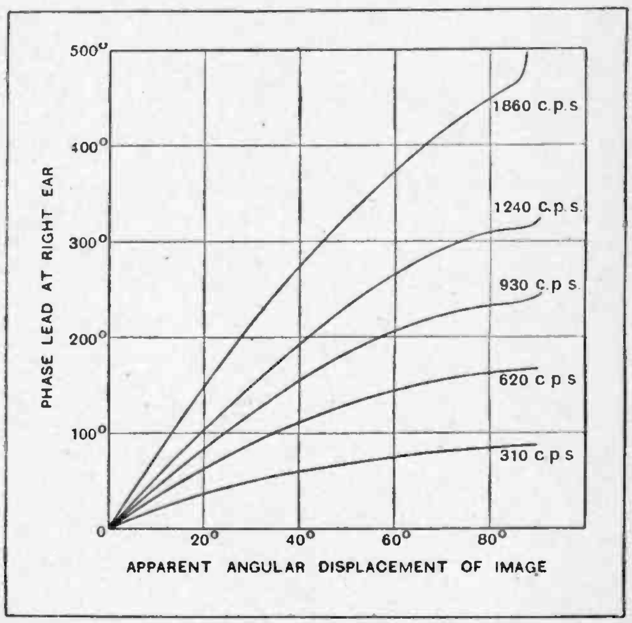

Fig. 19.—The sense of direction of sound depends upon a phase difference between the waves arriving at the two ears. This illustration shows such phase difference for tones of different frequencies.

How We Hear.—

spond to apparent displacements of the image of 39° to the right and 62° to the left. Obviously the location of the sound is going to be made much more difficult if it seems to come from more than one point, and most observers find that their judgment breaks down for frequencies higher than 1,000 c.p.s.; the chirp of a cricket, for example, seems to come from all directions at once.

The Evolution of Hearing.

We believe that all living beings may trace their descent from the life which began in the warm seas of some thousand million years ago. The fishes of to-day inherit an unbroken tradition of environment over this vast reach of time. What have we discovered about the hearing powers of fishes?

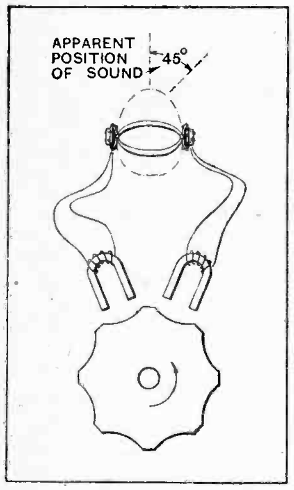

Fig. 20.—This experiment with earphones strikingly confirms the contention that sense of direction depends upon phase difference.

Well, with one or two exceptions, fish seem quite unable to hear. They are indifferent to sounds from a submerged buzzer, loud speaker, or submarine bell. A slight response is shown to violent shocks due to striking the wooden end of a small aquarium by a heavy hammer; this response has been traced to a structure in the head of the fish (shown in Fig. 10) composed of a tiny stone enclosed in a sac which is furnished with hairs. Vibration causes the stone to quiver, and the hairs, striking the sides of the cavity, bend and initiate messages along the nerves attached to them.

The chief purpose of such stones (or otoliths) is to give the direction of gravity, and so enable the fish to swim on an even keel. A certain species of prawn carries its otoliths, not in the head, but in an open cavity in the joint of its antenna, and when the stones drop out the prawn replaces them with grains of sand which it picks up with its forceps. When the prawn was put in an aquarium where iron filings had been placed, it soon became equipped with these magnetic otoliths, and when a magnet was brought near it changed its position as if it mistook the pull of the magnet for the pull of gravity.

As fish emerged from the silent ocean in which their deafness was no handicap, they found new enemies on land, but these were not the noiseless, darting hunters of the deep—their approach was always heralded by sounds, by footsteps, by rustle of reeds or trembling of twigs.

And so the emigrants from the sea began to develop a new sense; the full story is not yet known, but it appears that in amphibia and reptiles like the alligator which never quite forsook the water, and in birds which made the air their own, a tube (Fig. 11) has grown out from the original labyrinth, curved like a sickle, furnished with parallel fibres; in animals which have chosen the dry land this tube has developed into the spiral cochlea, and reaches its highest development among the carnivores and the deer-like tribes, the hunters and the hunted, for whom delicate hearing is a supreme necessity in the daily struggle for existence.

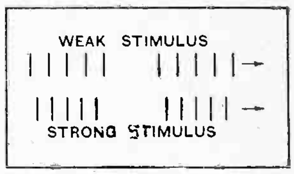

Fig. 21.—Nerve pulses may possibly not be continuous but may take a form of intermittent trains. The leading pair of pulses in each train may maintain a constant phase difference.

CLUB NEWS.

All About Metal Rectifiers.

Mr. S. A. Stevens, of the Technical Department of the Westinghouse Brake and Saxby Signal Co., Ltd., visited the Bec Radio Society on Tuesday, 19th November, lecturing on "Metal Rectifiers" with the aid of an extensive range of lantern slides and the explanatory film which his company have produced.

The lecturer made it clear that the metal rectifier is virtually a cold electronic valve, and an enlarged drawing was shown on the screen giving the manner of assembly of such a unit.

A detailed explanation of the meaning of half-wave and full-wave rectification followed, and an instructive collection of slides included diagrams showing the "centre-tap," "bridge," and "voltage-doubler" methods of obtaining full wave rectification.

The outstanding event of the lecture was the display of the company's film, in which one saw upon the screen living pictures of the performance of alternating and direct currents.

Hon. Secretary, Mr. A. L. Odell, 171, Tranmere Road, S.W.18.

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A Modern Receiver.

An interesting set embodying an indirectly heated A.C. screened grid valve with a magnification factor of 1,200 was demonstrated by Mr. Remington at the last meeting of the South Croydon and District Radio Society. The H.F. amplifier was followed by an anode bend detector, and the last low frequency stage embodied two L.S.5a valves in parallel. The set was operated from the mains. The design was made clear by means of diagrams on the blackboard, members being given full details of the transformers, the design of the moving coil loud speaker, and the wiring arrangements.

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

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New Club's Success.

The recently formed Sevenoaks and District Radio Club is already proving its value to wireless enthusiasts in the district. At the last meeting a powerful set constructed by one of the members was demonstrated. Interesting tests have also been carried out with a radio-gramophone. New members and visitors are cordially invited. Full particulars of the club can be obtained from the Hon. Secretary, Mr E. M. Dent, Cornwall Lodge, Dunton Green, Kent.

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Demonstrating Transmission.

The Muswell Hill and District Radio Society has among its membership no fewer than seven "hams," one of whom, Mr. J. Hum, G5UM, demonstrated his 171-metre transmitter before that Society on December 4th. In order to avoid interfering with broadcast listeners no radiating system was used, but the transmitter was put in an oscillating condition and the wave picked up on a receiver placed on an adjacent table. The lecturer dealt briefly with the principles of crystal control, power supply, and various types of transmitting valve, and then proceeded to show, with the help of the transmitter, the advantages of using crystal control from the point of view of steadiness of wave and purity of note.

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

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Soldering Aluminium.

The soldering of aluminium has always been a *bête noir* to the amateur, but two enthusiasts, Messrs. Hart and Perry, recently demonstrated to members of Wembley Wireless Society that the task can be robbed of its terrors. They also demonstrated brazing, silvering, and ordinary soldering. The Society is at present holding an interesting exhibition of historical wireless apparatus, and the Committee invites members to contribute with any gear which they may believe to have an antique value. The first half of the winter session was concluded on Friday last and meetings will be resumed early in January. An attractive list of fixtures has been arranged. A syllabus of meetings will be forwarded on application to the Hon. Secretary, Mr. H. Comben, 24, Park Lane, Wembley.

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Lecturettes by Club Members.

Several items of unusual interest appear in the forthcoming programme of the Wigan and District Technical College Radio Society, which will resume meetings on January 14th.

An interesting feature includes lecturettes and demonstrations by members themselves.

Hon. Secretary, Mr. M. M. Das, B.Sc., Library Street, Wigan.

LABORATORY TESTS.

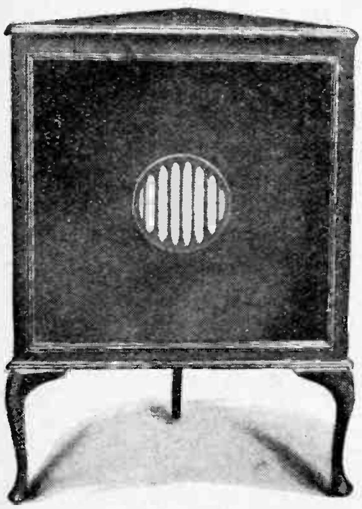
A Review of Manufacturers' Recent Products.

LOUD SPEAKER BAFFLE BOARD.

To obtain the maximum acoustic output from a cone-type loud speaker it is necessary to prevent circulation of the sound waves from the front to the back of the cone. The neutralising effect due to this cause is more devastating on the very low notes than on the higher frequencies. A large baffle board, some 3ft. square, helps to overcome the harmful effect, but, unless well finished, it is rather an eyesore, especially in a drawing room.

Recently the Morogoro Trading Corporation, Ltd., 7, Union Court, Old Broad Street, London, E.C.2, has placed on the market a handsomely finished baffle measuring 30in. × 30in., and mounted on three ornamental legs. The three-cornered design permits standing the baffle crosswise in a corner of the room.

An 8in. diameter opening is provided in the centre of the board, behind which will be mounted the diaphragm and movement. A supporting platform must be made up, but as the nature of this will depend on the chassis used, whether moving-coil or reed-type, the makers have left this to the constructor.



Morogoro three-cornered baffle board for cone loud speaker construction.

The price of the baffle in polished mahogany is 42s., and in oak 38s.

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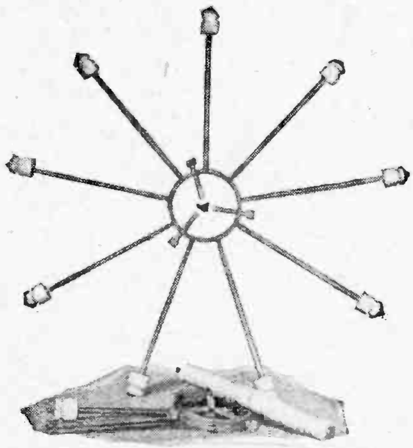
"ASHTON" AERIAL SPREADER. NEW MODEL.

Where facilities are not available for the erection of a suitable sized outdoor aerial of the orthodox pattern, satisfactory reception can be had by using a vertical wire with a cage-type collector at the top. The construction of this alternative device is rendered simple by the new model "Ashton Perfect Aerial Spreader." This consists of two spider-type supports, which are attached to a pole, or iron tube, and spaced about 3ft. apart. They are clamped to the pole by three screwed studs carried on the ring boss of each spider. On the end of each arm is a small porcelain bobbin. The wire is wound in zig-zag fashion, commencing from a top bobbin and finishing at one of the lower ones.

To assure that the device will not sustain damage in the post it is supplied in the form of a set of parts which can be assembled in about fifteen minutes.

The makers are Messrs. Harold Ashton, 8 and 10, Bull's Head Chambers, Hopwood Avenue, Market Place, Manchester, and the price has been fixed at 15s.



One of the spiders, assembled, for the "Ashton Perfect Aerial Spreader"; note the parts for the other.

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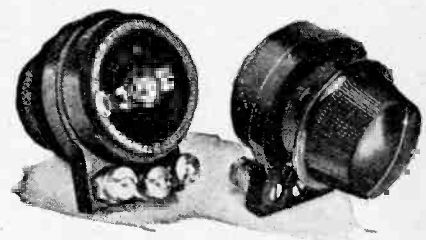
ROTOROHMS.

A wide range of variable high resistances and potentiometers are included in the list of Rotorohms marketed by Rotor Electric, Ltd., 2-3, Upper Rathbone Place, London, W.1. These components, admirably suited for use as volume controls, are available with resistance values ranging from 0 to 2,000 ohms up to 0.1 to 7 megohms. There are eleven models in all, the price being 6s. 6d. for the potentiometer and 5s. 9d. for the variable resistance.

Two specimens were tested, the type H, maximum resistance 25,000 ohms, and the type L, a 500,000 ohms potentiometer. The measured resistance of the first-mentioned model was 36,000 ohms. A graded resistance is adopted, the value changing slowly at first when the knob is rotated in an anti-clockwise direction, but later showing a more rapid rate of change for the same angular movement. This feature is exhibited in the other model. In this case the maximum resistance was found to be 750,000 ohms.

For control of volume, using a potentiometer in the input circuit of a valve, it is desirable that the resistance should change more rapidly at first and those that follow the logarithmic law generally prove most successful. It would appear that Rotorohms have been designed to



The resistance in Rotorohms is protected by a wire-wound track over which the variable contact rides.

meet these conditions, so that, used for this purpose, they should prove uniform in action.

TRADE NOTES.

The Loewe Radio Co., Ltd., 4, Fountayne Road, Tottenham, London, N.15, announce that their products can now be obtained on the hire-purchase system.

Full particulars of the scheme will be provided on application to the company.

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Lisenin Wireless Co., 5, Central Buildings, High Street, Slough, Bucks.—Descriptive folder dealing with H.T. and L.T. connectors. Insulated plugs and sockets for use in mains-operated sets are listed also.

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Messrs. Ferranti, Ltd., Hollinwood, Lancs.—Descriptive leaflet Wb 419, dealing with the Ferranti Model 31 A.C. mains receiver.

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In the Buyers' Guide 1929-30 list of receiving sets published in our issue of November 20th last, the price of the "Empire 3" receiver made by Messrs. C. F. and H. Burton was stated to include valves and royalties. This is, unfortunately, incorrect; valves and royalties are not included in the prices stated for the two models.

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On page 565 of the same issue the price of the Philips set, Model 2502, should read £12 10s., and not £15, as stated.

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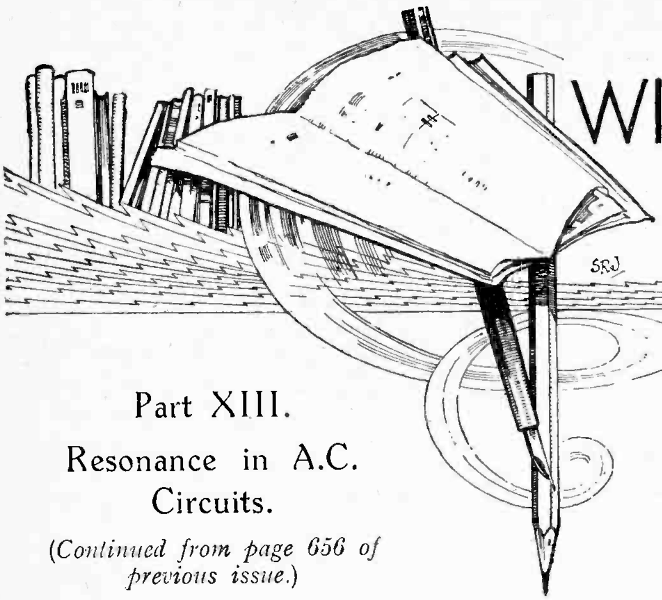
We learn that in some quarters the impression prevails that the "Ekco" Model C.2A. A.C. complete battery eliminator, described on page 537 in our issue of November 13th last, is made for alternating current supplies only. This is, of course, incorrect, as a D.C. unit, also styled Model C.2A., is available for use on D.C. mains. This particular unit was reviewed on page 81 under "Laboratory Tests" in our issue of July 24th last.



WIRELESS THEORY SIMPLIFIED

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

Part XIII.

Resonance in A.C. Circuits.

(Continued from page 656 of previous issue.)

At the end of the previous instalment the impedance was obtained for a simple circuit with resistance inductance and capacity in series. The value of this impedance was found to be $\sqrt{R^2+X^2}$ ohms, where R is the resistance of the circuit and X the resultant reactance, at a frequency f cycles per second, due to the combined effects of inductance and capacity. The value of X itself was found to be $\left(2\pi fL-\frac{1}{2\pi fC}\right)$ ohms, where L is the inductance in henrys and C the capacity in farads. $2\pi fL$ is the inductive reactance and $\frac{1}{2\pi fC}$ the condensive reactance.

Since the resultant reactance X is equal to the *difference* between the inductive and condensive reactances, it is clear that the last two partially neutralise each other if they are unequal, and one will completely neutralise the other if they are equal. When this happens the impedance of the circuit becomes

$$Z=\sqrt{R^2+0}=R \text{ ohms.}$$

That is to say, when $2\pi fL=\frac{1}{2\pi fC}$, the circuit behaves as though it were a non-inductive resistance as far as the relationship between current and voltage is concerned, but in some other respects its behaviour is phenomenal.

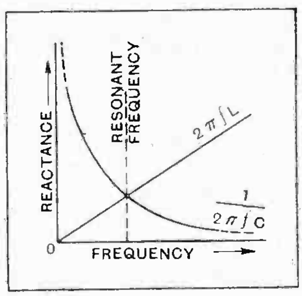


Fig. 1.—Curves showing how the inductive reactance and the condensive reactance vary simultaneously in a series circuit as the frequency is changed.

The value R ohms is obviously the lowest possible value of impedance the circuit can have, because no matter whether the resultant reactance X is positive or negative, the square of this quantity is always positive and therefore always goes to increase the impedance above the value R, or, in other words, the impedance of the circuit can never be less than R ohms.

Frequency of Resonance.

Now since the inductive reactance $2\pi fL$ is proportional to the frequency and the condensive reactance, $\frac{1}{2\pi fC}$ is inversely proportional to the frequency, it follows that at very low frequencies the condensive reactance will be greater than the inductive reactance, whereas at very high frequencies the inductive reactance will be the greater. Clearly, then, there must be one particular frequency for which the reactances will be equal and opposite. This is called the *resonant frequency* of the circuit, and at this frequency the circuit is said to be in complete resonance with the applied frequency. Although the resonant frequency is sometimes called the "natural frequency" of the circuit, this is not strictly correct—a point to be discussed later.

In Fig. 1 the reactance of the coil and that of the condenser are plotted as curves against frequency, ranging upwards from zero. At the point where the curves cross each other the reactances are equal, and this point gives us the value of the resonant frequency. It must be remembered that the condensive reactance is negative with respect to the inductive reactance and, therefore, at the point where the curves cross, the resultant reactance is zero. By finding the difference between the two curves at a number of frequency values we can obtain the curve of resultant reactance against frequency.

Value of the Resonant Frequency.

For the condition of complete resonance we have $2\pi fL=\frac{1}{2\pi fC}$, where f is the resonant frequency, and from this we derive the fundamentally important expression

$$f=\frac{1}{2\pi\sqrt{LC}} \text{ cycles per second}$$

for calculating the resonant frequency, L and C being in henrys and farads respectively.

In tuning a wireless circuit to a given frequency we are simply adjusting the condensive reactance to neutralise completely the reactance of the tuning coil.

Now we must see what is actually happening in a series circuit when a voltage having a frequency equal to the resonant frequency is applied to its ends. The circuit is shown in Fig. 2 (a), and the condition for resonance is that the reactance of the condenser is exactly equal to that of the inductance. Therefore the voltage E_2 re-

Wireless Theory Simplified.—

quired to drive the current against the back E.M.F. of the coil is equal to the voltage E_3 required to drive it "through" the condenser. But since E_2 was seen to lead the current by 90° and E_3 to lag by 90° the two voltages in question are always in direct opposition and so cancel each other out between the ends of the circuit. The complete vector diagram for the condition of resonance is shown in Fig. 2 (b).

Now as the two reactance voltages balance out completely it follows that the applied voltage E between the ends of the circuit is only employed in driving the current through the resistance portion of the circuit. Hence the applied voltage is simply $E = E_1 = IR$. This is in agreement with the previous discovery that the impedance of

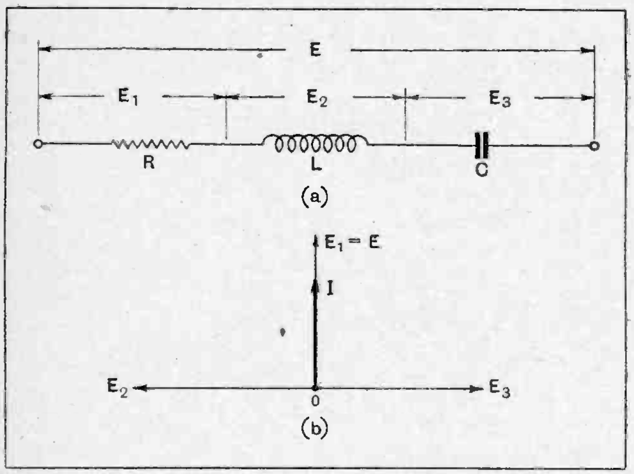


Fig. 2.—When a series circuit is tuned to complete resonance the inductive reactance is wholly neutralised by the condensive reactance. The voltages E_2 and E_3 are equal and opposite, and balance out.

the complete circuit is R ohms at the frequency of resonance. The vector diagram indicates the equally important fact that at this particular frequency the *applied voltage and current are exactly in phase.*

It would seem then that we are driving the current through the two reactances of the circuit in series without the aid of any E.M.F. from the external source. The secret lies in the fact that once the alternating current has been started and has reached a steady R.M.S. value, neither the inductance nor the condenser absorb any power from the source of supply. When the current is falling from one of its maximum values to zero the voltage across the condenser is building up from zero to a maximum and therefore during this time the whole of the stored energy coming from the collapsing magnetic field is being transferred to the condenser and *vice versa*. Hence the stored energy in the circuit is merely oscillating backwards and forwards between the condenser and the coil and no call is made upon the source of supply for assistance. A mechanical analogy for resonance in an A.C. circuit will be given in dealing with the parallel circuit as it can be more simply applied in that case.

Calculation of an Actual Circuit.

As it is very important to know how a resonant circuit behaves not only at the resonant frequency itself but also at neighbouring frequencies, it will be best to consider an actual circuit and calculate the numerical values of impedance and current over a band of frequencies ranging from well below the resonant frequency to well above it, and then to plot the results as curves.

Accordingly let us suppose that we have a coil whose inductance is 2532 microhenrys, that is 2532×10^{-6} henry, in series with a condenser of capacity 0.00025 microfarad. Let the resistance of the coil be 500 ohms. It was pointed out in a previous part that a coil possessing both resistance and inductance is equivalent to a series circuit with resistance and inductance separated. This high value of resistance is chosen to simplify the calculation and the effects of varying the resistance will be discussed afterwards.

The resonant frequency of the circuit will be

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{2532 \times 10^{-6} \times 0.00025 \times 10^{-6}}} = 200{,}000$$

cycles per second or 200 kilocycles per second, and at this frequency the impedance of the circuit will be numerically equal to its resistance, namely 500 ohms, because the reactances balance out.

Now let us calculate the impedance at a frequency just double that of the resonant value, that is, at 400 kilocycles. At this frequency the reactance of the coil will be $X_L = 2\pi f L = 2\pi \times 400{,}000 \times 2532 \times 10^{-6} = 6364$ ohms. The reactance of the condenser is

$$X_c = \frac{1}{2\pi f C} = \frac{10^6}{2\pi \times 400{,}000 \times 0.00025} = 1591 \text{ ohms.}$$

Thus the total reactance of the circuit at 400 kilocycles per second will be $X = X_L - X_c = 6364 - 1591 = 4773$ ohms, and the impedance is therefore

$$Z = \sqrt{R^2 + X^2} = \sqrt{500^2 + 4773^2} = 4803 \text{ ohms.}$$

If we choose a frequency below the resonant value, say 120 kilocycles per second, we find that the condensive reactance is greater than the inductive reactance, so that we get a negative value for the resultant reactance X. It works out to -3394 ohms and the impedance is therefore

$$Z = \sqrt{500^2 + (-3394)^2} = \sqrt{500^2 + 3394^2} = 3432 \text{ ohms.}$$

The impedance is always positive by its very nature.

Frequency-Kilocycles per sec.	$X_L = 2\pi fL$	$X_c = \frac{1}{2\pi fC}$	$X = (X_L - X_c)$	$Z = \sqrt{R^2 + X^2}$	Current = E/Z
0	0	∞	∞	∞	0
20	318	31,820	−31,502	31,510	0.317 mA.
40	636	15,910	−15,274	15,284	0.650
80	1,273	7,955	− 6,682	6,692	1.49
120	1,909	5,303	− 3,394	3,432	2.92
160	2,550	3,978	− 1,428	1,512	6.62
200	3,182	3,182	0	500	20.00
240	3,818	2,651	+ 1,167	1,267	7.89
300	4,773	2,121	+ 2,652	2,699	3.70
350	5,568	1,818	+ 3,750	3,785	2.64
400	6,364	1,591	+ 4,773	4,803	2.08

Wireless Theory Simplified.—

In this manner the impedance of the circuit has been worked out for a number of different frequencies ranging from zero to 400 kilocycles per second and the results are given in full in the table, the values being in ohms.

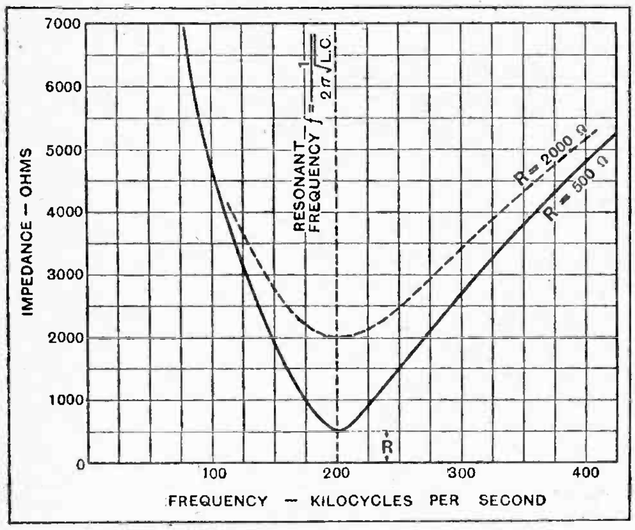


Fig. 3.—Curves showing how the impedance of a series circuit with inductance and capacity varies with frequency. L = 2532 microhenrys, C = 0.00025 μF.

An examination of the table will show that, as the frequency is increased from zero, the inductive reactance X_L rises in value from 0, whereas the condensive reactance X_c starts from an infinitely great value (∞) and falls as the frequency is raised, and further, that the two reactances are equal when the frequency is 200 kilocycles per second (this corresponds to a wavelength of 1500 metres). As regards the impedance of the circuit it will be seen that this has high values at each end of the frequency range chosen and falls to a minimum of 500 ohms at the resonant frequency.

The calculated impedance values given in the table have been plotted as a graph, shown by the full line curve in Fig. 3, to enable the reader to see at a glance how the impedance of a series circuit with inductance and capacity varies with frequency.

It will be observed that at frequencies far removed from the resonant value, the resistance of the circuit has a negligible effect on the value of the impedance—in these cases the impedances are nearly equal to the resultant reactances which are themselves very high. At frequencies very close to the resonant value however, the resistance is the controlling factor and at the resonant frequency itself the resistance is the only thing that counts.

The height of the lowest point of the impedance curve above the frequency axis is equal to the resistance of the circuit and to show the effect of changing the resistance value of the circuit without altering the inductance and capacity, the dotted curve has been included in Fig. 3, giving impedance values when the resistance is 2000 ohms. If the circuit could be imagined to have no resistance at all the impedance curve would actually touch the base line.

Resonance Curves.

In the last column of the table are given the values of current taken by the circuit at the various frequencies, assuming a constant E.M.F. of 10 volts R.M.S. value to be applied to the ends of the circuit. At any one frequency the current is obtained in amperes by dividing 10 volts by the impedance at that frequency, then multiplied by 1000 to give the result in milliamperes.

The values of current so obtained have been plotted as a curve against the frequency in Fig. 4 and from this curve we can judge at a glance the general behaviour of the circuit. The curve shows that as the frequency increases and approaches the resonant value of 200 kilocycles per second, the current increases very gradually at first and then very rapidly for frequencies between 150 and 200 kilocycles per second. It reaches a maximum value of 20 milliamperes at the resonant frequency and then begins to fall rapidly again when the resonant frequency is exceeded.

Selective Effect of Tuned Circuit.

The main feature is that the circuit allows much greater currents to pass if their frequencies are at or near the resonant value than if they have frequencies far removed from the resonant value. The circuit is thus seen to have the property of selecting currents whose frequencies lie within a comparatively narrow band of values in the neighbourhood of the resonant frequency, and of choking back currents whose frequencies are outside this band.

The curve of Fig. 4 is called the *resonance curve* of the circuit, and from its shape and the sharpness of the peak the performance of the circuit can be judged. It should be noted that the peak of the resonance curve has a rounded top; this is so because the impedance of the circuit is equal to the resistance R at the resonant frequency, and any very small change of frequency will only introduce a small amount of unbalanced reactance, negligible with respect to the resistance; and so the current curve must have a horizontal portion just at the top. Another point is that the peak of the curve is not symmetrical in shape.

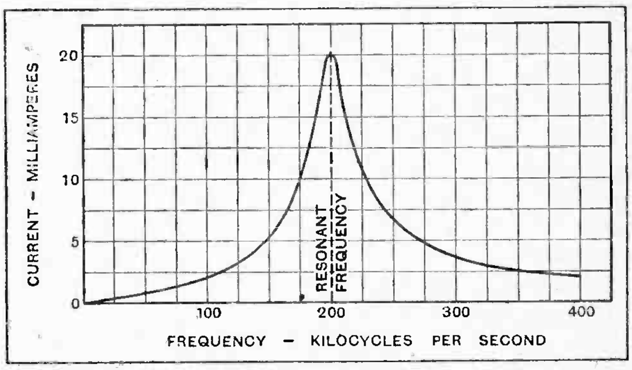
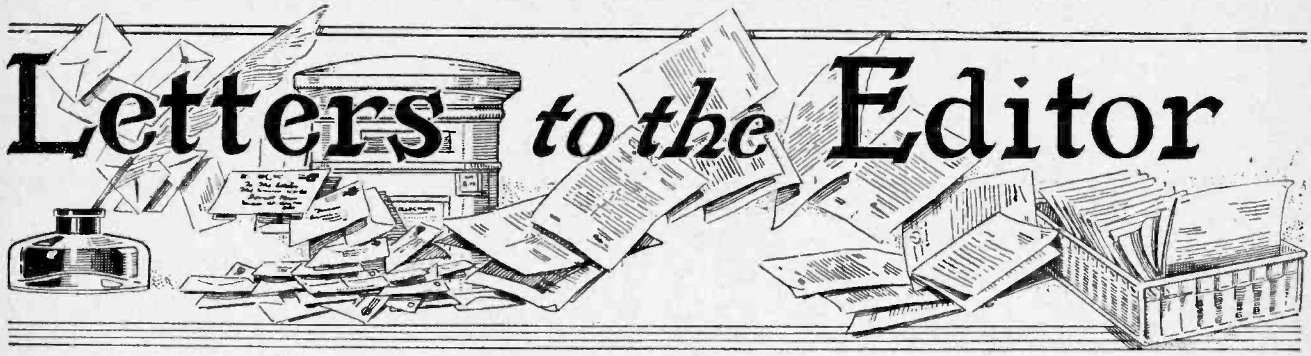


Fig. 4.—Resonance curve for a series tuned circuit where L = 2532 microhenrys, C = 0.00025 mfd. and R = 500 ohms.

The degree of selectivity of a tuned circuit and its general efficiency depend upon a number of factors and a discussion of them will constitute the subject of the succeeding instalment.

(To be continued.)



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.

THE THIRST FOR POWER.

Sir,—As a reader of your paper, and one who has so far been in agreement with its opinions, I must take exception to the leading article, "The Thirst for Power," in the last issue. There are a very large number of wireless listeners in this country who pay their licence fee and yet do not get the type of programme they want. Moreover, here there are very large gaps on Sunday in which no transmission takes place and what is given is severely restricted in type.

Continental stations give programmes all day on Sunday and their week-day evening transmissions give an alternative source of enjoyment in the form of splendid orchestral concerts, operas, etc., to the interminable series of talks, jazz music, chamber music, etc., which we are given here. I venture to say that the ordinary man, when he returns home in the evening and sits down, likes to listen for a couple of hours to an uninterrupted programme of lively music, or a concert, such as are regularly broadcast abroad. At present an efficient three-valver will, with foreign transmitters working on 7 to 20 kW., give good results on a loud speaker. Those who possess more selective and powerful sets—mine is one of your four-valve circuits—get still better results, and I find stations like Turin, Vienna, Brateslava, etc., come through as well as, and generally better than, 5GB. Now, sir, when more powerful stations are working, such as Rome and Oslo soon will be, on 50 kW., they will give L.S. results in this country, judging from my experience, practically as good as 2LO. Listeners here, therefore, who have to go abroad for their entertainment owing to the restricted and classical type of programme that is given will in no way feel alarmed, but will welcome such increase of power. I am unable to understand why your correspondent, A. W. Scott, gets such "mushy" results. I can assure him that there are at least ten foreign stations, including those I have mentioned, which I receive regularly every evening at tremendous strength on a M.-C. speaker. They drown out all mush, Morse and background noise. Fading is, of course, sometimes present, but increased power will minimise this and present better reception for the weaker set. I trust you will find space to publish this letter as I am sure many thousands of listeners hold these views. J. CHANDLER.

Upminster, Essex.

FOREIGN STATION RECEPTION.

Sir,—I deeply sympathise with Mr. A. W. Scott, of Chipstead, Surrey. He must, indeed, have been bitterly disappointed, after having gone to the trouble and expense of making a "reasonably up-to-date" set of "your own excellent design," to find that all he can receive of the ten to fifteen foreign stations which are available almost any night is a mixture of "transmission *plus* atmospherics *plus* heterodynes *plus* fading *plus* Morse."

I am very sorry for him; but I do consider that he is unreasonable in supposing that the majority of other listeners (more than 99 per cent. of them, in fact) can get no better results than he can.

Surely Mr. Scott must be almost unique if he experiences troublesome fading on the long waveband; and surely if his neighbours are as relentless with their oscillating as to heterodyne continuously all his fifteen stations, his best course would be to send an appeal to the Postmaster-General.

My own experience of foreign reception is admittedly far less disturbing to the nerves. No doubt it is not advisable to amplify foreign programmes to concert-room loudness: to reproduce them with powerful moving-coil speakers; but for all that there are, even in London, a large number which can be received and which can be enjoyed. Not every one every night, it is true, but there is rarely a night on which more than one cannot be well heard.

On a four-valve portable set of a well-designed (and, admittedly, rather expensive) type I can usually get conveniently enjoyable reception from Huizen, from Radio Paris, from Warsaw, from Motala, from Kalundborg, from Hilversum (on its long wavelength), or from Konigswusterhausen on the long waveband; and from Budapest and Vienna (though sometimes entangled with Morse), Berlin, Frankfurt, Toulouse, Breslau, and many others on the shorter waves.

I find that in the country (unless near the sea) I can get many more.

I may add in conclusion, in case Mr. Scott should think that my standards of reproduction are perverted, that for local reception of the London programme I use a very carefully designed set, employing in the last stage two L.S.5A valves, running on 300 volts, and feeding a well-made moving-coil speaker. C. K. HERBERT.

London, S.W.1.

Sir,—I read with interest the letter of Mr. A. W. Scott (27/11/29) criticising your attitude to the Regional Scheme, and as my own experiences of "foreign listening" are similar to his I fully endorse his views.

Situated three miles N.E. of Glasgow, I can pick up most of the leading European stations at loud-speaker strength, but after three years of "foreign listening" I have decided that distance and quality seldom go together, for reception is more than often marred by statics on the long waves and fading and heterodyning on the short waves. In fact, I could easily count the number of nights on which a "distant programme" was received without some kind of extraneous Morse or interference. Even 5XX is not free from static on some occasions, and although the volume and quality of Brookmans Park are good there is periodic fading.

So the local station only remains, and even it is not above reproach, for about 80 per cent. of the programme comes over 400 miles of land-line before being transmitted. So until Scotland has its own regional station, and one transmission does not require the assistance of the land-line, then only can we hope to have first-class quality.

So may the regional station for Scotland materialise and the scheme prosper. K. M. TOPPING.

Glasgow.

Broadcast Brevities

By Our Special Correspondent.

Listeners' Reports on Twin Transmissions.—Mains Sets for Schools.—Money and Music.

Listeners and the Twin Transmitters.

Mr. Noel Ashbridge, the B.B.C.'s Chief Engineer, is agreeably surprised at the number of listeners who have taken the trouble to report favourably on the twin transmissions from Brookmans Park. Profiting by earlier experience, however, he refuses to be beguiled by the first batch of letters. Those who first take up the pen are the enthusiasts—the people who have good sets; the smaller fry who have only a hazy notion of what the scheme is all about are probably just discovering that additional selectivity is now necessary.

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Erratic Modulation.

From my own experience I would say that it will be easier to judge how comfortably the two stations can be separated when the 261-metre transmitter settles down to a fairly uniform output. Modulation appears to be erratic and there are times during the late dance music when the new transmitter suddenly spreads itself out in a manner which must cause pain to many listeners living within 5 miles of Brookmans Park.

However, it is too early to criticise. Who knows what a week may bring forth?

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L.C.C. and School Wireless.

"Mains Sets for Schools" seems to be the new slogan of the London County Council. I hear that the question of school sets appeared on the agenda at last week's meeting of the Council, following upon an inspection in several schools where battery-operated receivers were proving costly and difficult to maintain.

As an indication of the importance which the L.C.C. attaches to broadcast lessons it is significant that steps are to be taken to ensure that only the best and latest design of receivers are to be used for the work, with power supply from the electric mains.

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School Sets Need Supervision.

According to the B.B.C. at least 3,000 schools up and down the country are known to be taking one or more of the broadcast courses. Little information is forthcoming regarding the type of quality of the sets employed, though the B.B.C. engineers undertake to inspect sets and give advice when requested to do so. Is this good enough? Some responsible authority should surely be commissioned to see that scholars are ensured decent, distortionless reception. The schoolmaster entrusted with the management of a class cannot be expected to pay attention to grid bias and H.T. battery voltage at the same time.

The L.C.C. is acting wisely in the matter, and it is to be hoped that other educational authorities will also tackle the question.

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The "Early to Bed" Station.

Two main programmes nightly in water-tight compartments will be the principle adopted by 2LO, 5GB and other stations early in the New Year.

Beginning on January 6th, 5GB will start its first programme at 6.30 p.m. and its second at 8.35, and a noteworthy feature will be the introduction of a nightly talk at 8 o'clock—the first serious attempt to introduce talks from the experimental station. The station will close down at 10.30 each evening.

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Original Programmes from Regional Twin?

2LO, 5XX and other stations will start their two main programmes at 7.45 and 9.45 respectively Comparing these times with those of 5GB, it will be seen that the experimental station will provide light relief during the 7 to 7.45 talks period from the other stations

What of the programme from the twin station at Brookmans Park? I am asked to understand that an *original* programme will be provided, but I retain the belief that the provincial stations may help to contribute.

CHRISTMAS PROGRAMME FEATURES.

London and Daventry (5XX).

DECEMBER 23RD.—Nativity play relayed from St. Hilary's Church, Cornwall—"Bethlehem," by Bernard Walke.

DECEMBER 24TH.—Carols relayed from St. Mary's, Whitechapel.

DECEMBER 25TH.—"Cox and Box," comic opera, by Burnand and Sullivan.

DECEMBER 26TH.—"Cinderella," a pantomime, by Ernest Longstaffe.

DECEMBER 28TH.—"Rupert of Hentzau," a play by Anthony Hope.

Daventry Experimental (5GB).

DECEMBER 24TH.—Light orchestral programme and solos.

DECEMBER 25TH.—"Cinderella," a phantom pantomime, by Ernest Longstaffe.

DECEMBER 26TH.—"The Messiah" (Handel).

DECEMBER 27TH.—"Rupert of Hentzau," a play by Anthony Hope.

Cardiff.

DECEMBER 23RD.—Carols relayed from the Exchange, Cardiff.

DECEMBER 27TH.—"A Visitor for Christmas," a Yuletide playlet, by F. Morton Howard.

Manchester.

DECEMBER 24TH.—"Christmas Eve at Browns," by Edwin Lewis.

DECEMBER 25TH.—Christmastide request orchestral programme and songs.

Glasgow.

DECEMBER 24TH.—"No Room at the Inn," a Christmas morality play, by David Cleghorn Thomson.

DECEMBER 27TH.—Tullytassie Hogmanay Gathering—grand soiree and concert, followed by an assembly in the Burgh Hall, Tullytassie.

Belfast.

DECEMBER 24TH.—"Christmas Eve in Ballmulcaghey."

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The European Network.

A step forward towards that European relay network to which reference was made recently is indicated by the news that the B.B.C. now prepares a list of attractive musical features to be broadcast six weeks ahead. This list is sent to broadcasting authorities in Germany and Belgium, i.e., countries in which the land lines are favourable for musical transmission. I understand that the courtesy is reciprocated.

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Matters Musical.

Dr. Adrian Boult's appointment as musical director of the B.B.C. is to be deferred until May 15th next. This will enable Mr. Percy Pitt, the present holder of the post, to prove that an artist's powers of expression do not frizzle up immediately their possessor attains the age on which the B.B.C. sets the seal of superannuation.

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An Expensive Orchestra.

Meanwhile the future of Sir Thomas Beecham's "National Orchestra" is coming up for discussion. It is an open question whether this experimental combination which Sir Thomas is conducting will become a permanent institution, as was suggested during its formation, although no changes are likely before next autumn. In the interval, of course, the B.B.C. is faced with its liabilities in regard to a number of the players who will be drawing anything between £15 and £25 per week from Savoy Hill for the next three years.

In view of this expenditure of listeners' money, the public will want to hear a good deal more of the orchestra between now and 1932.

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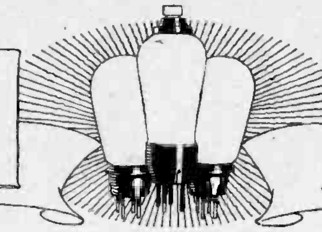
The Truth.

"The Truth About the B.B.C." was the striking title of an article published a few days ago. Some doubt is expressed as to whether this is the 254th or the 255th time that this striking title has been employed.

READERS'  PROBLEMS.

"The Wireless World" Supplies a Free Service of Technical Information.

The Service is subject to the rules of the Department, which are printed below; these must be strictly enforced, in the interest of readers themselves. A selection of queries of general interest is dealt with below, in some cases at greater length than would be possible in a letter.

Moving the Reaction Condenser.

My detector—2 L.F. set—would be quite satisfactory were it not for the fact that hand capacity effects are troublesome when operating the reaction condenser. I am told that this is because the condenser is connected in such a way that both its moving and fixed vanes are at high potential; this seems to be correct, as an experimental reversal of connections does not have any noticeable effect.

I am sending you a circuit diagram of the receiver. Will you please tell me if there is any easy way of overcoming the difficulty?

G. P. S.

Your diagram (of which the part in question is reproduced in Fig. 1) shows that the reaction condenser is connected between the detector valve anode and the high-potential end of the reaction coil: in this position hand capacity effects are likely to be evident, particularly if the condenser is unscreened, and if its operating knob is of such dimensions that the operator's hand comes into close proximity to the "live" spindle.

We suggest that the condenser should be moved to the position indicated by "X" in the diagram, the existing connections being, of course, joined together. Although this sounds easy enough, it may possibly be necessary to rebuild the coils if interchangeable plug-in inductances are fitted, or, alternatively, if waveband switching is used, to elaborate the switch change-over connections. This is because an extra connection must be led out from the coil assembly to enable you to work with an "earthed" reaction condenser.

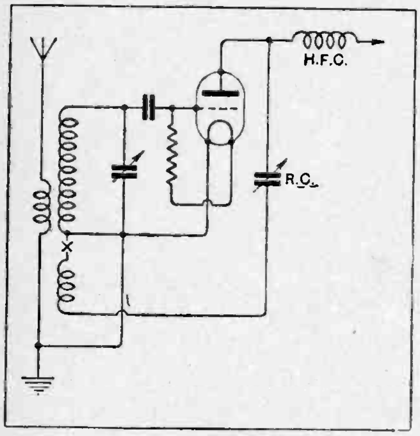


Fig. 1.—Hand capacity effects in a regenerative detector valve circuit may generally be overcome by transferring the reaction control condenser to the position marked X.

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Modified "A.C.2."

My "A.C.2" receiver, as described in "The Wireless World" for August 22nd, 1928, was sufficiently selective until the new 2LO started working; now I find that this station tends to "spread" very seriously unless a value of series aerial condenser sufficiently small to cause considerable diminution of signal strength is inserted. Would it not be possible to alter the tuned circuits of this receiver to conform with the arrangement included in the "Two-Circuit Two" ("The Wireless World," February 6th, 1929)? It is realised that the cathodes and heaters will be connected in the conventional manner; is any other alteration necessary, and do you anticipate that any difficulty will be encountered? W. R. N.

There is no reason why your proposed alteration should not be effected, and no alterations other than the obvious ones will be necessary. Due to the high efficiency of the detector valve as compared with battery-heated types, there will be an increased tendency towards self-oscillation, but this can be overcome by suitably setting the relative values of the reaction feed condenser and the reaction control condenser.

oooo

Simple Pick-up Connection.

I believe that it is possible to convert the "Everyman Four" for gramophone reproduction simply by connecting a pick-up by means of a length of flex to an ordinary coil plug, and inserting this plug in the socket normally occupied by the long-wave loading coil. Please tell me if this is correct.

J. le G. L.

The answer to this question depends on whether it relates to the original "Everyman Four" or to the model with potentiometer control of detector grid bias, as described in the last edition of the "Everyman Four" booklet.

It is quite in order to connect a pick-up to the modified receiver in the manner that you describe, but some form of volume control will be required; this should not be "later" in the chain of amplification than in the grid circuit of the first L.F. valve. Of course, the value of negative bias normally applied to the detector must be reduced when this valve is made to function as an amplifier; this is easily done by giving a partial turn to the potentiometer knob.

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Two Eliminators.

I am about to rebuild my receiver, and intend to add a push-pull output stage requiring much more energy than can be supplied by my existing eliminator, which is quite satisfactory except only in the matter of power output.

In order to save trouble and expense, it is proposed to use the original eliminator for feeding the H.F. valve, detector, and first-stage L.F. amplifier, and to build a new power unit for the output valves only. Is there likely to be any unforeseen difficulty in doing this? Current is A.C. at 250 volts. G. D.

There is no reason whatsoever why this plan should not be adopted successfully. It can only be criticised on the grounds that it involves the upkeep of two separate rectifiers; in all probability there would be sufficient surplus output from the proposed new power unit to feed the earlier stages of the receiver.

RULES.

(1.) Only one question (which must deal with a single specific point) can be answered. Letters must be concisely worded and headed "Information Department."

(2.) Queries must be written on one side of the paper, and diagrams drawn on a separate sheet. A self-addressed stamped envelope must be enclosed for postal reply.

(3.) Designs or circuit diagrams for complete receivers cannot be given: under present-day conditions justice cannot be done to questions of this kind in the course of a letter.

(4.) Practical wiring plans cannot be supplied or considered.

(5.) Designs for components such as L.F. chokes, power transformers, etc., cannot be supplied.

(6.) Queries arising from the construction or operation of receivers must be confined to constructional sets described in "The Wireless World" or to standard manufacturers' receivers.

Readers desiring information on matters beyond the scope of the Information Department are invited to submit suggestions regarding subjects to be treated in future articles or paragraphs.

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(17th Year of Publication)

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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.

CONTENTS OF THIS ISSUE.

A MINISTRY OF BROADCASTING.

IN the House of Commons some days ago a Member drew the attention of the Speaker to the fact that when he handed in a question complaining of the broadcasting service in the East of Scotland he was informed that there was no department to which he could address it, nor could he address it to the Prime Minister. He asked how the grievance of people who by law paid 10s. a year for receiving instruments could be ventilated. The Speaker said that it was one of the rules governing questions that they must be put to a Minister on subjects for which Ministers had some responsibility. In the matter of broadcasting he understood there was no such Minister. The Postmaster-General stated that he understood that in the matter of broadcasting the Post Office had a responsibility for questions of general policy but no responsibility for questions in detail. Sir W. Mitchell-Thomson, Postmaster-General in the late Government, stated that he had always refused to answer questions relative to broadcasting on particular details as not being himself responsible.

As long ago as November 24th, 1926, writing in *The Wireless World* at the time that publication was given to the new Charter for the Broadcasting Corporation, we chose "A Ministry of Broadcasting" as the title for our leaderette, and, after commenting on the scope of the Charter and referring to the importance with which the subject of broadcasting was treated in a debate in the House of Commons, we concluded by saying "This brings us to the question of how long the Broadcasting Service will remain under the thumb, so to speak, of the Postmaster-General. Probably it will always be necessary for the Service to obtain its licence to operate the stations from the Postmaster-General, but it seems that at a comparatively early date all justification for the Postmaster-General to have authority in other directions will have disappeared, and, to judge by the ever-growing national importance of the Broadcasting Service, it seems to us highly probable that in the not far distant future the appointment of a Ministry of Broadcasting will be regarded as just as essential as other Ministries which have been created to control various other activities of a national character."

If in 1926 there was sufficient evidence to suggest a good case for the formation of a Ministry of Broadcasting, how much stronger a case could be put forward to-day! Had broadcasting in this country remained as in America, largely in the hands of private enterprise, then there would have been no occasion for considering such a step, any more than it could be justified in this country in connection with the Press; but seeing that our national broadcasting service is firmly established under Government control, and taking into account its importance as a national influence, it seems incongruous that this organisation should be without a spokesman in the House of Commons.

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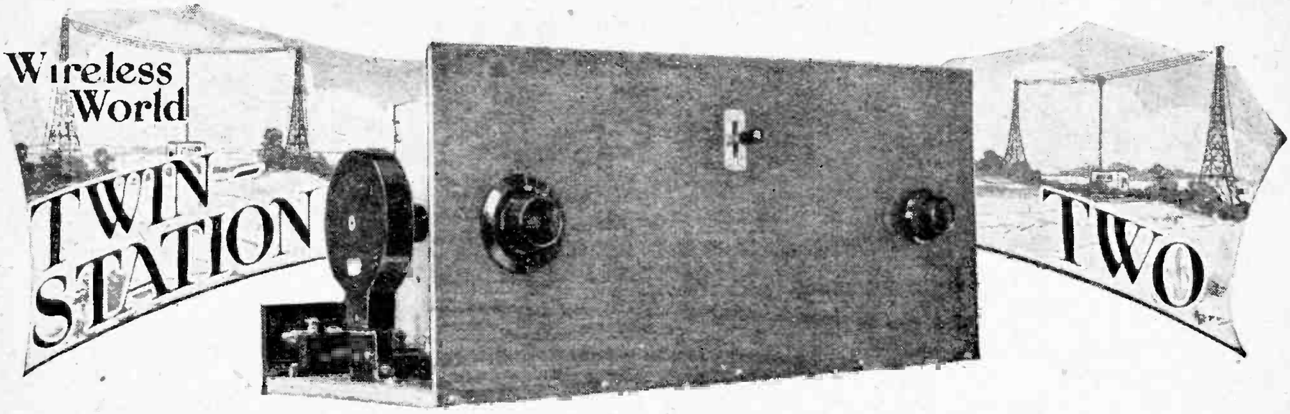
OBITUARY.

OUR readers will have learned, with sorrow, of the loss of one of the greatest of our pioneers of practical wireless telegraphy through the death of Admiral Sir Henry Jackson. Admiral Jackson's career has been a long record of service to his country, and his personality had endeared him to everyone who came in contact with him.

Elsewhere in this issue we record some of the activities of Admiral Jackson's career, which will ensure for him undying recognition in the annals of British history.



Alternative Programmes Without Retuning.

By H. F. SMITH.

CONTRIBUTORS to these pages have more than once put forward the suggestion that we are all inclined to expect rather too much of our radio receivers, and have hinted that in many cases more enduring satisfaction would result from the use of a set designed for a definite and strictly limited performance under a fairly rigidly defined set of conditions.

It would be futile to suggest that such a rule should be universally applied, and that, having decided exactly what programmes we want to hear, we should design, have designed, or buy ready-made a receiver capable of satisfying these requirements—no more or no less—in our own particular locality. Except in special cases it would be technically impossible to do so.

Although the general-purpose set is perfectly satisfactory for average requirements and localities, there is at least one body of wireless users who should seriously consider the use of a specialised type of receiver. Under this category are included those who live within a few miles of Brookmans Park (or, of course, of any similar twin regional station that may be built). These unfortunate people—or perhaps fortunate; everything depends on one's point of view—will need, for anything like satisfactory distant listening, a highly selective and ambitious receiver—so ambitious that to use it merely for local reception would savour of cracking nuts with a steam-hammer. They will probably either satisfy themselves with local programmes only, or will have two separate receivers, one of which will be designed exclusively for long-distance work.

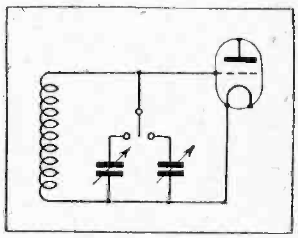


Fig. 2.—Another method of wave switching.

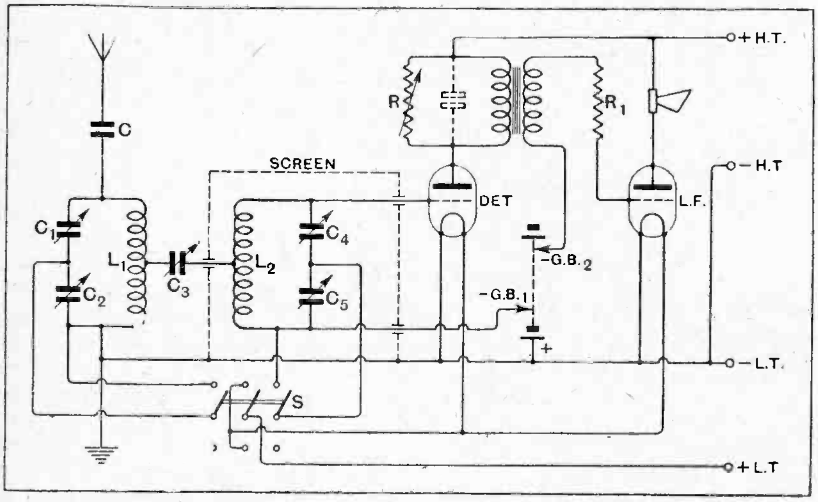


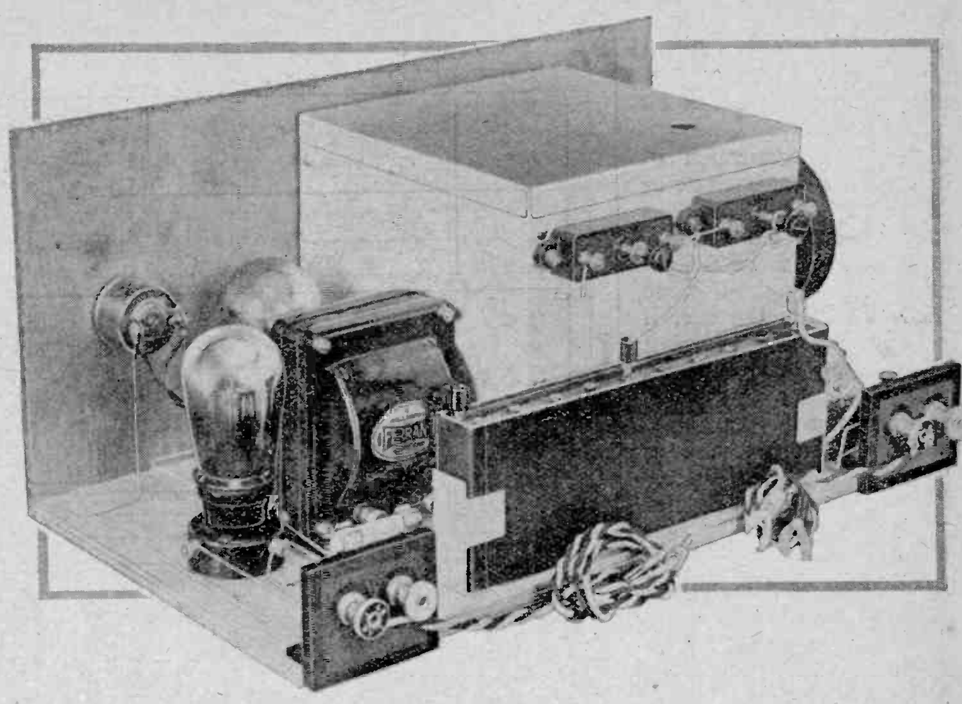
Fig. 1.—Complete circuit diagram. The condenser shown in dotted lines is built into the L.F. transformer. C, aerial shortening condenser, 0.0002 mfd.; C_1, C_2, C_4, C_5, tuning condensers, min. 0.0002 mfd., max., 0.001 mfd. (depending on wave-length); C_3, coupling condenser, 0.0001 mfd. L_1, plug-in aerial coil; L_2, secondary coil (see text); R, volume control resistance; R_1, H.F. stopping resistance, 100,000 ohms. S, combined wave-changing and on-off switch.

Quick-change Reception.

If either of these courses is decided upon it will be readily agreed that the local-station set should be as simple in construction and operation as is possible, and, to avoid the need for constant retuning, a quick and easy change-over from one alternative programme station to the other is clearly desirable. The receiver to be described in this article represents one of the many ways in which these features may be combined in a satisfactory manner. As it is intended for use in a strictly restricted area, it follows that the design as it stands will be suitable for an equally restricted number of readers, but it is hoped that those living outside this area who are interested in the undoubtedly attractive feature of quick-change, programme-to-programme switching will be able to glean some suggestions applicable

Twin-station Two.—
to their own needs and geographical situation.

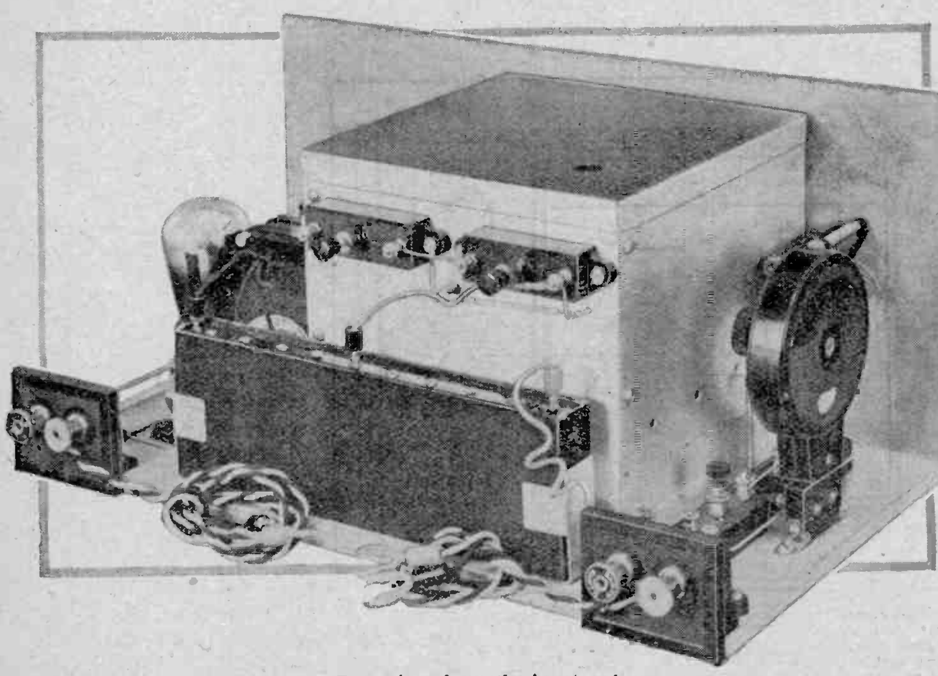
When it is said that the basic circuit diagram comprises an anode-bend detector without reaction, transformer-coupled to an output valve, it will be realised that the set is most distinctly not for long-range work, or even for medium distances. This point should be emphasised, as there is nothing more unsatisfactory than a receiver without sufficient sensitivity—one should say a reserve of sensitivity—for the purpose it is intended to serve. The set gives good results only where signals are really strong: sufficiently strong, say, for a crystal set to operate headphones loudly enough to be audible several inches away from the ear. Of course, the aerial plays its part, and its effectiveness must be increased as we move farther away from the transmitting station.



Rear view, from the output end.

In order that adequate selectivity for any locality may be obtained, a two-circuit aerial tuner is provided, with variable capacity coupling which serves both as a pre-detection volume regulator and selectivity control. From the circuit diagram given in Fig. 1 it will be seen that the coupling condenser C_3 is connected between the centre points of aerial and grid coils; adequate linkage of the circuits is obtained by these means with a condenser of standard capacity range, and the disturbing effects of coupling changes are less evident than when it occupies the usual position between the high-potential ends of the coils.

The connection of the tuning capacities C_1, C_2, and C_4, C_5, together with the wave-changing switch, may at first appear complicated, but the matter is really quite simple if it is realised that a pair of semi-variable condensers are joined across each circuit, and that one unit of each pair is short-circuited when it is desired to receive the longer of the two twin-station wavelengths. The shorter wave is tuned-in by opening the short-circuiting switches and, without disturbing the settings already obtained, adjusting the remaining condensers. Having once found the right values, programme selection should be merely a matter of throwing the switch to the appropriate position: one condenser of each pair short-circuited for longer wave and both in series for shorter wave. The centre pole of the switch breaks



Rear view, from the input end.

Twin-station Two.—

the filament supply circuit when in the intermediate position, and so switches off the set.

This series connection of tuning condensers has one or two minor advantages, as compared with the alternative method of wave switching shown in Fig. 2. For one reason, it allows the use, if necessary, of the simplest single pole on-off switches.

The remainder of the circuit arrangement is so simple and conventional that it calls for little comment. The grid coil L_2 is screened in an aluminium box in order that coupling between it and the aerial coil L_1 may be almost entirely through the intermediary of the condenser C_3, and consequently under proper control. A post-detection volume regulation may seem rather superfluous in a two-valve set, but it was considered best to fit a variable resistance across the transformer primary, as overloading of the ordinary power valve will set in before the detector grid circuit is fully loaded. An H.F. stopping resistance R_1 is inserted in series with the output valve grid.

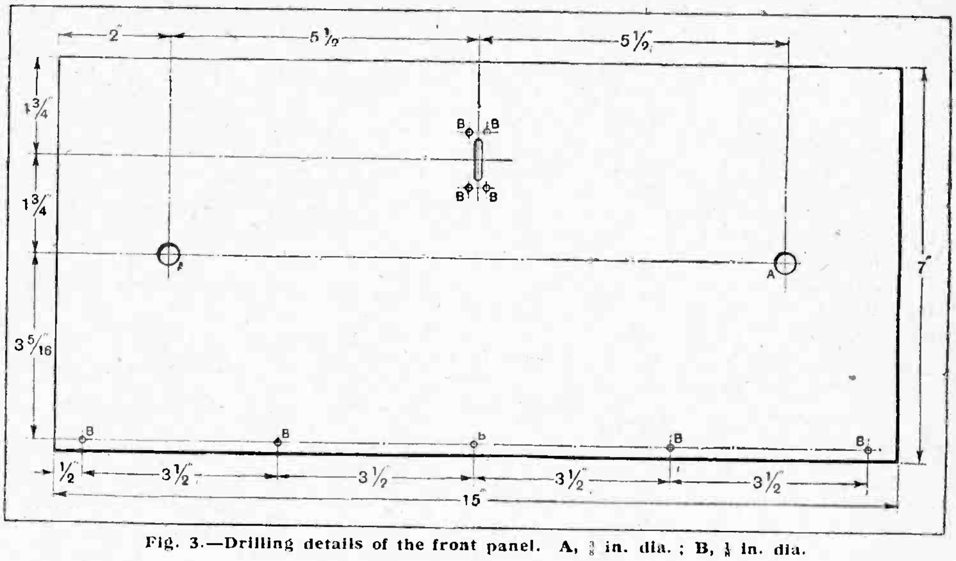


Fig. 3.—Drilling details of the front panel. A, ⅜ in. dia.; B, ⅛ in. dia.

Regarding details of construction, it will be seen that the semi-variable condensers C_4 and C_5, which tune the secondary or grid circuit, are mounted on the back of the screening case. Holes coinciding with their control knobs, and of from ⅜in. to ½in. diameter, should be drilled through the back of the containing cabinet so that a screwdriver may be inserted for initial adjustment or at any subsequent time if necessary. The remaining tuning condensers are on the baseboard, and are also set with the help of a screwdriver.

Coil-winding Details.

The plywood front panel carries H.F. input and L.F. output volume controls, and a combined on-off and wave-changing switch. In order that the lid of the screening box may be removed when required, it is necessary that the box itself be set back about $\frac{1}{16}$in. to ⅛in. from the rear surface of the panel by interposing a distance piece in the form of a thin strip of wood, ebonite, fibre, or some similar material; the switch lever and securing screws are passed through this strip.

For the aerial circuit a centre-tapped plug-in No. 40 coil is used, as shown, while the secondary inductance L_2 is a simple, home-made coil consisting of fifty turns of No. 24 D.C.C. on a Pirtoid former measuring 3½in. long by 3in. in diameter. A tapping is brought out from the centre point (25th turn). The winding should be started about ½in. from the upper end of the tube, the lower end of which is secured to the wooden sub-base of the screening box with the help of a wooden disc or in any other convenient manner.

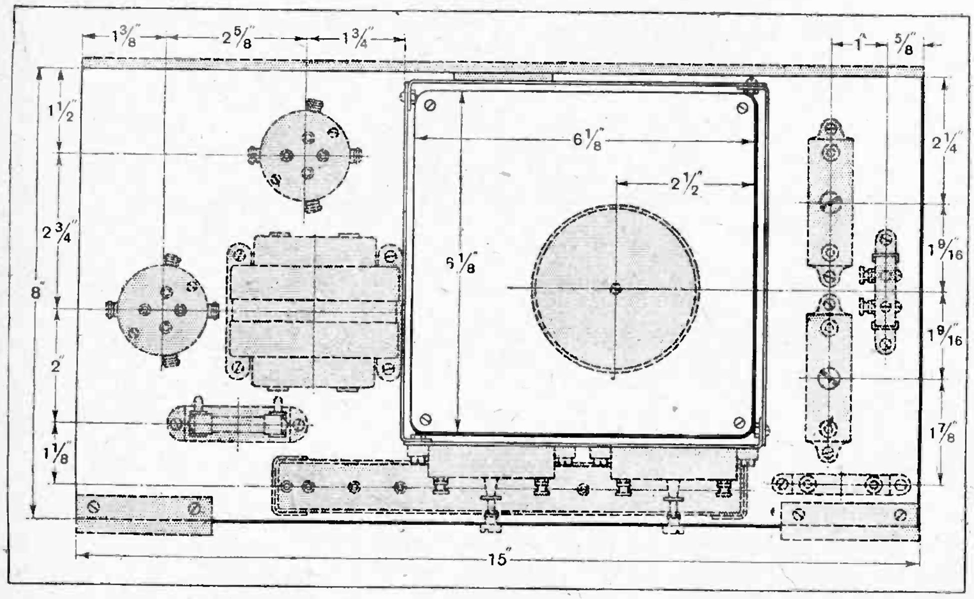


Fig. 4.—Layout of components on the baseboard. Note distance piece between screening box and panel.

"Junit" terminal blocks, screwed to the rear edge of the baseboard in the manner shown, carry terminals for aerial, earth and loud speaker, while

LIST OF PARTS.

1 Wood panel, 3-ply, 15×7in.
1 Wood baseboard, 5-ply, 15×8in.
1 Screening box, aluminium, 6½×6½×6in. high.
1 Inductance coil former, 3½×3in. dia. (Pirtoid).
1 L.F. transformer (Ferranti, A.F.5).
2 Valve holders (Burton, Midget).
1 Switch, 3-pole change-over (Burton).
1 Reaction condenser, 0.0001 mfd. (Burton).
1 Variable resistance (Standard Clarostat).
1 Single coil-holder (Lotus).
1 Coil, No. 40, centre-tapped (Lewcos).
4 Semi-variable condensers, 0.001 max. (Formodensers, Type G).
1 Resistance, 100,000 ohms (Ediswan).
1 Holder for above (Bulgin).
1 Fixed condenser, 0.0002 mfd. (Trix).
2 Terminal mounts (Junit).
4 Terminals: "Aerial," "Earth," "L.S.+," "L.S.—" (Eelex).
1 Grid bias battery, 15 volts (Ripaults).
1 Pair bias battery clips (Bulgin).
5 Wander plugs (Clix).
2 Spade terminals (Clix).
Sistoflex, wire, screws, etc.

Approximate cost, £4 2s. 6d.

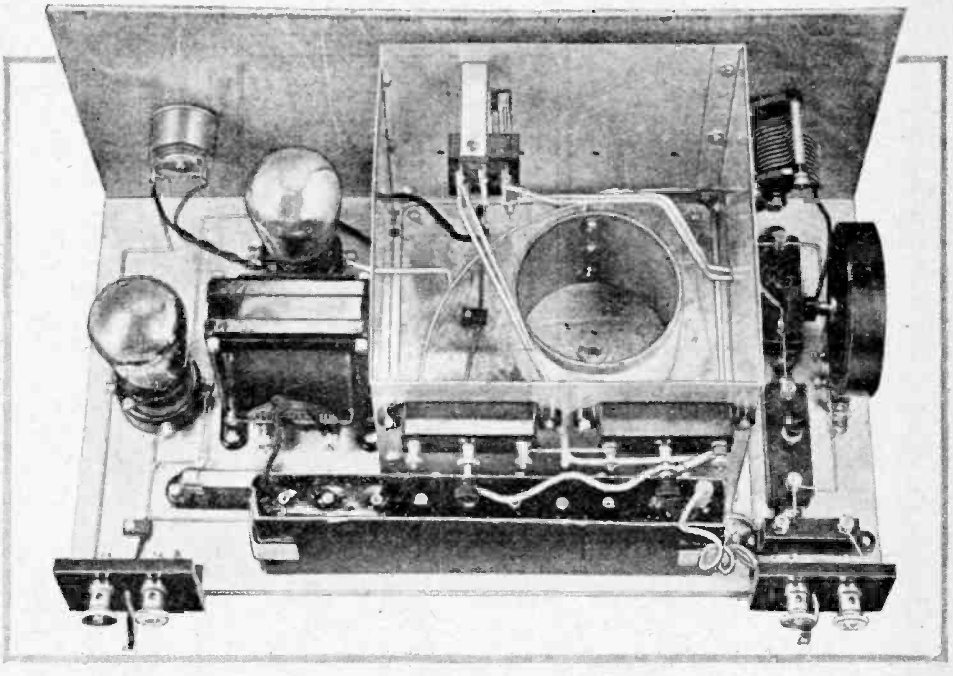
In the "List of Parts" included in the descriptions of THE WIRELESS WORLD receivers are detailed the components actually used by the designer and illustrated in the photographs of the instrument. Where the designer considers it necessary that particular components should be used in preference to others, these components are mentioned in the article itself. In all other cases the constructor can use his discretion as to the choice of components, provided they are of equal quality to those listed, and that he takes into consideration in the dimensions and layout of the set any variations in the size of alternative components he may use.

flexible leads for connection to L.T. and H.T. batteries are led out through holes provided in these blocks.

One can hardly go wrong in the wiring of a simple set of this type, particularly with the help of the diagram given in Fig. 5, but some attention should be paid to the connections between tuning condensers and switch, the leads being run parallel and close together in pairs, as clearly indicated both in the diagram and in the illustration on this page. This is to minimise stray inductive coupling due to the fact that the aerial circuit wiring at this point is of necessity passed into the secondary circuit screening compartment.

Apart from permissible modifications in design, a certain amount of latitude is allowable with regard to the choice of components. Semi-variable tuning condensers operate best towards the minimum end of their capacity range, as in this position a given rotation of the control knob brings about a much smaller capacity change than at the other end of the scale. To cover the wavelengths of the alternative London stations, Formodensers rated at 0.0002-0.001 mfd. (but actually with a slightly lower minimum) are accordingly used. Obvious adjustments as to values can be made when dealing with other wavelengths.

A transformer used for linking an anode-bend detector to a succeeding L.F. valve should be of first-class design, and must have a high primary inductance, which implies a low step-up ratio. Unless a high-grade transformer is used, it does not pay to employ this circuit arrangement. The detector valve itself should be one of the types specially designed for this particular function, and should have a rated impedance not appreciably greater than 10,000 ohms—preferably less. Marconi or Osram "D.E.L.," or Mullard "D" types are suitable. There is no need to discuss the output valve, of which the choice will, as usual, depend on current supply facilities and requirements as to volume.



Plan view. The separate pairs of tuning condensers are wired with parallel side-by-side conductors. Holes with an ample clearance are drilled to pass wires through the screening box.

While dealing with the question of volume it should be made quite clear that a simple set of this type can produce a really large output, always provided that sufficient energy is picked up by the aerial; and it must be remembered that extraordinarily high signal voltages are developed at a few miles' distance from the present high-power stations. A recent article[1] showed that an arrangement similar to that under discussion, with a P.M.6D. valve with 150 volts H.T. and 10½

[1] "The Valve as an Anode Bend Detector," The Wireless World, March 27th, 1929.

Twin-station Two.—

volts bias, fed with maximum possible signal voltage consistent with avoidance of grid current, will provide a peak output of 110 volts (total swing), implying a bias of 55 volts for the L.F. valve. This is, of course, a much greater output than is ordinarily required, but it should be made quite clear that it is only attainable at a very short distance from the transmitting station.

With regard to the question of H.T. voltage, it is hardly fair to expect good results with a pressure of less than 100 volts; normally 120 volts may be regarded as a minimum. This may be increased to 150 volts with the usual gain, but if the supply is considerably greater than this it is as well to provide a separate connection for feeding the output valve. The receiver is not prone to troubles brought about by interaction, and consequently it may be fed from a simple—even a crude—eliminator.

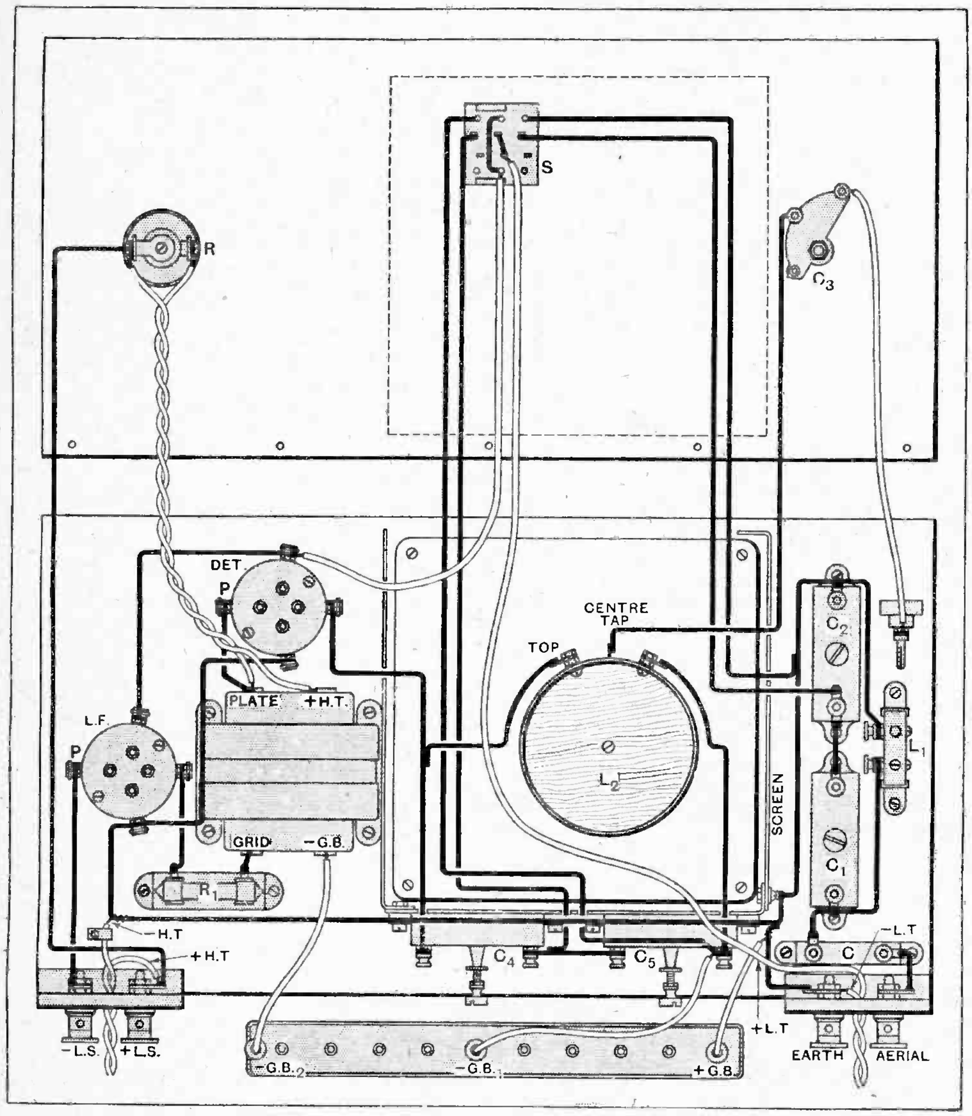
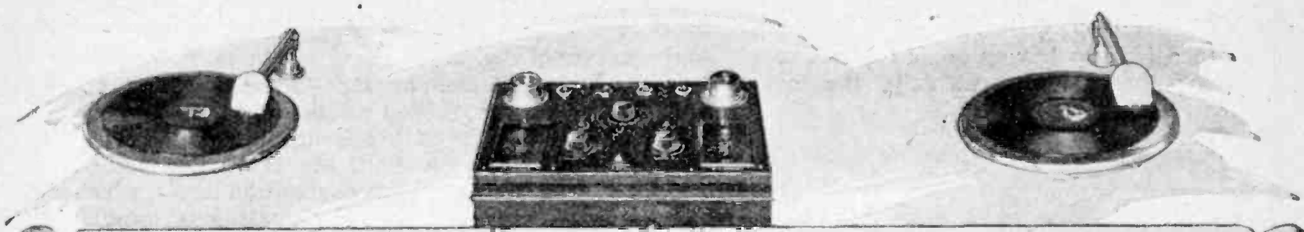


Fig. 5.—Practical wiring plan. Rigid conductors are used except where clearly shown to the contrary.

As a good deal of attention has lately been devoted to the question of operating two-circuit tuners, it is quite unnecessary to give lengthy instructions, but it should be emphasised that efforts should first be concentrated on the longer of the two wavelengths to be received, tuning with the condensers C_1 and C_4, while C_2 and C_5 are "shorted" by means of the switch. When making the short-wave adjustment with switch open and condensers in series, it will be found that the tuning of condensers C_2 and C_5 is now apparently "broad"; this is because their effective capacity range is reduced. This represents one of the advantages of the series method of connection when compression-type tuning condensers are used. The stations should first be tuned in with a very weak coupling (i.e., with a low-capacity setting of the condenser C_3), afterwards increasing strength if necessary by tightening coupling to the optimum value.

Except at very short ranges volume control will normally be effected by operation of the variable resistance R. With exceptionally large aerial inputs, distortion may be evident, even though this resistance may be set to such a low value that L.F. valve overloading is obviously impossible. These symptoms will indicate that the detector itself is overloaded, and the remedy is to reduce H.F. input to it by weakening coupling, afterwards bringing up intensity to the required level by rotation of the knob controlling R.

In situations where greater sensitivity than that afforded by the set described is necessary a stage of H.F. amplification may be added, with its tuned coupling controlled in the manner discussed. Generally speaking, it will be possible to omit the separately-tuned aerial circuit. Where a grid detector with reaction, followed by L.F. amplification, is preferred to an "H.F." set, the Hartley circuit, or one of its variants, is to be recommended, as it lends itself readily to easy wave-change switching with separate coils and condensers for each wavelength.



PICK-UP VOLUME CONTROL

Potentiometer and Variable Shunt Resistance Methods Compared.

By F. L. DEVEREUX, B.Sc.

THE voltage output from an electromagnetic pick-up is frequently in excess of the maximum input for which the associated amplifier has been designed. Further, the general level of output from records of different types varies between wide limits. A continuously variable volume control is, therefore, an essential component of any electrical gramophone equipment.

The simplest and most generally favoured method is to connect some form of variable resistance across the pick-up terminals in order that the voltage may be reduced to the required level before it reaches the grid circuit of the first amplifying valve. Properly applied, this method is quite sound, but there are one or two serious pitfalls to be avoided.

Matched Impedance.

Strictly speaking, an electromagnetic device such as a pick-up should be designed to work into an impedance of known value, e.g., the primary winding of an input transformer. When this is done, the correct procedure is to apply the volume control by means of what is known to telephone engineers as a "T" network. The opportunities of applying this method are, however, few, since the majority of commercial pick-ups are designed—or rather intended—to be connected direct to the grid circuit of the first amplifier valve, i.e., to work into an infinite resistance or open circuit. In these circumstances the connection of a resistance across the pick-up terminals may result in serious high-note loss as the following examples show.

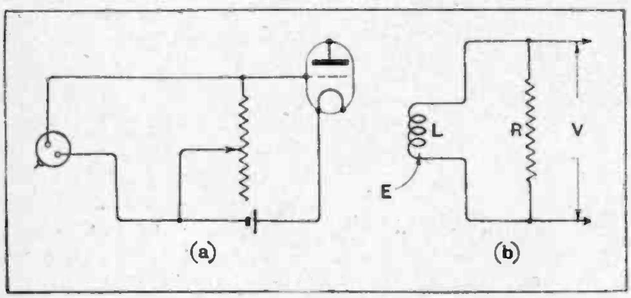


Fig. 1.—(a) Variable shunt resistance volume control producing high-note loss and (b) equivalent circuit.

Let us suppose that a variable resistance R is shunted across the pick-up terminals as in Fig. 1 (*a*). For simplicity we will assume that the impedance of the pick-up windings is mainly inductive, in which case the equivalent electrical circuit will be as shown in Fig. 1 (*b*). The inductance L and resistance R will form a series circuit, and the alternating E.M.F. (E) generated by the movement of the armature may be represented as being injected into the inductance L. The voltage drop V across R will be the voltage output to the first valve of the amplifier. For distortionless reproduction the relationship between V and E should remain constant for all frequencies. Unfortunately, the higher the frequency the higher becomes the impedance of L, until at very high frequencies R may represent only a small fraction of the total impedance of the circuit. Consequently, V at high frequencies is only a small fraction of the total E.M.F. (E) in the circuit.

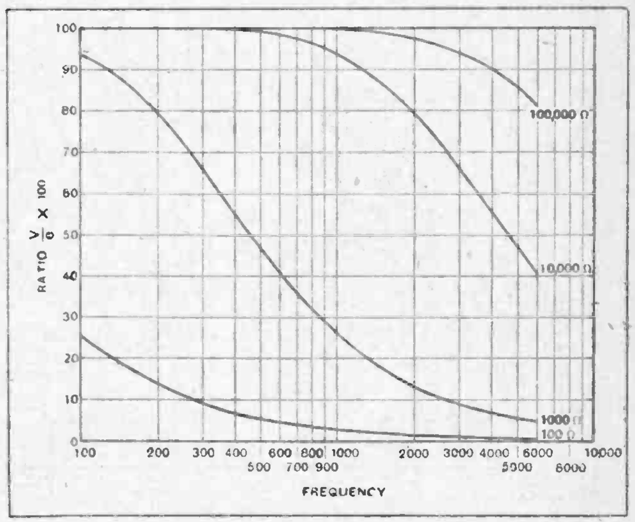


Fig. 2.—Calculated curves showing high frequency cut-off for various values of R in Fig. 1. It is assumed that the pick-up impedance is purely inductive and an inductance of 0.6 henry has been taken as a basis for calculation.

The curves in Fig. 2 show that, as might be expected, the high-frequency loss is greater the lower the shunt resistance. For simplicity the D.C. resistance of the winding has been neglected; its effect will be considered later.

Pick-up Volume Control.—

The curves of Fig. 3 are the result of actual measurements on a pick-up having an inductance of approximately 0.6 henry. Unfortunately, the mountainous nature of the curve somewhat obscures the progressive high-note loss. By comparing the difference in the height of the two curves at 500 cycles with that of 5,000 cycles, where the general level is approximately the same, it will be seen that whereas the 10,000-ohm shunt produces a reduction of only 20 per cent. at 500 cycles, the loss at 5,000 cycles is at least 50 per cent. Incidentally, these curves show that the resonance in the pick-up is mechanical, not electrical; otherwise the shunt resistance would have the effect of flattening the resonance peak.

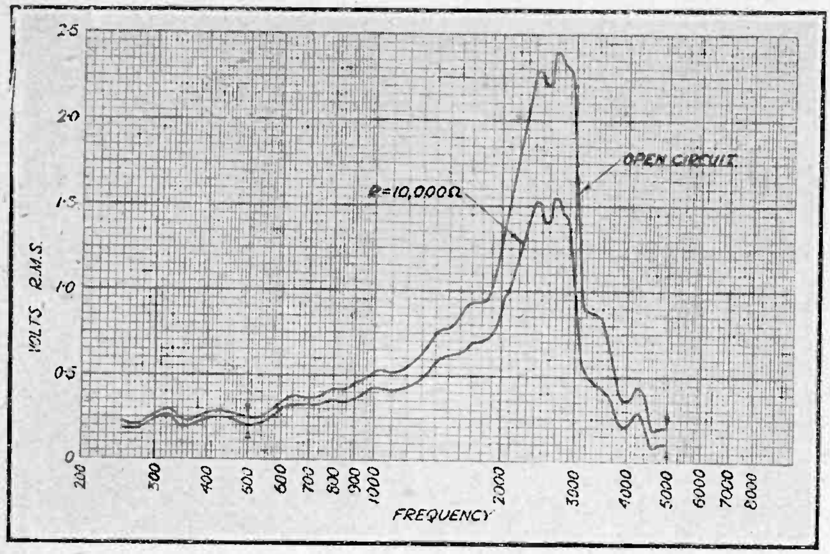


Fig. 3.—Characteristics of experimental pick-up with 10,000-ohm shunt and on open circuit. Comparison of the curves at 500 and 5,000 cycles where the output level is of the same order shows that the shunt resistance produces a greater reduction of output at the higher frequency.

The *percentage* difference in voltage output between the two curves, irrespective of variations in amplitude, is shown in Fig. 4. Comparing this with the 10,000-ohm curve in Fig. 2, it will be seen that they are in agreement at 5,000 cycles where the inductive impedance is high compared with the resistance. The practical curve, however, fails to reach the 100 per cent. line. This is accounted for by the resistance of the pick-up windings which was not taken into account in calculating the curves of Fig. 2.

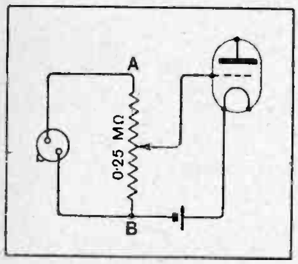


Fig. 5.—Potentiometer volume control. The high-note loss is negligible provided the total resistance of the potentiometer exceeds 100,000 ohms.

It may therefore be taken for granted that the variable shunt resistance as a method of volume control is definitely bad. This leaves us with the alternative potentiometer scheme as shown in Fig. 5, which gives, without high-note loss, provided the total resistance of the potentiometer is sufficiently high, a range of volume from zero to maximum. Investigation of a number of representative commercial pick-ups indicates 0.25 megohm (250,000 ohms) as a good average value. In general the total resistance across the terminals should not be less than 100,000 ohms, but in the unlikely event of a pick-up being found with an excessive high-frequency output a lower value might be usefully employed to correct matters.

In conclusion, a word about the correct method of connecting a potentiometer. Many components of this type have a logarithmic distribution of resistance. In other words, the resistance change for a given angular movement of the contact arm is greater at one end of the scale than at the other. The reason for this is that the acoustic output from the loud speaker is proportional to the square of the input voltage from the pick-up. If the potentiometer resistance is divided logarithmically the sound output is evenly distributed over the range of movement of the contact arm. It is essential, however, to connect the ends of the resistance the right way round, otherwise the range of control will be crowded to one end of the scale. The low-resistance end should be connected at A in Fig. 5, and the high-resistance end at B.

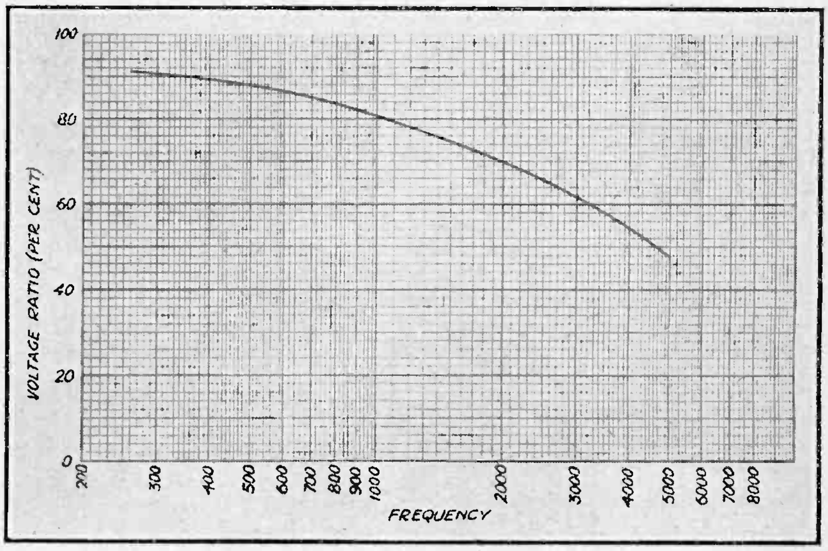


Fig. 4.—Curve derived from Fig. 3 showing percentage reduction of output with frequency due to 10,000-ohm shunt.

CURRENT TOPICS.

Events of the Week in Brief Review.

THE COMPLIMENTS OF THE SEASON.

To all readers of *The Wireless World* from the Arctic to the Antarctic we extend our best wishes for a Merry Christmas and a Happy New Year.

oooo

CHRISTMAS GREETINGS BY WIRELESS.

Special facilities for sending Christmas messages to ships at sea are announced by the Postmaster-General. From Rugby Radio greetings can be addressed to "ships on all seas" at 1s. 6d. a word. Ships up to five days from any British port can be reached *via* British and Irish land stations at 11d. a word.

oooo

BROADCAST "STUDIO" ON POLISH TRAIN.

The first of the wireless-equipped trains on the Warsaw-Cracow line is now ready, writes a correspondent. Each seat is fitted with a receiving point fed from a central receiver in a special "studio" which includes a microphone for announcements and a gramophone amplifier. Passengers pay a small fee for the hire of headphones, which are disinfected after use.

oooo

FRENCH BROADCASTING "WAR": ANOTHER STAGE.

The "Broadcast Defence Committee" is the name of an organisation formed in Paris by the minority party who are in favour of complete State control of broadcasting, writes our Paris correspondent. It is unlikely that the Committee will exert much influence on the progress of the broadcasting Bill, but as this intricate piece of legislation can hardly take practical shape before the autumn of 1930, the minority still hope that its terms can be modified. The Bill aims at creating a semi-State monopoly on the lines of the B.B.C.

oooo

FRANCE WINS "SUPERHET" CLAIM.

M. Lucien Levy, the French wireless worker, has received official advice from the American Patent Office admitting his claim as the inventor of the superheterodyne. The claim was also recognised recently by the German Patent Office.

oooo

WHAT IS YOUR WAVELENGTH?

"Every man has his own wavelength," declares Dr. Moineau, a French scientist, who claims to have invented an animal wavemeter. He states that human beings radiate waves of between 22 and 45 millimetres. The new police radio organisation in France should make a note of this.

oooo

5SW RELAYED IN AMERICA.

5SW, the short-wave broadcast station at Chelmsford, and the Post Office telephony station at Rugby, both transmitted Marchese Marconi's speech from a B.B.C. studio on December 12th when the inventor described his first experiments in Transatlantic wireless telegraphy twenty-eight years ago. The 5SW transmission was selected by the Radio Corporation of America for relaying to listeners in the United States. Many enthusiastic reports have been received.

oooo

HIDDEN ADVERTISEMENTS COMPETITION.

A large number of readers entered for the Hidden Advertisements Competition in our issue of December 11th, and the following are the prize-winners :—

1st Prize (value £7 10s.): Herr Robert Käubler, Jordanstr 31, Dusseldorf, Germany.

2nd Prize (value £5): Mr. Alfred Jackson, 48, Fenwick Road, Peckham, S.E.15.

3rd Prize (value £2 10s.): Mr. Maurice R. Guy, 70, Cambridge Road, New Malden, Surrey.

Consolation prizes (each to the value of £1) are awarded to the following: Mr. S. H. Lewis (Guildford), Mr. R. de S. Stawell (Falmouth), Mr. R. Harrison (London, S.E.3), Mr. J. Lovell (Brigg, Lincs), and Mrs. M. Martin (Edinburgh).

oooo

SOUTHWARD HO! Operating the Marconi direction finder in the chart room of "Discovery II," the Royal research ship which left London on December 14th for a three years' scientific research voyage in the Antarctic.

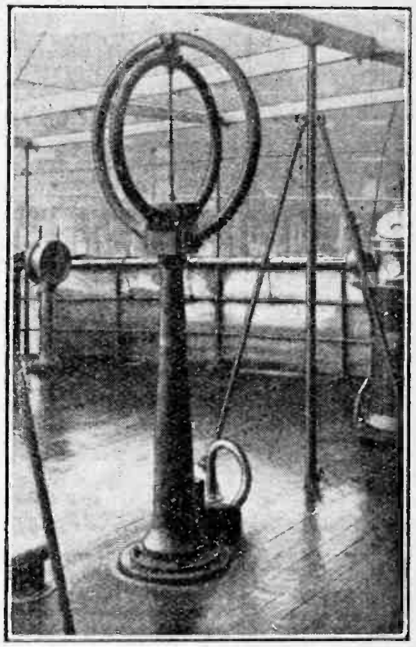
WORLD BROADCASTING ON FIFTEEN WAVELENGTHS.

Long-distance listeners who are seeking fresh worlds to conquer can begin with the New World by picking up the G.E.C. transmissions from Schenectady (New York). Some fifteen channels are now in use, ranging from 790 kilocycles (380 metres) to 23,080 kilocycles (13 metres), the last-named being that of W2XAW.

For broadcast to foreign countries considerable use is made of W2XAF, 31.4 metres (9,530 kC.), and W2XAD on 19.6 metres (15,340 kC.), but experimental transmissions are also carried out on 187.4 metres (1,604 kC.), 125 metres (2.398 kC.), 100 metres (3,256 kC.), 62.6 metres (4,795 kC.), 46.7 metres (6,425 kC.), 34.7 metres (8,650 kC.), 23.4 metres (12,850 kC.), and 17.3 metres (17,300 kC.).

The following call-signs are used indiscriminately, viz., W2XAZ, W2XAH, W2XK, W2XAC, W2XO, W2XAH, and W2XAK, in addition to W2XAW already mentioned.

Television tests are conducted on about 139.5 metres with the call-letters W2XCW. All telephony tests with aircraft are carried out on 130.4 metres (230.2 kC.) and 97.3 metres (3,076 kC.) with the call-sign W2XCH.



DIRECTION FINDING IN THE ANTARCTIC. The Marconi direction-finder aerial on the bridge of "Discovery II."

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RADIO MANUFACTURERS' ASSOCIATION.

Captain J. W. Barber, of the Brownie Wireless Co. of Great Britain, has been elected chairman of the Radio Manufacturers' Association in succession to Mr. John T. Mould. The new vice-chairman is Mr. R. M. Ellis, of Climax Radio Electric.

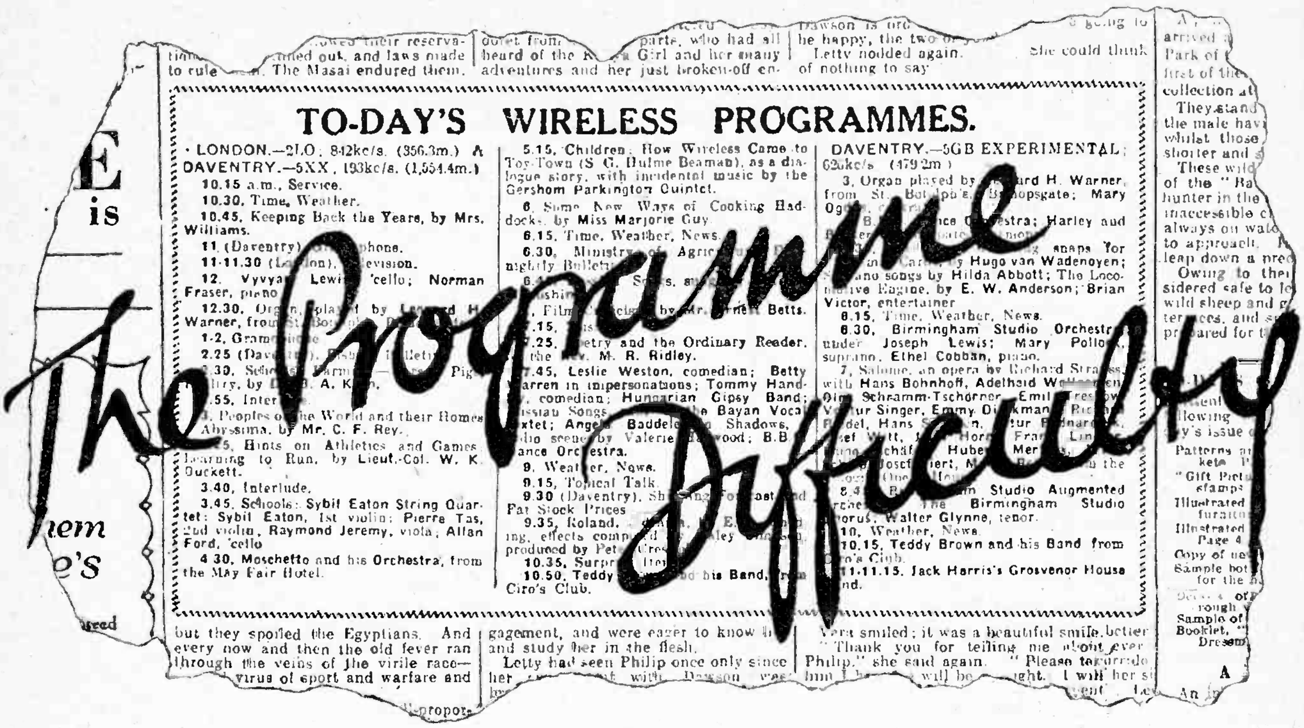
oooo

THE PARALLEL-FED L.F. AMPLIFIER.

It is regretted that an error occurred in the appendix to the article "The Parallel-fed L.F. Amplifier" on p. 647 of our issue of December 11th. The design formula should read thus :—

$$C = 2L\left(\frac{B}{A}\right)^2 \quad \text{Where } A = R_a + r + \frac{R_a}{R}r = R_a + Br, \quad B = 1 + \frac{R_a}{R}$$

Lines 31, 32, 33, second column, p. 644, should therefore be read: ". . . the resistance r representing the transformer primary resistance."


TO-DAY'S WIRELESS PROGRAMMES.

LONDON.—2LO, 842kc/s. (356.3m.) A DAVENTRY.—5XX, 193kc/s. (1,554.4m.)
10.15 a.m., Service.
10.30, Time, Weather.
10.45, Keeping Back the Years, by Mrs. Williams.
3.40, Interlude.
3.45, Schools: Sybil Eaton String Quartet: Sybil Eaton, 1st violin; Pierre Tas, 2nd violin, Raymond Jeremy, viola; Allan Ford, 'cello.
4.30, Moschetto and his Orchestra, from the May Fair Hotel.

5.15, Children: How Wireless Came to Toy Town (S. G. Hulme Beaman), as a dialogue story, with incidental music by the Gershom Parkington Quintet.
6, Some New Ways of Cooking Haddock, by Miss Marjorie Guy.
6.15, Time, Weather, News.
7.45, Leslie Weston, comedian; Betty Warren in impersonations; Tommy Handley, comedian; Hungarian Gipsy Band;
9, Weather, News.
9.15, Topical Talk.
10.35, Surprise Item.
10.50, Teddy Brown and his Band, from Ciro's Club.

DAVENTRY.—5GB EXPERIMENTAL; 626kc/s (479.2m.)
3, Organ played by Leonard H. Warner, from St. Botolph's, Bishopsgate;
6.15, Time, Weather, News.
6.30, Birmingham Studio Orchestra under Joseph Lewis; Mary Pollock, soprano, Ethel Cobban, piano.
7, Salome, an opera by Richard Strauss, with Hans Bohnhoff, Adelheid Wollgarten,
10, Weather, News.
10.15, Teddy Brown and his Band from Ciro's Club.
11-11.15, Jack Harris's Grosvenor House Band.

The Programme Difficulty

A Low-power Synchronised Transmission Scheme.

By HUMPHRY MacCALLUM, B.Sc.

ONE of the advantages of the gramophone, as compared with radio, is that, within the limits of your means or your foresight or your borrowing capacity, you can listen when you like to what you like; one of the limitations of radio is that you cannot do so. If you have a gramophone and access to records of all sorts you can make your own programmes and you can make them just when you want them. But with radio you have a limited choice, since you can listen only to what is in the programmes of those stations that are broadcasting at the moment and happen to be within range.

Radio can give quality reception which is beyond serious criticism, quality which can be relied upon to please the discriminating ear of the music critic, and indeed of the musician himself—provided he is satisfied to forgo long-distance reception and to rely almost entirely upon the fare offered by the B.B.C. But at present this is not an altogether attractive prospect. The most enthusiastic supporter of the B.B.C. is forced to recognise that there are periods during which individuals or groups, if not whole classes, of listeners are thoroughly bored. On some occasions, indeed, listeners are transported beyond the boundaries of boredom to the regions of exasperation.

One cannot blame the B.B.C. programme department for this. They have done more than well with the limited facilities at their disposal, for they have at least succeeded in providing programmes which, on the whole, have been sufficiently attractive to make broadcasting a feature in the lives of the people.

It is quite definitely impossible to please everyone with one programme, or even with two programmes, though the availability of an extra programme is an immense step in the right direction. If you remove the church service to please the radio dealer, who does not want to talk shop to an accompaniment of the Psalms, you will most certainly upset a large body of serious-minded listeners, and if, in response to the clamour of the afternoon dance enthusiast, you discontinue the fading out of so-and-so's orchestra which prefaces the friendly "Good afternoon, scholars," you will upset another, perhaps larger, body of serious-minded listeners. Clearly you can't do much with one programme. In present circumstances the alternative programme is, as a rule, either inaccessible to the listener or is received at diminished volume, and in any case it is rarely a true alternative, which, of course, detracts immensely from its value.

THE writer, who was intimately associated with British broadcasting in its earliest days, suggested the sites for the original chain of $1\frac{1}{2}$ kw. stations which has held sway, with modifications, for the last seven years. While "The Wireless World" disclaims responsibility for the views expressed in this article, it is felt that they are worthy of more than passing attention.

The scheme of broadcasting suggested in this article is designed to ensure that the listener will receive a true alternative which is, to an extent, of his own selection, and that he will not find himself asked to listen to some-

The Programme Difficulty.—thing he does not want to hear. If it is adopted, our dance enthusiast will not have his dance music faded out to give place to the unexpected and unwanted voice of the scholar's mentor. The susceptibility of the religiously inclined will not be shocked by the change from a religious address to a secular concert. The earnest scholar will have facilities for gleaning the knowledge he so assiduously seeks. The highbrow will have his heights and the lowbrow his depths. Mayfair and Kensington, Peckham and Tooting, Mile End Road and Dockland, will have programmes to their liking, and all these not at arbitrary times fixed by the B.B.C. but, as far as possible, continuously available at the will of the listener.

The Listener to Choose His Fare.

The means by which these alternatives can be provided appear to be quite practicable, and it is somewhat remarkable that they have not previously been suggested. They will be dealt with shortly. In the meantime it will no doubt be universally agreed that the provision of alternatives in the manner indicated is eminently desirable. It would even seem that the introduction of a scheme providing such facilities would result in radio receiving an impulse of the most powerful kind and that, because of the new possibilities, its future prospects as a means of entertainment and education, as well as an industry, would be considerably greater than has hitherto been considered to be the case.

FIRST STEPS IN BROADCASTING. A photograph taken in the tiny studio at Marconi House in 1922. In the early days the technical novelty of broadcasting overshadowed programme considerations.

The essential point in the suggested scheme is that the listener shall himself be able to select what class of entertainment he is to listen to, and to change at will to a true alternative programme. An individual listener does not always want to listen to the same type of entertainment. While detesting talks, Brown, who is an enthusiastic motorist, may be anxious to hear an address by Sir Henry Segrave. Jones, who, as a rule, considers the News a waste of time, may tune in to see whether Compston has beaten Hagen at golf, though normally he would wish to listen to dance music at that time of the evening. Robinson is a bee expert and of musical taste as well. He usually listens to symphony concerts and the like, but a talk on bees will lure him away from his normal vogue. And so on and so forth.

Now if Brown and Jones and Robinson have the choice of, let us say, four programmes which we may call A, B, C, and D respectively, and if—and this is the essence of the proposition—they all know that talks on bees can only be heard from station D, and that symphony music can only be heard from station B, that golf reports emanate from station C, from whence also comes Sir Henry Segrave's address, and so on, then every listener by tuning in to one or other of the four alternatives, will make sure of hearing at any rate the *class* of broadcast he wishes to hear at that particular time.

Common Wavelengths Synchronised.

To make this perfectly clear we can assume a hypothetical table of programme classification as follows:—

Station A.—Broadcasts only "popular" entertainment.

Station B.—Broadcasts only "highbrow" entertainment.

Station C.—Broadcasts Time, News, Weather, Politics, Talks (other than educational), etc.

Station D.—All Educational and Religious broadcasts from this station.

This classification is merely by way of suggestion in order to fix ideas. That eventually adopted would, no doubt, be the result of a somewhat interesting research carried out by the programme department of the B.B.C. on the lines indicated.

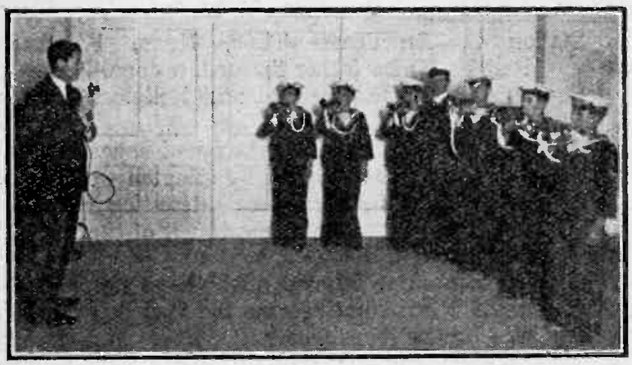
The four-programme scheme might have been introduced in 1922, when what became the B.B.C. chain of stations was under consideration. Four high-power stations grouped together at, say, Daventry, would have filled the bill. But in those days the authorities were hard-hearted on the subject of power, which was limited to $1\frac{1}{2}$ kW. There are obvious drawbacks to this method, however, and in any case the time for its adoption is past, if only because there now exists a large body of listeners who regard themselves as having a vested interest in their own particular local station. Any scheme which does not meet this difficulty cannot be considered seriously.

An alternative four-programme scheme with fewer drawbacks, and one which appears to have the merit of novelty, is based upon the use of one wavelength for a number of stations sending out simultaneously the same programme.

Recent research has disclosed the fact that although the common use of one wavelength by stations sending out different programmes is unsatisfactory, if not unworkable, excellent reception over a limited area surrounding each station can be assured when two or more perfectly synchronised stations are sending out the same programme. The attempt at sharing common wavelengths with Continental stations was doomed to failure because the programmes differed and because synchronisation was imperfect. Where all the stations taking part

The Programme Difficulty.—
in the scheme are under one control, as in the case of the B.B.C. stations, conditions are favourable for best results in regard to synchronisation, and the B.B.C. engineers have shown that it is possible to maintain stations permanently synchronised under practical conditions. The provision of identical programmes is mainly a matter of land-line facilities, though in certain cases a radio link becomes possible without increasing the number of wavelengths in use.

The scheme now put forward is based upon the use of low-power stations using four wavelengths but, to meet certain limitations, two additional stations of high power, operating on two extra wavelengths are suggested. The total number of wavelengths required for the whole country would, therefore, be six, one of which might be the existing 5GB wave, and another the 5XX wave.



AN EARLY "SURPRISE ITEM." Boys of the training ship "Exmouth" broadcasting a bugle call from Marconi House.

One Station, Four Wavelengths.

At present we are using ten wavelengths; there is therefore a saving in this derection which would allow for extra wavelengths for television or other services, or alternatively, would allow for wider spacing between the used wavelengths and therefore less liability of interference.

The main scheme provides only for densely populated districts. The two extra stations are intended to provide for the sparsely populated areas, the inhabitants of which, under the new scheme, would have the choice of two British programmes only and, of course, such Continental programmes as their apparatus enabled them to pick up. The sparsely populated districts will suffer by comparison with the centres of population, but this is only relative, and owing to considerably improved programmes and less interference the listeners in these districts will really be better off than at present.

Listeners at centres of population will have a full choice of four alternative programmes classified in the manner suggested, and available at good strengths and of ideal quality. For them at any rate, i.e., for the vast majority of the population, the scheme would appear to provide a complete solution to existing programme difficulties.

What can we find against this ambitious scheme? The technical difficulties do not appear to be insurmountable. We know it is possible to send out four programmes on four different wavelengths from one broadcasting centre, and Captain Eckersley has published results from which we are entitled to deduce that such centres can be duplicated or multiplied within reason as required without increasing the number of wavelengths in use.

The Financial Aspect.

Is the scheme financially unsound to a degree that would put it out of court? Will it cost too much to broadcast four waves from each important centre of population? Will it cost too much to provide four classes of programme continuously? Figures are not available, but it would seem reasonable to suppose that a very greatly increased revenue from licences would result from the introduction of the scheme, and that this would more than provide for any increased expenditure. Each centre of population would, in a sense, become self-supporting. The larger centres, like London, Manchester, etc., might be expected to contribute, through the medium of licences, sufficient funds to cover the provision of the four simultaneous broadcasts at appropriate power, whereas smaller centres, though less important financially, might be expected to contribute funds sufficient to provide for the needs of the districts which would be met by a simultaneous broadcast on reduced power.

SATISFYING THE PIONEER LISTENER. In 1922 the only instrument which was faithfully reproduced throughout its range of frequencies was the set of tubular bells seen in the picture. Listeners were delighted!

It is possible that the scheme might be developed along these lines to an extent which would enable quite small centres of population to come in economically, and by a low-power local broadcast add one or more programmes to those already received from the high-power stations, without increasing the number of wavelengths in use. A series of such stations held at the disposal of the Educational Authorities, and paid for

The Programme Difficulty.—

by Government grant would give free scope for educational activities and avoid the necessity for interfering with the two high-power programmes.

It will be realised that the cost of producing programmes is not likely to increase abnormally, since four only are required for the whole country. Each may be the very best of its class, and fees will be correspondingly heavy, but a counterbalancing economy results from the fact that there is no duplication as at present with the large number of stations in existence.

The scheme suffers from the drawback that it fails to provide for the programme of purely local origin. The best of the "local" items will find their outlet, however, in the appropriate national programmes.

A further, though not very serious, disadvantage of the suggested scheme lies in the possibility of items of equal attraction to the individual listener running concurrently in different programmes. Robinson's "talk on bees" might conceivably coincide with his favourite symphony, and he would perhaps be annoyed at not being able to hear both. But this class of fault is surely outweighed by the many good points of the scheme, which may be summarised as follows:—

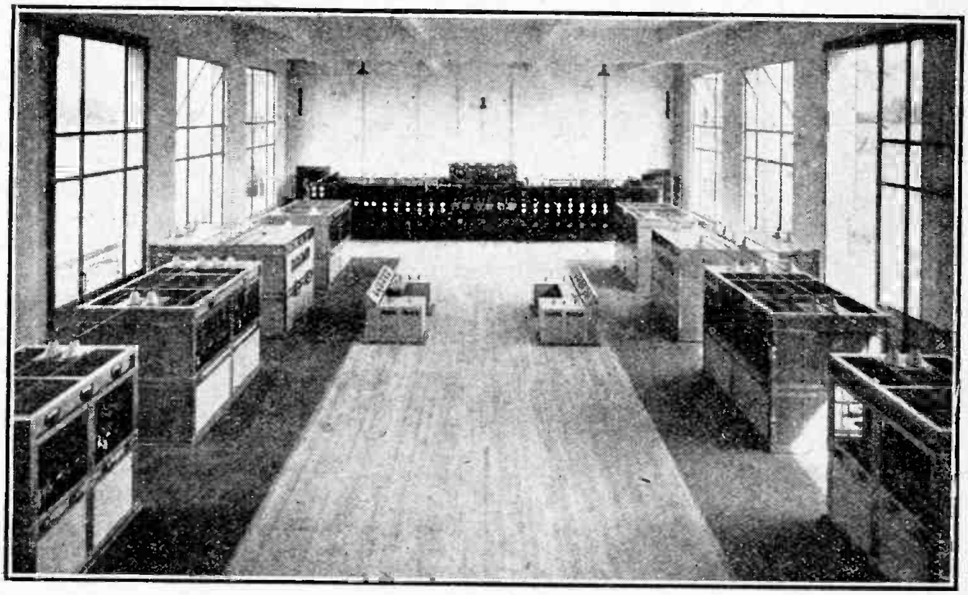
(1) A greater choice of programmes than has hitherto been possible is provided at good strength at all important centres of population. Every listener at these centres has available, at equal strength, and all the time during broadcasting hours, four different classes of programme.

(2) Considerable economy in wavelength is obtained, the whole country using six waves only for home broadcasting purposes.

(3) The cost of programmes is reduced and/or their quality improved, since only one first-rate programme of each class is required instead of some half dozen second-rate programmes, as at present.

(4) Long-distance listening, with its unavoidable unreliability, is discouraged by the provision of reliable near-by transmissions of the very best quality, offering a choice of programme unobtainable elsewhere. As a result of this, radio is likely to assume a popularity far in excess of that held by it at present, and, indeed, in excess of the wildest dreams of its most ardent supporters.

(5) Although the scheme provides continuous and unlimited entertainment of a type suited to every class of listener, it also provides uninterrupted scope for programmes of an instructional, educational, political, and religious type. The conflict of interest between the various sections of thought regarding the provision of programmes automatically comes to an end since each section has a free choice of sufficient alternative programmes at adequate strength.



IS THIS TYPE OF TRANSMITTER NECESSARY? The twin transmitters at Brookmans Park, which, if our contributor's scheme were to materialise, would be the biggest white elephants in the zoology of the ether.

It would seem that the scheme carries with it so many important advantages that it is at least worthy of serious consideration, and, should it prove to be practicable, its introduction by the B.B.C. will exterminate for ever the persistently recurring slander anent the intention of that body to provide what it considers to be good for the people rather than what the people consider to be good for themselves.

CATALOGUES RECEIVED.

The Marconiphone Co., Ltd., 210-212, Tottenham Court Road, London, W.1.—Publication No. 585a, revised edition of new catalogue containing full description of the Marconiphone range of receiving sets, loud speakers and gramophone pick-up.

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The Halcyon Wireless Co., Ltd., 313-319, Regent Street, London, W.1.—Illustrated folder dealing with two new 4-valve transportable receivers recently introduced.

Cambridge Instrument Co., Ltd., 45, Grosvenor Place, London, S.W.1.—Illustrated leaflet of the Cambridge Surface Pyrometers, an instrument to provide accurate and convenient means of determining the inside temperature of bakelite and other moulding material during the process of manufacture.

Tungstone Accumulator Co., Ltd., 3, St. Bride's House, Salisbury Square, London, E.C.4.—24-page book describing and illustrating the construction of the paste-filled lead-grids used in Tungstone batteries. Also illustrated folders of H.T. and L.T. batteries for wireless use.

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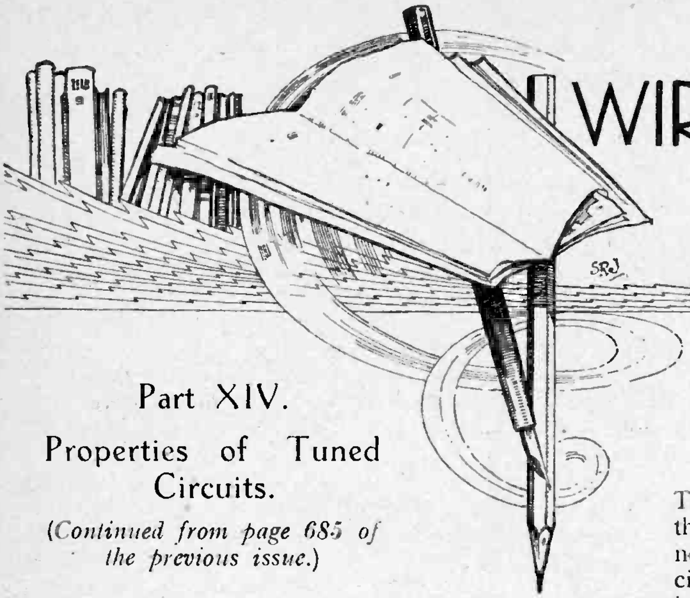
The Mainten Manufacturing Co., Ltd., Portland Road, Hove, Sussex.—Descriptive folders dealing with the range of battery eliminators, all-mains receivers, and metal cabinets manufactured by this firm.



WIRELESS THEORY SIMPLIFIED

Part XIV.

Properties of Tuned Circuits.

(Continued from page 685 of the previous issue.)

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

IT was shown last week how a series of circuit possessing inductance and capacity was capable of selecting currents whose frequencies were near the resonant frequency of the circuit whilst choking back currents with frequencies outside this band. Since the circuit allows maximum current to flow at the resonant frequency it is sometimes called an "acceptor circuit." It will be seen later that the parallel circuit has the reverse effect, and it is referred to as a "rejector circuit."

The resonant frequency of a series circuit is quite independent of the resistance, being determined by the product of inductance and capacity only, its value being $f = \frac{1}{2\pi\sqrt{LC}}$ cycles per second, but the amount of current passed at this frequency is determined by the resistance alone for a given applied voltage, because the respective reactances due to the inductance and capacity neutralise each other's effects completely at the resonant frequency.

The Closed Circuit.

To study the properties of a tuned circuit profitably we must do so from a practical point of view; that is to say, we must know the conditions under which the circuit is going to be used in practice and then find out the conditions in the circuit which will make for the highest efficiency.

The commonest example of a series tuned circuit in a wireless receiver is the ordinary tuned grid circuit preceding the first valve, *where the aerial is inductively coupled to the tuning coil* as shown in Fig. 1 (*a*). The alternating current in the aerial coil, produced by the signals being received, causes an alternating magnetic field to be linked with the coil L of the tuned circuit, and this in turn induces an alternating E.M.F. in the latter coil. Let the R.M.S. value of this voltage be E. This voltage will, of course, drive an alternating current round the closed circuit, R, L, C and the value of this current will be $I = \frac{E}{Z}$ amperes, where Z is the total impedance of the circuit.

Clearly we should get exactly the same effect if, instead of *inducing* the voltage E into the closed circuit by mutual induction, we were to connect a generator giving E volts at the same frequency anywhere in the circuit. This means that our closed circuit with applied E.M.F. induced in the coil is electrically equivalent to a series circuit with the voltage E applied to its ends as shown at (*b*) in Fig. 1. This is a point of fundamental importance; any closed circuit where the applied E.M.F. or energising E.M.F. is *induced* into it is equivalent to a series circuit; the current round the closed loop is simply given by $\frac{E}{Z}$, where Z is the impedance due to R, L and C in series.

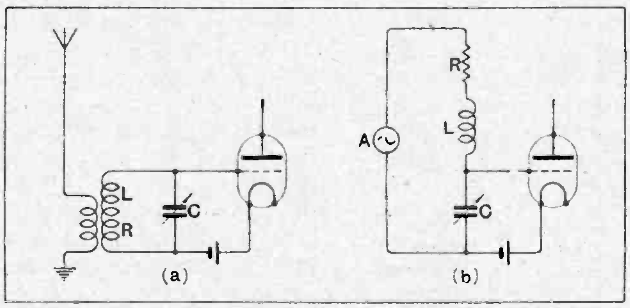


Fig. 1.—(a) Typical tuned grid circuit inductively coupled to the aerial. The tuned circuit is electrically equivalent to the series circuit shown at (b), where A is the source of alternating E.M.F. energising the circuit.

Voltage on the Grip of the Valve.

The valve depends for its action on the application of an alternating *voltage* between the control grid and filament and does not consume any current other than the small fraction of a microamp required to charge and discharge the grid when the valve is working under proper conditions. So the valve has its grid and filament connected across the condenser (or across the coil) of the tuned circuit as shown in Fig. 1 (*a*).

Now the voltage across the condenser is $I \times \frac{1}{2\pi fC}$ volts, where I is the current in the closed circuit and

Wireless Theory Simplified.—

$\frac{1}{2\pi fC}$ ohms is the reactance of the condenser. Thus the voltage applied to the valve is proportional to the current in the closed circuit and inversely proportional to the frequency. Obviously then the performance of this stage of the receiver will depend on the general characteristics of the resonance curve obtained by plotting the voltage across the condenser against the frequency rather than on the simple current resonance curve found previously. The required voltage resonance curve can be found very simply from the current curve merely by multiplying the current at a number of different frequencies by the condenser reactance at the respective frequencies.

The voltage resonance curve is necessarily not quite the same shape as the current curve, because in obtaining it we are multiplying the current values by a variable quantity—the frequency. In order to show the difference the values of voltage across the condenser have been worked out for the same circuit constants which were used before, namely, L=2532 microhenrys, C=0.00025 microfarads, and R=500 ohms. But this time the voltage applied to the circuit is taken as 0.1 volt instead of 10, that is to say, in the circuit of Fig. 1 (*a*), 0.1 volt is induced into the coil L, so that the current values shown in the last column of the table given in Part XIII are just a hundred times greater than in the present case.

The resonant frequency is 200 kilocycles per second and at this frequency the current in the closed circuit is a maximum, being $\frac{E}{R}=\frac{0.1}{500}$ ampere or 0.2 milliampere, and the reactance of the condenser is $X_c=3182$ ohms. Hence at the resonant frequency the voltage applied to the grid of the valve is $E_c=IX_c=0.0002\times3182=$ 0.636 volt. Note that this is 6.36 times greater than the voltage induced into the circuit by the aerial current even though the tuned circuit has the abnormally high value of 500 ohms.

Frequency Kilocycles per sec.	Condenser Reactance.	Current Milliamp.	Voltage across Condenser.
20	31,820	0.00317	0.101
40	15,910	0.0065	0.103
80	7,955	0.0149	0.119
120	5,303	0.0292	0.155
160	3,978	0.0662	0.263
200	3,182	0.200	0.636
240	2,651	0.0789	0.209
300	2,121	0.0370	0.0785
350	1,818	0.0264	0.048
400	1,591	0.0208	0.033

At the moment we are concerned with the shape of the voltage resonance curve and will return to the voltage step-up effect later.

The table gives the values of current, the reactance of the condenser, and the voltage across it for various frequencies between 20 and 400 kilocycles per second, the other conditions being as given above.

In order to make it easy to compare the shape of the voltage curve with that of the current curve, instead of plotting the actual values of current and voltages against the frequency, each is plotted as a percentage of the maximum value to a common base line denoting frequency values in Fig. 2. For instance, at 160 kilocycles per second the current is 0.0662 milliampere or 33.1 per cent. of the maximum value of 0.2 milliampere. By adopting this expedient the peaks of the curves are made to coincide.

The current curve is shown as a full line and the voltage curve as a broken line.

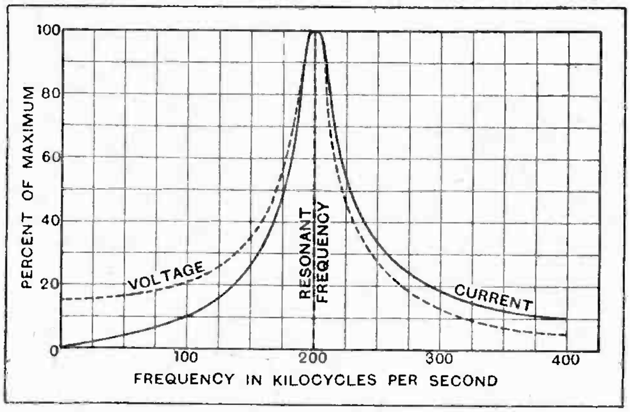


Fig. 2.—Current and voltage resonance curves for a series circuit. The values of each are plotted as a percentage of the maximum value to facilitate comparison. L = 2532 microhenrys. C = 0.00025 mfd. R = 500 ohms.

Although it can be shown mathematically that the peaks of the two curves do not occur exactly at the same frequency they are so close together for all normal values of circuit resistance that we can assume that they coincide at the resonant frequency. But it is clear that for frequencies far removed from the resonant value the two curves are rather widely separated; but even so, they are very similar in shape.

Conditions for Maximum Signal Strength.

From the resonance curves of Fig. 2 we see quite definitely that the voltage applied between the grid and filament of the valve will be a maximum when the current in the closed circuit is greatest at the resonant frequency. As explained, this current is determined alone by the resistance of the circuit and so from the point of view of obtaining the greatest signal strength it is of prime importance to make the resistance of the tuned circuit a minimum. At high frequencies the resistance of the tuning coil depends not only on the size of wire with which it is wound, but on other factors to which a section will be devoted at a later date.

In the actual circuit we have been discussing a resistance of 500 ohms was chosen to simplify the calculations and to accentuate the effects of the resistance relatively to the other constants. Even with a resistance as high as 500 ohms, in a circuit where L=2532 microhenrys and C=0.00025 microfarads, the voltage built up across the circuit at the resonant frequency was seen to be 6.36 times greater than the E.M.F. induced into the circuit. If the resistance were reduced to 50 ohms, a more practical value, the current in the circuit would be increased tenfold at the resonant frequency and the voltage across the condenser would be 63.6 times greater than the incoming

Wireless Theory Simplified.—
voltage. The importance of keeping the resistance down will thus be evident.

To show the important effect of resistance in this direction a number of current resonance curves are given in Fig. 3 for a circuit with the same inductance and capacity values as before but with different values of resistance as marked on the individual curves. It will be seen that the peaks of the curves have varying heights according to the resistance, but that they are all about the same width near the bottom. The values are worked for a voltage of 0.1 induced into the coil.

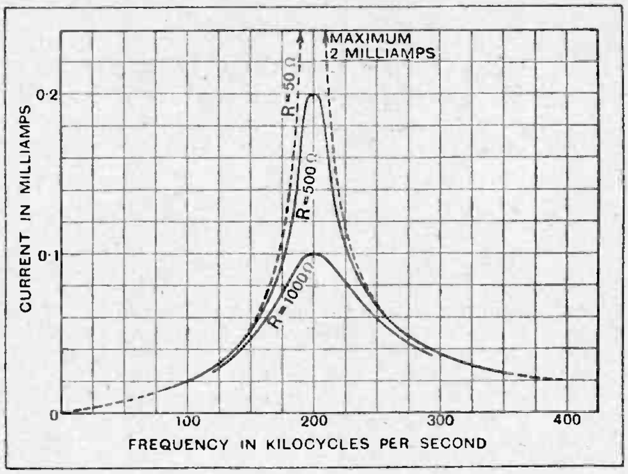


Fig. 3.—Current resonance curves for series circuit showing the effects of resistance. L = 2532 microhenrys. C = 0.00025 mfd.

How the Values of L and C Affect the Signal Strength.

It was shown that the voltage applied to the valve grid at the resonant frequency is not only proportional to the current in the circuit but also inversely proportional to the capacity of the tuning condenser. Now since the frequency to which the circuit is tuned is given by $\frac{1}{2\pi\sqrt{LC}}$ cycles per second it follows that the resonant frequency is determined by the *product* of inductance and capacity. Hence, if the inductance were doubled and the capacity halved the product would still be the same and the circuit would still be tuned to the same frequency. Furthermore if the resistance were not increased in the process the value of the current circulating round the circuit at the resonant frequency would be unchanged and so the voltage across the condenser would be doubled.

The inference is that for high voltage step-up in a tuned series circuit the ratio of inductance to capacity should be kept as high as possible. But of course a coil of higher inductance necessarily incurs an increase of resistance as more turns, usually of thinner wire, are required and so the gain in voltage is partly off-set by a reduction of the current. In practice we must strike a compromise which gives the optimum voltage step-up effect. The tuning condenser is usually a variable one, the inductance being fixed and in normal practice the value of inductance is so chosen that the maximum wavelength or minimum frequency to which the receiving set is required to tune calls for a variable condenser whose maximum value of capacity is of the order of 0.00025 to 0.0005 microfarad.

A tuned circuit where a variable condenser is employed gives the greatest voltage step-up effect at the higher end of the frequency scale or lower end of the wavelength band when the condenser is set to low values of capacity.

(*To be continued.*)

CLUB NEWS.

How Mains Sets Work.

The Philips 4-valve receiver was the subject of a lecture given by Mr. Cooper, of Philips Lamps, Ltd., on Friday, December 6th, before the Bristol and District Radio Society in their Club Room at Bristol University. By means of blackboard diagrams, the lecturer clearly explained how the A.C. mains were utilised for the working of wireless receivers.

The Annual Meeting of the Society will be held on January 24th, when it is hoped that all members will be present. Full details of the Society may be obtained from the Hon. Secretary, Mr. S. T. Jordan, 1, Myrtle Road, Cotham, Bristol.

Valve Manufacture Described.

A lecture on valves given by Mr. W. L. Hartshorne, of Messrs. Cossor, Ltd., was the chief item of interest at a recent meeting of Slade Radio (Birmingham). Many important details of manufacture were explained, while samples of the various parts exhibited were submitted to a searching examination by a group of interested members.

Details of the Society's activities may be obtained from the Hon. Secretary, 110, Hillaries Road, Gravelly Hill, Birmingham.

An Amplion Demonstration.

A large and enthusiastic gathering greeted Mr. P. K. Turner, of Graham Amplion, Ltd., for his lecture and demonstration of one of the Amplion A.C. mains receivers before the Muswell Hill and District Radio Society on December 11th. The necessary alternating current for the set was obtained from an A.C. generator running off the D.C. mains. Mr. Turner dealt with numerous points of design in the receiver and showed how good quality had been secured despite the use of reaction; though the judicious use of the latter, together with a screened grid valve, suited the set admirably for distant reception, as was proved in the subsequent demonstration, when numerous Continental stations were picked up at excellent strength with only an apology for an aerial.

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

Photo-electric Cells.

Photo-electric cells were described and demonstrated by Mr. Walker, of the General Electric Co., at the meeting of the Tottenham Wireless Society on December 3rd. With the aid of lantern slides the lecturer explained their theory and present-day use, concluding with a demonstration showing their capabilities in street lighting control.

Hon. Secretary, Mr. W. Bodemeaid, 10, Bruce Grove, Tottenham, N.17.

Mains Set Operation.

The operation of radio receivers from the mains formed the subject of a constructive lecture given by Mr. Wyborn, of Messrs. Ekco, Ltd., at the last meeting of the Southend and District Radio Society. The lecturer started with the simplest form of high tension eliminator for direct current mains. He pointed out difficulties in operating sets arising from this elementary apparatus. From this he proceeded in stages to a final high efficiency type suitable for powerful and complicated receivers used on the roughest of mains.

Hon. Secretary, Mr. F. J. Waller, Lynthorpe, Grange Gardens, Southend-on-Sea.

H.F. Amplification: Old and New.

A practical lecture on high frequency amplification was given by Mr. C. Neems-Stanley at a recent meeting of the Tottenham Wireless Society. The lecturer first reviewed the methods in general use for obtaining H.F. amplification prior to the advent of the screened grid valve. Some interesting comparisons were drawn between the efficiency of the early methods as compared with those of to-day. Practical hints were given for the construction of coils for use with modern valves.

Cutting Out Brookmans Park.

The problem of interference from the new Brookmans Park transmitter was fully dealt with in a lecture at the last meeting of the North Middlesex Radio Society. The speaker, Mr. E. H. Laister, dealt especially with the case of the simple unselective receiver which is in such extensive use at the present time. The use of a loose-coupled circuit was advocated as the simplest and probably most effective modification which could be made, and it became obvious, from the speaker's remarks, that the separation of stations of fairly close wavelengths was not the intricate task that many people imagined. Wave-traps were denounced owing, said the lecturer, to their disconcerting propensity for cutting out the wanted station as well as the unwanted.

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

BROADCAST BREVITIES

By Our Special Correspondent.

New Test for "B.P." Listeners.—European Programme Exchanges.—Greeting the New Year.

A Mixed Post.

"A spate of letters," to use the vigorous phrase of the B.B.C. Correspondence Department, has occurred in regard to the Brookmans Park twin transmission tests. A few are congratulatory, but the majority are plaintive. Most plaintive of all are those from listeners who wish to know what has become of London's late dance music. Apparently, in spite of the torrent of publicity, there are people unaware of the existence of twin transmission tests!

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Tuning Out Twin Tunes.

The most fruitful cause of complaint is of inability to separate the two transmissions. Sufferers under this head may have further reason for lamentation in a week or two, for I hear that those unobtrusive talks from the 356-metre transmitter are to be replaced by music; European ether searchers know how much more difficult it is to separate two tunes than a tune and a talk.

As I prophesied last week, many of the general public are finding the 261-metre wavelength beyond their technical resources.

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Brookmans Park Uses Wireless Link.

An unpleasant message from the Post Office awaited the B.B.C. engineers when they rolled up for duty at 9 o'clock on the morning of Saturday, December 14th. A technical catastrophe at Holloway had resulted in a complete break in all the five lines which connect Savoy Hill with Brookmans Park. Throughout the day, therefore, the London Regional station had to pick up its material by wireless from Daventry 5XX, which explains the B.B.C.'s polite apology for the unusual amount of atmospherics.

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Europe Makes Merry.

New Continental landlines are to have their first real test on January 3rd, when the B.B.C. will co-operate with the German and Belgian broadcasting authorities in an original "give and take" relay from 8 to 9.15 p.m. The first portion of the programme will come from Cologne, and will consist of Haydn's "Fourth London Symphony." This will be followed by a relay from Brussels of the works of Gretry, and the feature will conclude with a B.B.C. transmission of Henry Purcell's "Fairy Queen."

Listeners in Germany, Belgium and Britain will hear all three portions.

Sunday Education.

Up till now the B.B.C.'s educational campaign has been limited to six days in the week. In 1930 it is to wave its standard on Sundays as well. The transmitter involved will be 5GB, which will send out a talk every Sunday from 5.45 to 6.15 on subjects of interest to students of theology. The speaker will be Dr. E. S. Waterhouse.

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A Programme Quandary.

If Savoy Hill wishes to proclaim the general high standard of programmes there is no better way than to draw attention to the quandary in which it finds itself over National Radio Week. This week of rejoicing begins on Sunday, January 12th, and the original intention was that the B.B.C. should prepare special "star" programmes for the occasion. But the programme people feel that the "star" standard has now been attained with unfailing regularity for months past. How can they improve perfection?

In all seriousness, can anyone suggest a really original feature?

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The Grand Good Night.

For the fifth year in succession the B.B.C. will bid a Grand Good Night to everybody on New Year's Eve, and this time it is hoped that nobody will be forgotten. One year this unique message, for which Mr. J. C. Stobart is responsible, was intended to greet all the great towns and cities of Britain, but Dundee was unintentionally omitted, and Savoy Hill very soon heard about it. Another dreadful omission occurred last year when a greeting to men of all trades and professions left out the firemen.

This year a special greeting will go out to the National Broadcasting Company of America.

AS OTHERS HEAR THEM. Students of broadcast technique at the Berlin School of Music listening to their own microphone efforts by means of a magnetised wire recording instrument.

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"Exit 1929."

The birth of the New Year will be celebrated by the B.B.C. in a radio sequence on December 31st-January 1st. The people of those countries which keep Central European time will hold their festivities one hour in advance of Great Britain. The clocks in Holland, which observe an independent time, will strike midnight approximately twenty minutes before Big Ben. When the Old Year has died in London it will still have five hours of life in New York.

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Celebrating on the Continent.

Hence the programme sequence will be on the following lines:—At 11 p.m. British listeners will hear midnight in Cologne, followed by dance music by Jack Hylton and his Band relayed from the Kit-Cat Restaurant. At 11.10 p.m. the celebrations in Paris, Copenhagen, Hamburg, Vienna, Frankfurt, Buda Pesth, Brussels, Madrid, Milan and Turin will be heard, with more dance music by Jack Hylton's Band. At 11.35 p.m. a relay of the bells of St. Vitus, Hilversum, will usher in midnight in Holland.

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"Good Morning, Everyone."

At 11.50 p.m. the B.B.C.'s own celebration will include a message for 1930 by Canon W. H. Elliott and the singing of the hymn, "O God Our Help in Ages Past," while the bells of St. Michael's, Cornhill, will "ring out the old." The striking of midnight will be relayed from Big Ben, followed by the bells of Southwark Cathedral, rung by the Ancient Society of College Youths. "Auld Lang Syne" will be sung before the lingering sounds of the Old Year are heard from New York. Then comes the Grand Good-night and a closing salutation at approximately 12.10 a.m. of "Good Morning, Everyone."

This YEAR'S PROGRESS in COMMERCIAL WIRELESS

By Lieut.-Colonel CHETWODE CRAWLEY, M.I.E.E.

Privacy in Transatlantic Telephony.—The Radiotelegraph Convention.—Less Broadcast Interference.—Wireless Beacons.

PUBLIC attention has been focused on commercial wireless communications in 1929 as it never has been before, at any rate so far as this country is concerned, with the possible exception of 1913, when the first scheme for Imperial communications, better known under the old halfpenny Press heading of "The Marconi Scandal," was under discussion in the House of Commons. Again the interest has been caused by our Imperial communications, in connection this time with the merging of the cable and wireless interests as a result of the report of the Imperial Wireless and Cable Conference which was published in July, 1928.

It will be remembered that this conference, at which the whole Empire was represented, was appointed to examine the situation which had arisen as a result of the competition of the beam wireless telegraph services with the submarine cable services. The conference recommended that the Government cable and wireless services for Imperial communication be transferred on certain terms to private enterprise, being merged with the Eastern Telegraph and its associated companies and the Marconi Company so as to amalgamate in one commercial undertaking, with a certain amount of Government control, all the cable and wireless interests conducting communications between the various parts of the Empire. These recommendations were accepted by all the Governments concerned, and the Government services were transferred to the merger on the 30th of September last.

This great communication merger, with a capital of over £53,000,000, consists of two new associated companies, the Imperial and International Communications Co., Ltd., which deals with the traffic, and Cables and Wireless, Ltd., which deals with the manufacturing side of the business.

This is the first great combination of cable and wireless interests that has taken place in the world, but during the year similar ideas have taken strong root in the United States of America, and efforts are being made to get rid of the ban imposed by law in that country upon mergers of interests dealing with wire, wireless and cable communications.

Wireless Telephony.

Wireless telephony has been specifically omitted from the British merger, and the British Post Office reserves the right to conduct the external telephone services of Great Britain and makes terms with the company when it uses the company's stations for telephone purposes. So far, no commercial telephone service has been opened on the beam system between England and the Dominions, though several interesting demonstrations took place during the year, notably that of broadcasting the Thanksgiving Service for the recovery of the King on July 7th. The service was transmitted from London to Bodmin by land-line, thence by beam telephone to Montreal, Canada, and again by beam telephone to Sydney, Australia. This service was rebroadcast, and was heard well all over Canada and Australia.

On the same day, and by the same route, conversation was held between England and Australia. This was the first time that duplex telephone conversation had been held between the two countries.

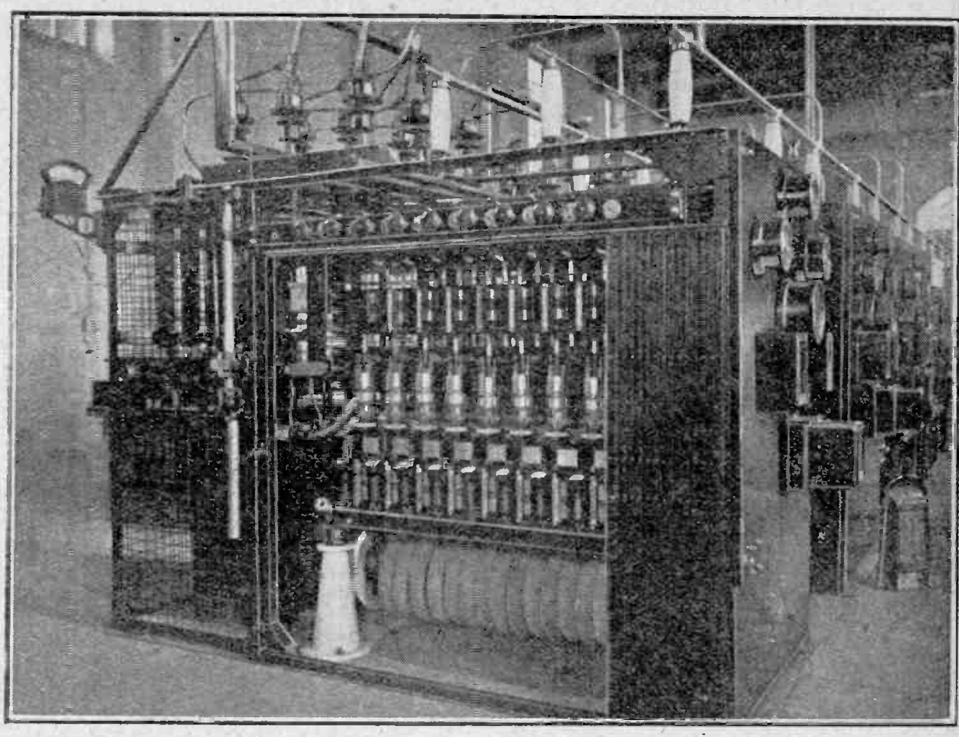
Another interesting experiment in long-distance telephony took place between Sweden and America, including the England-America wireless link. The total length of route traversed was about 14,000 miles, including the wireless link of 3,200 miles; this constitutes a record in distance for telephone communication.

The latest important wireless telephone link on the directive system was opened on October 12th between Spain and the Argentine. This is the longest wireless telephone circuit yet working, but by far the most extensive and important telephone link in the world is the Transatlantic circuit which was originally opened

This Year's Progress in Commercial Wireless.—

between London and New York in January, 1927.

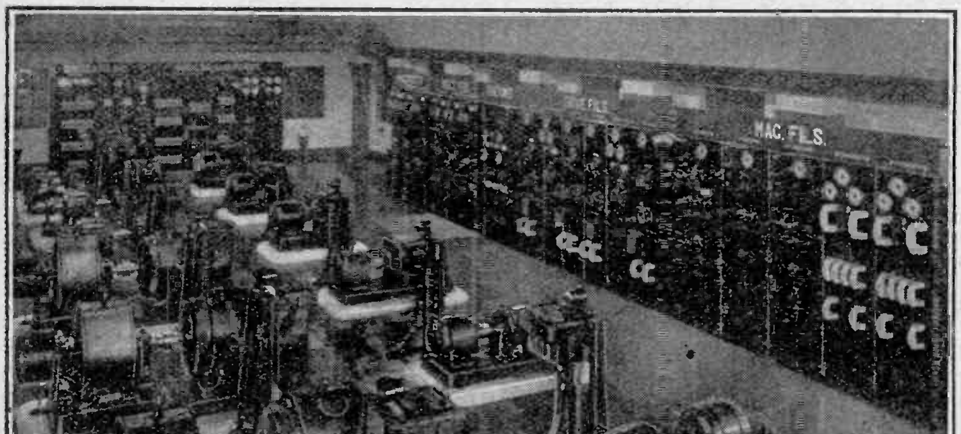
The use made of this Transatlantic wireless telephone circuit has increased considerably during the year, and there are now three short-wave channels working in addition to the long-wave channel. The traffic at present averages about 45 calls per day, the duration of each call being about six minutes. Ninety-five per cent. of the inward traffic comes from the United States, 4 per cent. from Canada and 1 per cent. from Cuba and Mexico. Of the outward traffic, 53 per cent. is from Great Britain, 34 per cent. from France, 7½ per cent. from Germany and 5½ per cent. from other European countries. The circuit suffered from the fact that it was possible to overhear conversations, but methods of imparting a high degree of privacy have recently been developed.



A valve panel at the Rugby station.

Short Waves.

This year has been notable for the almost universal adoption of short waves for long-range wireless telegraph circuits, and probably more new circuits have been opened than in any former year. The volume of traffic dealt with by wireless telegraphy has continued its rapid increase which began when the Imperial beam circuits came into operation three years ago, and by September, when these circuits were transferred to the merger company, they were dealing with some 900,000 words a week with this country.



The machine room, Tetney beam station.

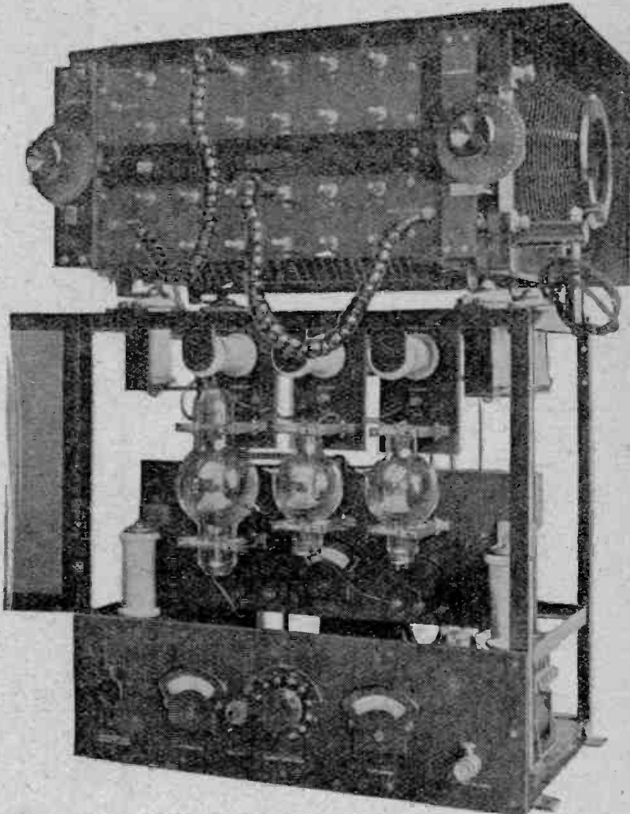
The Radio-Telegraph Convention.

As regards the wireless communications of ships, the most important events of the year were the coming into force on the 1st January of the new International Radio-Telegraph Convention, which resulted from the international conference held in Washington at the end of 1927, and the holding in London in April and May of an international conference on the Safety of Life at Sea.

The most important regulations brought into force by the Convention concerned the distribution of wavelengths amongst

This Year's Progress in Commercial Wireless.—
the various services; ships, aircraft, fixed, broadcasting and experimental. The use of the 300- and 450-metre waves, which had been extensively employed by small ships, has been curtailed in the interests of broadcasting, and is now practically abolished. For the same reason, spark sets at coast stations are being replaced by interrupted continuous wave installations, except in the case of very small ships' sets, in accordance with the regulations of the Convention. The qualifications required of ships' operators have been overhauled, and new regulations introduced in connection with distress and similar signals.

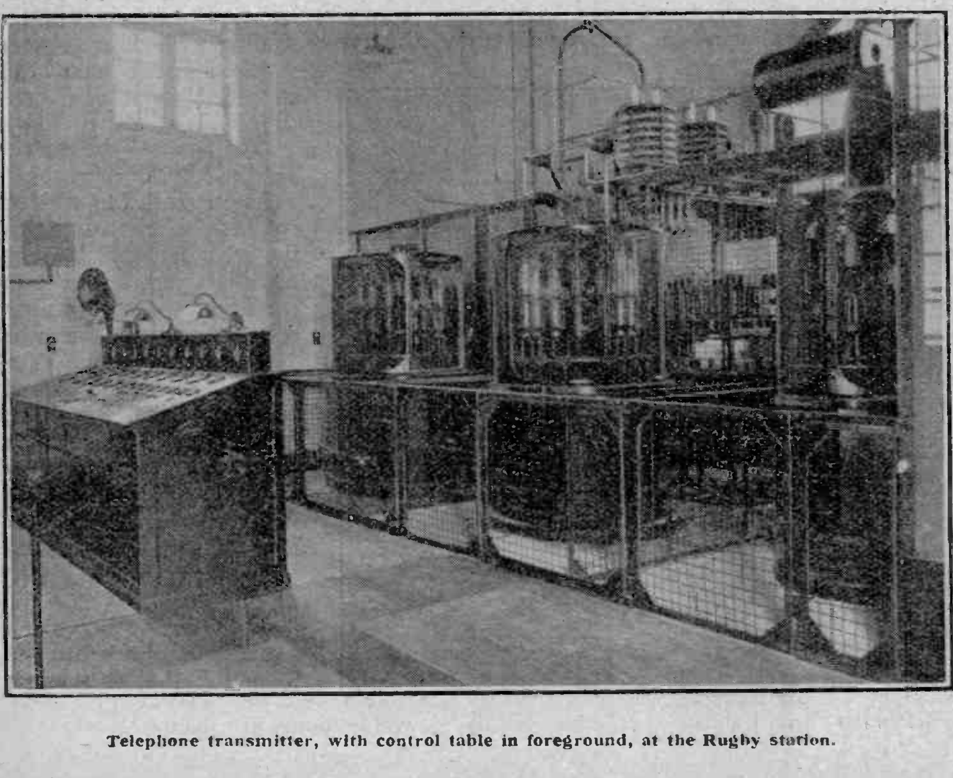
This regulation of wireless services throughout the world was long overdue as the provisions of the previous Convention of 1912 were quite inadequate and out of date, but it is surprising how well we had managed to get along since the War on a policy which had nothing behind it but goodwill and common sense.


A ship's long-range transmitter.

The Safety Convention.

The same might be said of the regulations governing the installation and use of wireless in ships in connection with the safety of life at sea. The only international convention dealing with this aspect of wireless signalling was produced in 1914, but owing to the War was never ratified by any of the countries concerned. Regulations were indeed introduced in this country just after the War on the general lines of those in the Convention, but, on the whole, the regulations in other countries were much less stringent. The new Convention, which will come into full force in 1931, will bring all other maritime countries into line with our present technical regulations, and will introduce several new important rules. For two years before this conference we alone had been using automatic apparatus for the reception of the alarm signal, and it was satisfactory that the conference recognised internationally the practical advantage of this apparatus for keeping a safety watch, and laid down watch-keeping rules for the ships in which it is fitted.

This will be, too, the first Convention to recognise the desirability of fitting directional receivers for safety purposes, and it stipulates that every passenger ship of 5,000 tons gross and upwards shall be provided with approved directional apparatus. The importance of wireless in connection with the dissemination, collection and distribution of meteorological data is fully recognised for the first


Telephone transmitter, with control table in foreground, at the Rugby station.

This Year's Progress in Commercial Wireless.—
time, and co-operation between the various Governments with this end in view is arranged for on general lines. The watches to be kept in different classes of ships for safety purposes are also laid down.

Ships' Wireless.

The chief advances made in ship-and-shore signalling apparatus include the substitution of I.C.W. for spark sets in many ships and coast stations, and the continued increase in the number of ships fitted with automatic receivers for the alarm signal and with directional receivers. The number of automatic receivers now fitted in British ships is over 1,000, and the number of directional receivers over 800.

A number of new all-round wireless beacons have been installed at various points on the coast, and a directional beacon from which ships not fitted with directional receivers can obtain bearings has been installed experimentally at Orfordness in Suffolk.

The increase in long-range short-wave sets in ships has been marked. About 80 sets were working throughout the world at the beginning of the year, whereas about 180 are working now.

Wireless telephony, too, is at last beginning to emerge from its long chrysalis state so far as ship communications are concerned. Previously only a very few ships, mostly fishing vessels, were fitted, but during the last few months some of the large liners have been fitted, and experiments with short-wave telephony with the object of a commercial service are now in hand. In Germany a commercial service connecting with the telephone system of the country is being tried experimentally with some small ships. A few lifeboats have been fitted with wireless telephony for the first time during the year.

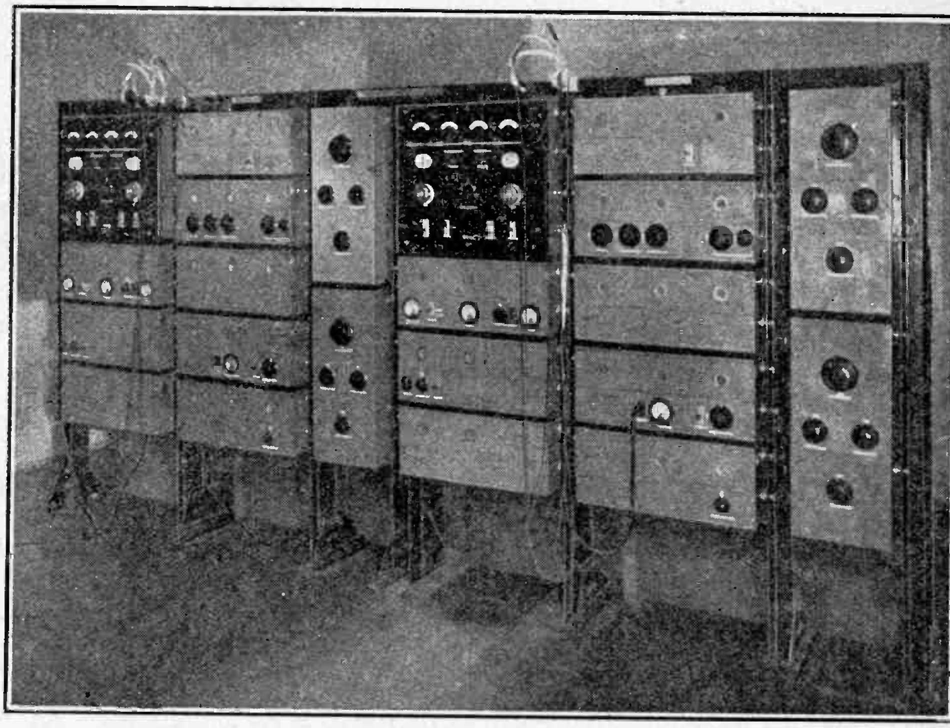
Experiments have been carried out with the facsimile transmission of weather charts to ships, but no commercial service has yet been commenced.

The Hague Conference.

This last year has been notable for international regulations for the control of wireless communications, as in addition to the coming into force of the International Radio-Telegraph Convention of Washington, and the holding of the international conference for the safety of life at sea in London, there was held an international conference in Prague for the regulation of broadcasting services, and an international conference at the Hague to advise on various technical matters which had arisen out of the regulations framed by the Washington Conference.

The Prague Plan for the international regulation of broadcasting wavelengths is rather outside commercial wireless, and has been already fully dealt with in this journal, but we might glance at some of the principal recommendations of the Hague Conference.

Most of the recommendations referred to methods of measurement, and technical problems which require further study. The terms long and short waves have always given rise to a certain amount of confusion, and the conference recommended that waves be classified as follows: Below 100 kcs. (over 3,000 metres), long waves; 1,500 to 100 kcs. (200 to 3,000 metres), medium waves; 6,000 to 1,500 kcs. (50 to 200 metres), intermediate waves; 30,000 to 6,000 kcs. (10 to 50 metres), short waves; above 30,000 kcs. (below 10 metres), very short waves. Waves between 50 and 13 metres are to be reserved in principle for long distances, 50 to 85 metres for moderate distances, 85 to 200 for the shorter distances.



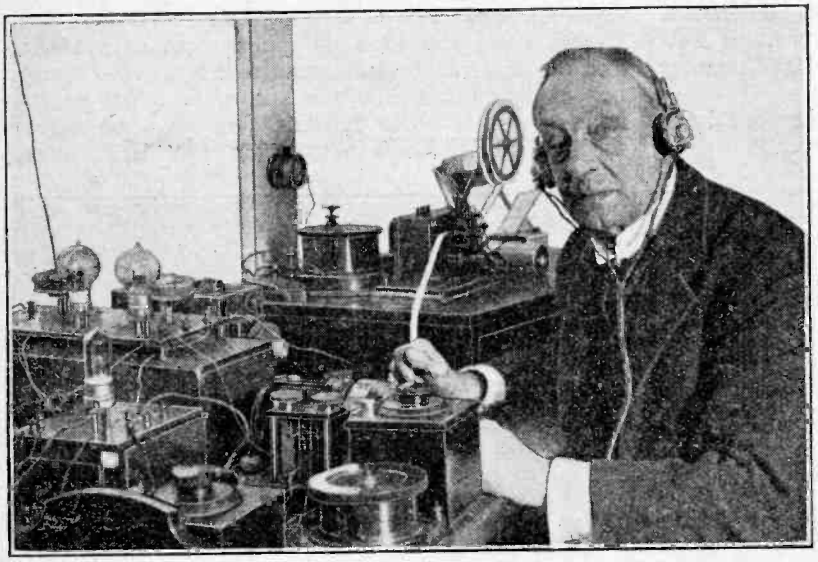
The Indian and Australian receivers at the Skegness beam station.

It was agreed that in practice a separation of 0.1 per cent. frequency is desirable to avoid interference. This is the great problem which confronts the development of wireless communication, viz., how is it possible to crowd into the ether, without causing mutual interference, a sufficient number of waves to meet the demand? As the year closes, claims are being made that a new method has been devised to deal with this problem, but we must wait for next year to see how far these claims are justified.

A WIRELESS PIONEER.

The Late Admiral Sir Henry Jackson.

THE world of wireless has lost one of its most notable personalities by the death, on December 14th, of Admiral of the Fleet Sir Henry Bradwardine Jackson, G.C.B., K.C.V.O., F.R.S., D.Sc., M.I.E.E. A career of distinguished naval service, culminating in an appointment to the highest rank during the War, would in itself provide the material for an engrossing biography, but it is the late Admiral's untiring devotion to the cause of wireless from the earliest days which must appeal to every amateur and experimenter.



The late Admiral Sir Henry Jackson in his wireless laboratory. This photograph was taken soon after the war.

Born at Barnsley on January 21st, 1855, Henry Bradwardine Jackson entered the Navy in 1868. After service abroad he joined the torpedo school ship *Vernon* in 1881 and quickly demonstrated those scientific talents which were later to be applied to the study of Hertzian waves. It was in 1893 that Sir Henry, while commanding the *Edinburgh*, conceived the idea of utilising electro-magnetic waves for signalling purposes. His experiments principally consisted of exciting a circuit which included a filings coherer tapped by the hammer of a high-resistance trembling bell. In 1896 Sir Henry met the young Marconi, and the two collaborated in experiments, which finally proved to a reluctant Admiralty Signals Committee that wireless was to supersede all other methods of communication at sea.

Sir Henry Jackson remained responsible for the progress of wireless telegraphy in the Navy until 1906, when he became a Rear-Admiral. Lord Fisher had already recognised his special scientific ability by selecting him, in 1905, for the office of Third Sea Lord and Controller of the Navy. A spell of service afloat was followed by an Admiralty appointment, and when, in 1915, Lord Fisher left the Admiralty, Sir Henry was appointed First Sea Lord. In December, 1916, after rendering invaluable service, he retired from this post; he was promoted G.C.B. in the same year, and on July 31, 1919, was advanced to the rank of Admiral of the Fleet. In 1920 he was appointed Chairman of the Radio Research Board. He retired from the Navy in July, 1924.

The late Admiral, who always showed a deep interest in amateur experimental research, in 1922 occupied the Presidential Chair of the then Wireless Society of London and was a frequent figure at the meetings of the Radio Society of Great Britain. Sir Henry was elected a Fellow of the Royal Society in 1901. He was a member of the Institute of Electrical Engineers, Hon. D.Sc. of Oxford and Leeds, and Hon. LL.D. of Cambridge.

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.

THE "STENODE RADIOSTAT."

Sir,—The brief description of the action of the Robinson "Stenode Radiostat," given in your current issue, appears to me to carry one rather farther in the explanation of the apparently paradoxical performance of this device than is indicated in the article in question. I refer to the words: "The above explanation certainly discloses an ingenious method by which ringing might be prevented on a set of high selectivity, but it certainly does *not* explain why the sidebands in broadcast transmission get through on such a set." Is this not rather a contradiction?

For convenience modulation is thought of in terms of sideband frequencies, the principal reason being that the system used for obtaining selectivity invariably employed in present practice is a resonant circuit, which has the property of becoming more and more slow to respond to changes of applied e.m.f. by corresponding changes of current, as the selectivity is increased by reducing the damping. But I see no prima facie reason why this should be an inherent property of all selective systems. Thus, if a telephony transmission is regarded as an oscillation of constant frequency and variable amplitude, the ordinary tuned circuit, if made so selective as to respond substantially only to this single frequency, must necessarily be of such low damping that the variations in the amplitude of the signal e.m.f. are not matched by corresponding variations in the current in the circuit (and corresponding e.m.f. available for operating the receiver). In other words, the modulation is cut off, leaving only the carrier. The high modulation frequencies obviously suffer first.

On the other hand, if Dr. Robinson has been able to produce a highly selective system which is able to respond to changes in amplitude at audio frequencies (and why should he not?), it is obvious that it would have the properties claimed for the "Radiostat."

This conclusion is arrived at without assuming any knowledge of Dr. Robinson's system, or any fallacy in existing theory, but simply by discarding the popular but unwarrantable assumption that all selective systems must have the same properties as the particular one commonly used.

Lee, S.E.12. M. G. SCROGGIE, B.Sc., A.M.I.E.E.

Sir,—I was interested in your description of the above, and venture to give an explanation of how it was possible to receive the sidebands up to 5 kilo-cycles and yet eliminate an interference frequency difference of 1 kilo-cycle.

It is well known that a tuned circuit is not symmetrical about the point of tune. For example, the response to a frequency, say, 1 kc. below the resonant frequency is less than the response 1 kc. above. This difference is far more marked on longwave-tuned circuits such as the intermediate stages of a superhet., and when several stages are used the effect is greatly increased. The result is to give a superhet. a response curve extremely steep on the lower side and a more gradual falling off on the other side.

With such a tuning curve it is possible to tune in the signals in such a way that the carrier frequency and one sideband only is received. If then the interference frequency is such that it comes within the sideband which is dropped, it will not be apparent in the audio-frequency output.

With regard to the low-resistance circuit, your implication that such remains selective when frequencies are applied for an exceedingly short time, does not seem correct.

An example is the super-regenerative receiver in which, when actually receiving and amplifying, the resonant circuit has negative resistance.

Yet such receivers are very unselective.

Sheffield. R. E. RAYNER.

Sir,—Re the Robinson "Stenode Radiostat" described in the December 11th issue of *The Wireless World*, it appears that the chopping up of the signal to neutralise the lag of a H.F. circuit is enough to explain the result described. This is because the H.F. circuit does not amplify the higher frequency modulation when the lag is present, and it appears that the sidebands have no objective existence, but are obtained by Fournier Series only. So that when the lag is eliminated, the circuit may be made as selective as possible. R. SUGDEN.

London, W.11.

OURSELVES.

Sir,—I can only crave your pardon for taking up your valuable time with this letter—let its subject matter be at once its excuse and its justification.

It was with pain and indignation that I read in your Editorial views in to-day's issue the criticism of Mr. Brown, of South Norwood, of your policy in increasing the price of your paper, and I feel so keenly the attitude of this gentleman that I cannot resist writing to express my resentment.

How puerile are Mr. Brown's ideas! Does he not, for example, give any thought to the fact that although he may be able to obtain technical advice from the manufacturers of components (I have not been similarly fortunate!) the replies published each week to readers' queries are absolutely invaluable *to others who have exactly similar problems*? I could mention numbers of instances where I have been helped by these published replies. Does not Mr. Brown further realise that successful wireless reception can *only* be obtained by most careful quantitative analysis and experiment? And where will he obtain such technical articles, by such experts in this most technical of all subjects, except in your paper?

There is a stage which we amateurs reach at which we begin to realise how little we know, and how extraordinarily efficient your contributors are. It is at that stage that we appreciate the fact that your paper is the *only* one which will help us. Were you to double or even treble the price of *The Wireless World* it would still be cheap by comparison with the quality of its technical articles.

Perhaps you will kindly accept seasonable greetings from a staunch supporter. H. D. McCLENAGHAN.

Dublin.

Sir,—I beg to point out that my letter has been misquoted in your Editorial. I said "the bulk of the queries that you receive could no doubt be accurately replied to *by the mechanic or draughtsman in the experimental workshop.*"

Fair play, please! Thanks for your letter.

South Norwood. E. H. BROWN.

The complete sentence in Mr. Brown's original letter read: "The bulk of the queries that you receive could, no doubt, be accurately replied to by the mechanic or draughtsman in the experimental workshop. The rest you can refer to the component manufacturers, who are only too pleased to give technical information, as I have often proved."

It is regretted that in our editorial we misquoted Mr. Brown by implying that he proposed "the bulk of the queries" should be referred to manufacturers instead of "the rest."—ED.

BOOKS RECEIVED.

Electrical Wiring and Contracting. Edited by H. Marryat, M.I.Mech.E. Parts 2 to 4, which complete the first volume, include drawing—with useful illustrations indicating the generally accepted symbols used in electrical diagrams and the conventional section lining to denote various materials—electricity and magnetism, A.C. work and index to Vol. I.

Parts 5 to 8, which comprise Vol. II, include D.C. and A.C. generators and motors, testing and measuring instruments, wires and cables, also a section on mathematics as applied to wiring and contracting.

Each part pp. 64, with numerous diagrams and illustrations. Published by Sir Isaac Pitman and Sons, Ltd., London. Price 1s. per part.

A general notice of this publication and the contents of Part I appeared in our issue of October 23rd, page 474.

Radio Traffic Manual and Operating Regulations, by R. L. Duncan and C. E. Drew. A handbook primarily intended for the use of operators and amateur transmitters in U.S.A. and comprising instruction in Morse, operating rules and regulations of the Radio Marine Corporation of America, International Radiotelegraph Convention of Washington and the Regulations attached thereto, U.S. Radio Act of 1927, Ship Act of July 23rd, 1912, and regulations governing the issue and renewal of operators' licences in U.S.A. Pp. 187, with 15 illustrations, examples of operators' abstracts, logs, etc. Published by J. Wiley and Sons, Inc., New York, and sold by Chapman and Hall, Ltd., London. Price 10s. net.

Handbook for Wireless Telegraph Operators (Revised 1929), issued by the G.P.O. The principal additional matter in this revised edition relates to the classification of Radiotelegrams, especially those in code or cypher, and the charges for five-letter code words. Published by H.M. Stationery Office. Price 6d. net.

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Modern Gramophones and Electrical Reproducers, by P. Wilson, M.A., and G. W. Webb, with a foreword by Compton Mackenzie.

A comprehensive text-book on the theory and practice of gramophone construction and the various problems involved in the recording and reproduction of sound. Pp. 272+xvi, with 116 illustrations and diagrams.

Published by Cassell and Co., Ltd., London, price 10s. 6d. net.

READERS' PROBLEMS.

J.R.S.

"The Wireless World" Supplies a Free Service of Technical Information.

The Service is subject to the rules of the Department, which are printed below; these must be strictly enforced, in the interest of readers themselves. A selection of queries of general interest is dealt with below, in some cases at greater length than would be possible in a letter.

Uncontrollable Oscillation.

I have just completed construction of a detector-2 L.F. receiver, using a commercial two-range tuner which includes a reaction winding. So far, results have been disappointing; on the medium waveband, uncontrollable oscillation is produced unless the reaction control condenser is disconnected. On the long-wave side, it is impossible to stop oscillation even in this way unless H.T. voltage is reduced to a ridiculously low value. Can you tell me how to put matters right? H. G. S.

It seems that the tuning unit is designed for a small reaction condenser having a lower minimum value than that of the condenser you are using; this would account for the behaviour of the set on the medium band, while H.F. choke resonance is probably responsible for the trouble on the long waves.

Removal of a few turns from the reaction winding (or windings), combined with the substitution of another choke for the existing component, would almost certainly effect a cure, but we think that your best plan is to try the effect of connecting a small fixed condenser (of about 0.0001 mfd. or even 0.0002 mfd.) between anode and negative filament terminals of the detector valve. This addition will almost certainly overcome the tendency towards uncontrollable self-oscillation, and will improve detector efficiency, probably to a very noticeable extent. The addition of this capacity may possible modify the frequency characteristics of the L.F. amplifier, but is hardly likely to do any harm.

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Where D.C. Resistance is Unimportant.

I am going to make up a small battery eliminator (to work on my A.C. supply) for providing grid bias potentials for a large amplifier. Will you tell me if the primary and secondary winding of a disused L.F. transformer are likely to be satisfactory for smoothing purposes in this piece of apparatus, or would it be safest to order a special choke? Of course, the windings will be joined in series. G. H. C.

There is no reason why the windings of a reasonably good L.F. transformer should not be quite satisfactory for this purpose. Their ohmic resistance is likely to be considerable, but it should be an easy matter to ensure that this value will be low compared with that of the potentiometer across which the biasing potentials are developed.

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The Baby Alarm.

Please do not consign this letter to the waste-paper basket before reading it through: my query is a perfectly serious one, and I am emboldened to ask it as I seem to remember that a similar problem was treated in your pages some years ago.

Now for the question. Is it possible to install a microphone over a baby's cot in a distant room, and to connect the instrument to a receiver so that the child's cries will be superimposed on the broadcast programme? My set is an H.F.-det.-L.F. combination, with grid detection and transformer coupling: if this addition can be made to it, will you please show me how to proceed? T. S. W.

You need have no fear that your query will be treated as frivolous; hardly a week goes by without our receiving a request for information on this subject. Many harassed parents seem to feel a very real need for means of knowing that all goes well with their slumbering progeny while they themselves are listening to the evening programmes.

Fortunately, it is by no means difficult to arrange that any sounds indicative of untoward happenings in the child's bedroom may be amplified by the set and heard through the loud speaker. As a rule, at least two magnifying stages are necessary, so in your case the detector valve must be made to amplify: rectification will, of course, introduce distortion, but this should not matter.

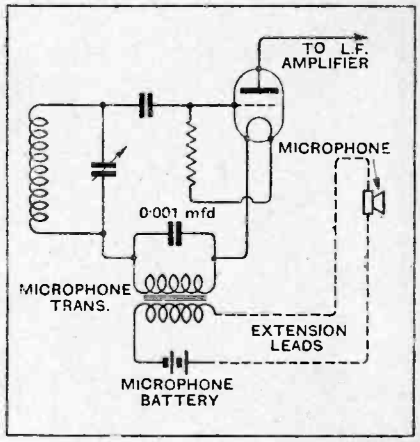

Fig. 1.—Where distortion can be tolerated, the detector valve may be made to work as an extra amplifier in a microphone circuit.

The secondary winding of a microphone transformer is inserted in the grid return lead of the detector valve in the manner shown in Fig 1, and should be shunted by a fairly large H.F. by-pass condenser. Connection is made between the transformer primary and the distant microphone through extension leads, a small battery being interposed; very often it is possible to use the receiver L.T. cells for this purpose. Some method of breaking the microphone circuit must be provided to prevent waste of battery current.

Microphone and transformer should be obtained from the same source, and it is desirable that these pieces of apparatus should be designed for working together.

May we express the wish that you will have no cause to test the functioning of the apparatus during the Christmas festivities?

RULES.

(1.) Only one question (which must deal with a single specific point) can be answered. Letters must be concisely worded and headed "Information Department."

(2.) Queries must be written on one side of the paper and diagrams drawn on a separate sheet. A self-addressed stamped envelope must be enclosed for postal reply.

(3.) Designs or circuit diagrams for complete receivers cannot be given; under present-day conditions justice cannot be done to questions of this kind in the course of a letter.

(4.) Practical wiring plans cannot be supplied or considered.

(5.) Designs for components such as L.F. chokes, power transformers, etc., cannot be supplied.

(6.) Queries arising from the construction or operation of receivers must be confined to constructional sets described in "The Wireless World" or to standard manufacturers' receivers.

Readers desiring information on matters beyond the scope of the Information Department are invited to submit suggestions regarding subjects to be treated in future articles or paragraphs.