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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

EDITORIAL COMMENT

Television

America Takes the Plunge

IN an address to the Radio Manufacturers' Association in New York a few days ago, Mr. David Sarnoff, President of the Radio Corporation of America, propounded his views on television and announced the intention of the Radio Corporation of America to start a limited programme service to the public from its television transmitter on the Empire State Building in New York.

Mr. Sarnoff stated that the results of the experimental field tests of television in the New York area conducted by the R.C.A. and its broadcasting and manufacturing units, had convinced him that television in the home was "now technically feasible." That television in the home was technically feasible would, we should have thought, have been obvious to Mr. Sarnoff for a very long time, in view of the position on this side; but, nevertheless, it is interesting to have his assurance that in America, too, they are satisfied with the technical success of the tests they have carried out.

An Experimental Service

Next, Mr. Sarnoff admits that many technical, artistic and financial problems still confront "those who would establish an acceptable and regular service of television to the home" and that these problems must be solved before a "national service of a network of television programmes can be made available to the public." He has also come to the conclusion that "the problems confronting this difficult and complicated art can be solved only by operating experience gained by actually serving the public in their home." This, we believe, represents a change in the attitude hitherto adopted towards television in America, where it has generally been implied that retaining television in the laboratory was favoured until it was so perfected that it could be launched to the public on a big scale.

Small Beginnings

The R.C.A. proposes to demonstrate television to the public at the New York World's Fair in April, 1939, and by that time the National Broadcasting Company hopes to be transmitting television programmes "for at least two hours a week." The R.C.A. is ready to build and supply television transmitters to broadcasting authorities and believes that development of television has now reached a stage where receivers can be supplied to the public in those localities where transmitters become available. A manufacturing programme for a limited number of receivers is therefore planned. Other manufacturers in the United States are also arranging to produce television receivers.

England has had the lead in television for a number of years and those who have been involved in development on the technical side and on the programmes have worked hard and productively towards the goal of establishing a new national service and a new national industry. There are still problems to be solved and the two which loom largest are unquestionably those of nation-wide distribution of television and financing the transmitting project as a whole. We in this country have not yet found the solutions to these major problems, and if we placidly wait for "something to turn up," America, which will soon be faced with the same difficulties, may well find the answers first. If so, we shall soon find her forging ahead of us.

Crystal Band-Pass Filters

Part I.—QUARTZ CRYSTALS AND THEIR CHARACTERISTICS

By E. L. GARDINER, B.Sc.

THE applications of quartz crystals have recently been greatly extended by the development of band-pass circuits in which they form essential elements. These filters have very desirable properties and offer advantages not only in broadcast receivers but in communication sets and commercial equipment. In this series of articles, the properties of such filters will be described in detail and the subject is started by a discussion of the properties of the crystals themselves.

IN *The Wireless World* of September 15th, 1938, appeared a preliminary description of a new type of band-pass filter developed by Dr. James Robinson in which a pair of quartz-crystal resonators is used to determine the width of the pass-band. Filters of this kind have many attractive properties, which include a very sharp cut-off and readily adjustable characteristics, and which make them very suitable for use in communication or broadcast receivers. They are singularly simple to design and construct, whilst their cost may be less than that of conventional filters having comparable performance. They have also a variety of commercial applications, of which carrier - current telegraphy and telephony are examples. The present writer has carried out much of the experimental work on crystal filters that has been going on since the invention of the single crystal filter, or "crystal gate," by Dr. Robinson in 1929, and in these articles will describe the performance to be expected from them and the methods by which they may be designed.

The Single Crystal Circuit

It was shown in the preliminary article how the combination of two single crystal filters can lead to a band-pass characteristic, and that effect will not be enlarged upon for the moment. We shall study it in detail later, after a selection of performance figures has been given. However, since the crystal band-pass filter has been largely evolved from the single crystal variety, it will be helpful to recall some of the properties of the latter. The "crystal gate" is now so widely used in the better class of communication receivers that it will be familiar to most readers, and particularly to those who hold amateur transmitting licences. It is generally regarded as the most selective device available for the reception of CW telegraph signals, and is used to a lesser extent for telephony, but it is probably not so widely known that the circuit was originally evolved for the reception of broadcasting.

About 1929 the selectivity of receivers left much to be desired, and it was seldom possible to separate the more powerful signals without considerable loss of the higher modulation frequencies, which resulted in rather "woolly" reproduction. Except, perhaps, in a few advanced technical circles the distinction between band-pass and single-peaked tuning was but vaguely understood, it being generally thought impossible to employ really high selectivity in a broadcast receiver without loss of quality. About this time Dr. Robinson brought forward his "Stenode" theory of reception, which stated that signals could be received through any circuit, however selective, and that the original tone quality could be restored after detection by increased audio-frequency amplification of the higher tones, or any equivalent form of correction. When this was done he showed that the interfering programmes after removal by the selective circuits would not be restored by tone correction.

General technical opinion at that time held that all interference would be restored after correction, leaving no overall improvement, and considerable controversy ensued. Eventually, however, the "Stenode" theory was proved to be sound, and is now universally accepted. In practice, it has been found to result in an improved ratio of signal to interference as compared with practical band-pass filters, an effect not originally expected, but explainable through the effects of detector demodulation. A sharply selective response reduces all neighbouring carriers in relation to that of the wanted station, which is therefore much stronger at the detector. In consequence it is able largely to demodulate the weaker carriers, and since interfering modulations have thus been removed, they cannot be restored by tone correction. An exhaustive investigation organised by the Radio Research Board in 1932[1] finally established the soundness of these principles.

The high selectivity required for Stenode reception is not easily obtained from ordinary circuits. It is either necessary to employ a number of these in cascade, when tone correction is not a linear function and is difficult to carry out, or else to rely upon critical reaction, when circuit conditions are not easily stabilised. The quartz crystal was introduced to overcome these difficulties. Used as a coupling between two IF stages it provides high selectivity in a single resonator, which is the condition most easily tone-corrected by audio-frequency amplification increasing proportionally to frequency.

Under practical conditions it at once became apparent that the self-capacity of the crystal holder could not be neglected, but allowed appreciable interfering voltages to by-pass the crystal. A bridge circuit of the type shown in Fig. 1 was therefore adopted, in which the unwanted capacity coupling can be neutralised by the condenser C. The adjustment of this condenser enables us to obtain a symmetrical resonance curve from the crystal, corresponding to that of a resonator of extremely high "Q," as was explained in the preliminary article. By varying the adjustment of C we can also assist one side band of a transmission and depress the other, obtaining in the extreme case an attenuation of as much as 80 db. at one frequency where the voltage through the condenser is almost equal and opposite in phase to that through the crystal. This effect is widely used to cut out an interfering signal when receiving telegraphic signals through a "crystal gate."

Broadcast receivers employing the crystal as the chief source of selectivity

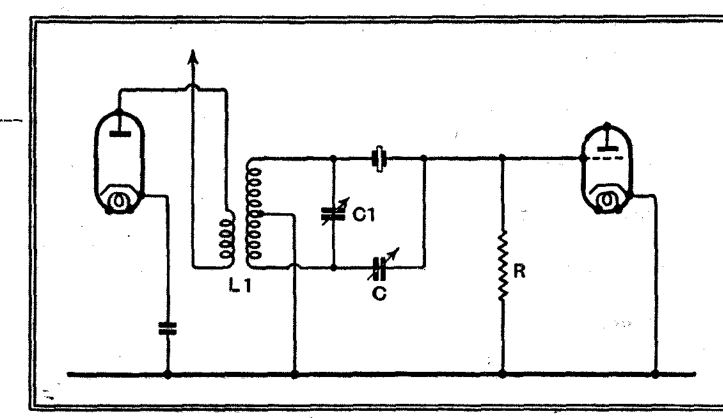


Fig. 1. This diagram shows the usual circuit arrangement for a single quartz crystal. It is widely used for CW reception.

[1] Special Report No. 12, by F. M. Colbrook, 1932.

Crystal Band-Pass Filters—

were designed in 1930, giving excellent results in the laboratory, and providing a ratio of signal to interference probably better than can be obtained by any other method. In only a few cases, however, have commercial receivers made full use of the principle, since certain difficulties were found to exist, and were not easily overcome with the components and methods available in the past.

As an example, the sharpness of tuning needed to get signals into resonance with the crystal and keep them so made adjustment very difficult for the average listener, and is only now being finally overcome through the development of automatic tuning compensation. Secondly, the relatively low amplification given by early valves prevented adequate tone correction without increased cost, and it was necessary to await new methods such as negative feed-back before simple correction without attendant drawbacks became practicable. It is only in quite recent months that most of these difficulties have become less important, suggesting the likelihood of increased use of the Stenode principle in future receivers.

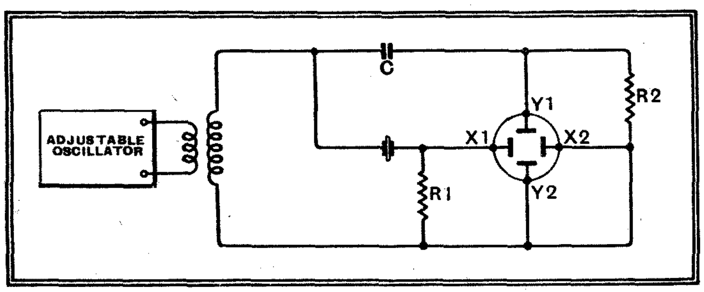


Fig. 2. This circuit is recommended for testing quartz crystals for secondary resonances.

Crystal Characteristics

Meanwhile, an alternative method of design exists in the band-pass filter, and one which, while not capable of quite such high selectivity, has the advantage that its use does not complicate a receiver in any other respect. Up to the present it has not been easy to obtain good band-pass performance without the use of a number of circuits, and difficulty has been found in keeping all these lined up throughout the life of a receiver. The quartz crystal, however, seems to provide a method for improving filter performance, at quite reasonable cost, and with an actual simplification of the circuits used, while the selectivity will remain almost unchanged over the longest periods. Variable selectivity can, in addition, be very simply provided by the switching in of one or two alternative crystals, a single pole switch being adequate for the whole alteration.

In introducing the study of such filters it will be natural to commence with the crystals themselves, and to enquire whether they are obtainable in suitable form, whether they are satisfactory, and not prohibitive in cost.

Early in experimental work it became clear that insufficient was known about crystal design, and about the equally important matter of their mounting in suitable holders. Even when a single crystal is employed in a "crystal gate" it may be necessary to take some trouble in its selection, but when it is attempted to combine two or more crystals into a band-pass filter, it is clearly essential that they shall be suitably matched, and shall remain so from day to day. The crystal itself is, of course, a highly stable and reliable device, but unfortunately it cannot be used without a holder, and the latter may be responsible for a good deal of variation in performance. Moreover, all crystals are not necessarily suitable for use in filters.

For a number of years quartz resonators have been mainly used to stabilise the frequency of transmitters. The main requirements of a crystal for this work are that it shall be accurately ground to the desired frequency, shall remain as near to that frequency as possible under changes of temperature, shall oscillate readily and shall handle considerable RF power without fracture. Development has therefore been mainly concentrated along the lines of great frequency accuracy and a low temperature coefficient, neither of which is necessarily of first importance in filter design for radio purposes. Transmitting crystals are generally expected to remain accurate to within a few cycles per second, but we can usually tolerate a variation of as much as 1 kc/s in the intermediate frequency of a receiver. They are also made comparatively large, so that the crystal can pass considerable RF current in safety, and will not become unduly hot under oscillating conditions. This provision will not be necessary when the crystal is used in a receiving filter, since it then has to handle very small currents only. In fact, a large crystal may actually prove inferior to smaller types.

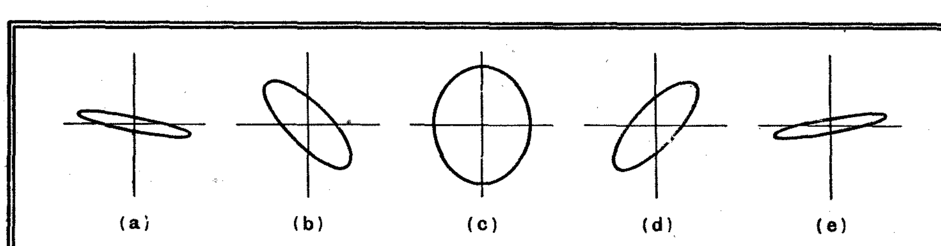


Fig. 3. As the frequency of the test oscillator is varied through the crystal resonance the pattern on the CR tube screen varies smoothly as shown here. At (a) the oscillator is considerably below the crystal frequency and at (b) it is approaching resonance which is reached at (c). At (d) the oscillator is a little higher than resonance and at (e) it is much higher.

On the other hand, there are certain properties needed in a filter crystal which are not important in one intended as an oscillator. Foremost amongst these is freedom from secondary resonant frequencies near to the main frequency. The frequency of a crystal depends, of course, upon its dimensions, and there are always at least two frequencies at which it can be made to respond, and which depend upon two of its principal measurements. There may also be other frequencies, including harmonics or "partials" of the main response frequencies, but the whole of these alternatives are well removed from the main response, and the crystal can be prevented from operating at them by the use of external selective circuits. Thus, for example, if a crystal be ground to a main frequency of 465 kc/s, it will also respond to certain higher frequencies, but none of these will lie within 100 kc/s of 465 kc/s. The ordinary tuned couplings of an IF amplifier can easily eliminate signals so far removed from resonance, and we are therefore quite justified in ignoring their existence in the majority of circumstances.

Secondary Resonances

The troublesome secondary frequencies referred to are those which may occur within a few kilocycles of the principal frequency. They are probably due to slight inaccuracies in the cutting of the crystal, or to lack of uniformity in the quartz from which it is made. It would be outside the scope of this article to describe in detail the cutting of crystals from the natural quartz. The subject is a wide one, and fully explained in a number of text-books and several other publications.[1]

However, high-frequency crystals are generally prepared in the form of thin plates, their principal frequency being determined by the thickness of the plate. Most transmitting crystals are of this form. Now, clearly, the whole surface of this plate will only respond at the same frequency if the thickness be exactly uniform. Should any portion of the plate be slightly thicker or thinner, it will tend to respond at a slightly lower or higher frequency, and may impart a secondary response to the crystal. Also it is likely to reduce the activity of the crystal at its principal frequency, because the total area active at that frequency has been reduced.

It is very difficult in practice to prepare large thin plates of exactly uniform thickness from quartz, and as a result most transmitting crystals of that form show serious secondary responses which make them unsuitable for filter work. Many receiving crystals were first made in this

[1] "Quartz Crystals and Resonators," P. G. Vigeseux, H.M. Stationery Office

Crystal Band-Pass Filters—

way, and as a rule were unsatisfactory. Until very recently the writer had not encountered a single example which was entirely free from secondaries when tested under exacting conditions, although most would be quite satisfactory when used as oscillators, since a crystal will generally oscillate freely only at its principal resonant frequency. American crystals found in communication receivers are often still of this type, and some of those met with to-day show no measurable secondaries. Nevertheless they should be tested carefully before use in band-pass filters. It is doubtful in any case whether their characteristics are ideal for the purpose, as will be shown later.

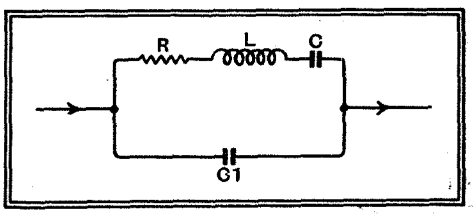


Fig. 4. This diagram shows the equivalent electrical circuit of a quartz crystal. L, C, and R form the series tuned circuit, resonance in which corresponds to the crystal resonance, while C1 represents the capacity of the crystal holder.

A very sensitive method exists by which a crystal can be tested for secondary responses. Voltage from an oscillator at the principal frequency is applied through a condenser C which serves as an amplitude control to one pair of plates of an electrostatically deflected cathode-ray tube. The same voltage is passed through the crystal to the second pair of plates, as shown in Fig 2. The resistances R1 and R2 should be comparatively low, as this assists in minimising stray potential through the capacity of the crystal holder, which must not be too great. Upon the screen of the tube will now appear an ellipse, which is the figure produced by two similar voltages of identical frequency but differing somewhat in phase. Now, the phase of the voltage through a crystal varies rapidly on each side of its resonant frequency. If, therefore, the frequency of the oscillator be slowly varied from about 20 kc/s below to 20 kc/s above resonance, the ellipse will change from nearly a horizontal straight line, opening out as resonance is approached and the voltage through the crystal increases, to become nearly a circle at resonance. Since there is some loss of voltage in the crystal, however, it will probably become merely an open ellipse, having its principal axis perpendicular to the original straight line, or vertical in the case described. Passing beyond resonance, the process is repeated, the ellipse reverting to a horizontal line in the opposite direction. Fig. 3 shows sketches of the change which occurs.

In the absence of secondary responses the above process will be uniform and smoothly carried out, but if we should pass through a secondary response frequency there will be a momentary disturbance of the phase relationship. The slope of the major axis of the ellipse measures the angular phase difference between the voltage applied to the crystal and that passing through it at any instant. Therefore a momentary change of phase will be shown as a discontinuity in the even rotation of the ellipse, which will twitch or shudder as the secondary frequency is passed. The phase changes caused by a secondary are greater than those of amplitude, and thus the method shows up defects which would need very careful search to detect if the output through the crystal were measured by a voltmeter, for example. Under receiving conditions these quite small secondaries might be serious, since they may coincide with the frequency of a very powerful interfering station, and it is important that they should be absent from a really good crystal.

Crystal resonators are also cut in the form of relatively long rectangular bars, in which the principal frequency is determined by their length; 100 kc/s frequency standards are usually of this form, which lends itself well to frequencies between about 1,000 kc/s and 50 kc/s or below. It is therefore suitable for the most widely used intermediate frequencies, which we shall take as being 465 kc/s. A bar-type crystal is more easily cut to exact dimensions, since small errors represent a much smaller proportion of the total length. It is found that if certain ratios of length to breadth and width are adhered to, crystals can be made which are inherently free from secondaries, and it has been found that considerably less than 1 per cent. of those so prepared show defects. They are, therefore, very suitable to filter design.

The Crystal Impedance

The original form of crystal-cut developed by Currie and termed the "X-cut" is effective, comparatively simple to prepare, and makes the most economical use of the available quartz. When it is employed, the resonator is cut from the natural crystal so that its major surface is perpendicular to the electrical axis of the crystal, and one other dimension is parallel to the optical axis. The resulting slice, when cut to exact dimensions, is loosely termed "a crystal." X-cut bars have a moderately large temperature coefficient, of perhaps six parts in a million per degree centigrade. Smaller coefficients can be obtained in transmitting crystals by cutting obliquely to the optical axis, but for any ordinary filter purpose the coefficient mentioned is amply satisfactory.

In one other respect the shape and size of a crystal have an important influence. They determine the effective values of L, C and R in the equivalent circuit of Fig. 4, and hence the impedance to which the crystal falls at resonance. Broadly speaking, the impedance of all crystals will be extremely high at a few kilocycles from resonance, usually exceeding one megohm. At resonance it will fall to a value very roughly proportional to the mass of quartz forming the crystal. Thus large crystals may fall to a few thousand ohms, or even below 1,000 ohms, while a small crystal may fall to some figure such as 20,000 ohms. We can therefore speak broadly of high impedance and low impedance crystals.

Plate-type crystals have low values of impedance, and the sudden large drop at resonance gives the impression that they are extremely "active." For certain applications, such as a single crystal filter having suitably designed input and output transformers, these crystals may be excellent. The small X-cut bar might seem inferior if used in the same circuit, in which conditions have been chosen to match a low crystal impedance. But the coupling circuits between valves are inherently of fairly high impedance, the anode load of a typical RF stage being usually between the limits of 10,000 and 100,000 ohms. It is therefore natural to employ high impedance coupling circuits between valves, and any change to a low impedance, such as by the use of large step-down transformer ratios, is likely to reduce efficiency. The high impedance crystal is therefore admirably suited for use in band-pass inter-valve filters, in which the impedance matching must in any case be chosen to match the crystal, as will be explained in a later article.

We have now selected a small X-cut bar as one very suitable type for use in band-pass filters. This crystal may have an effective Q of the order of 20,000, and may represent an impedance of between 5,000 and 15,000 ohms at resonance. It can be of almost any frequency, but so as to confine our remarks at present to a useful range and enable definite statements to be made, we will assume it to be near 465 kc/s. Unfortunately this crystal cannot be used alone, but must be inserted into a holder of some kind. The electrical capacity of this holder can be compensated for by the balancing condenser C of Fig. 1; but there will be other effects caused by the holder which are less simply treated.

RADIO LABORATORY HANDBOOK

By M. G. Scroggie, B.Sc., A.M.I.E.E.
(The Wireless World, 8s. 6d.)

Here's a book for young and older
By a quite unusual bloke,
Who can think, and write, and solder,
And who likes his little joke.

He twits the academical,
The cultured folk like we,
Who take no care financical.
(But we do, as much as he!)

There's guidance without stinting
For the handy wireless man.
Good pictures, index, printing.
You should buy it if you can.

* * *

When you're up against it, flabber-
Gasted, puzzled, sick and foggy,
Do not rage or moan or blabber;
Take a chair and read your Scroggie.

L. B. T.

The above has been received from a reader, and we hope he will not take exception to its publication for the benefit of all who care to enjoy it.

How a Receiver is Designed.—XXIX.

All-wave Battery Set

CONSTRUCTION AND ADJUSTMENT

THE theoretical considerations underlying the design of this receiver have been fully discussed in previous articles, and its construction is now dealt with. Details are also given of the procedure for the initial adjustment of the set.

MOST details of the mechanical aspects of the receiver can be gleaned from the drawings and photographs and there is little which requires explanation. The gang condenser is not mounted directly on the tuner chassis, however, but is slightly spaced from it. Three bolts are placed through the chassis from the underside and nuts run-on and tightened on top. The condenser is then placed over the bolts and further nuts used to secure it. In this way the condenser is spaced from the chassis by the thickness of one nut. This spacing is adopted in order to make it easier to reach the solder-tags of the fixed plates with a soldering iron.

When wiring the tuner it is advisable to connect the lengths of wire to the tags for the moving arms of the switches before the switches are mounted. When the switches are in place these tags are rather inaccessible with an ordinary iron. The connections to the gang condenser are then best completed and afterwards the valveholder wiring, the coils and other switch leads being left to the last.

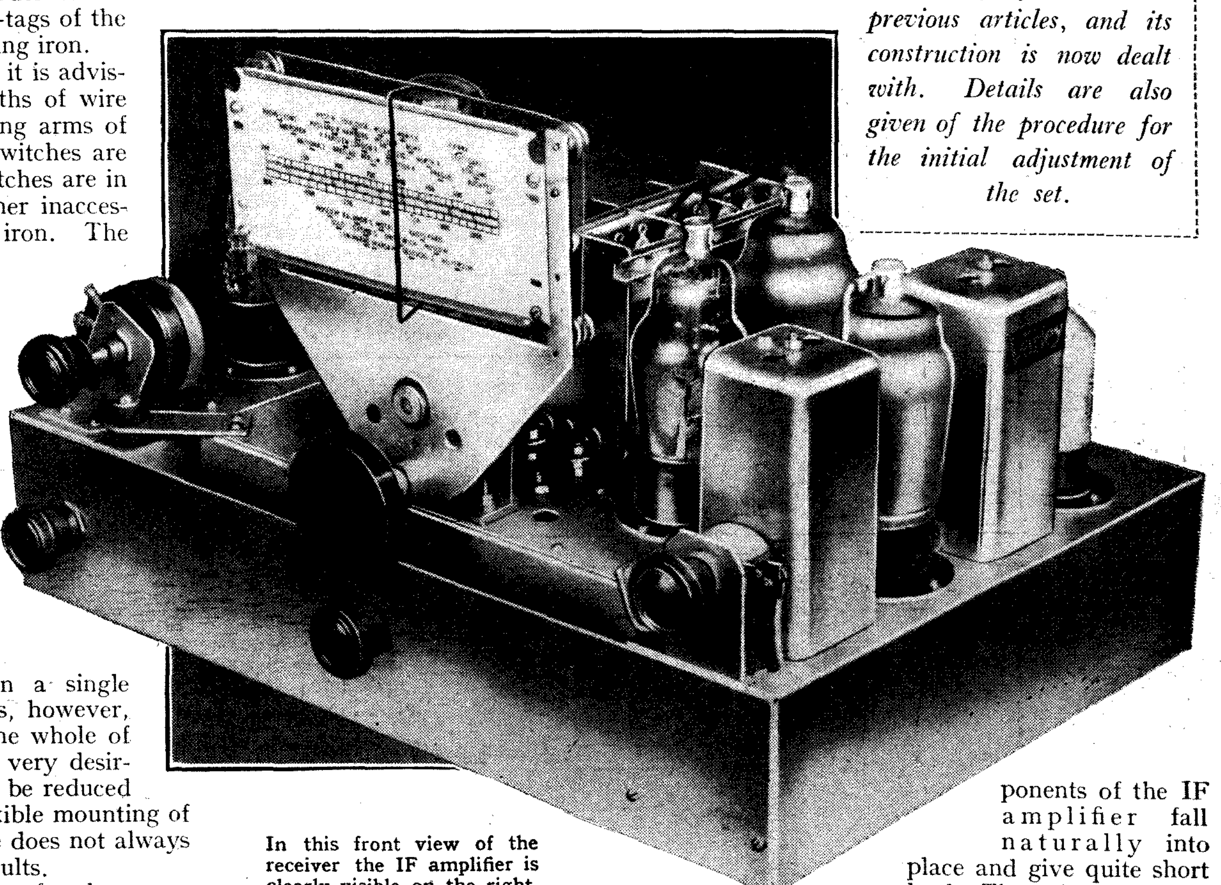
Some surprise may be felt at the general mechanical arrangement of the receiver, for it would undoubtedly have led to a somewhat simpler lay-out and wiring if all components were on a single chassis. On short waves, however, a flexible mounting of the whole of the tuning equipment is very desirable if microphony is to be reduced to a minimum. The flexible mounting of the gang condenser alone does not always give such satisfactory results.

With a unit construction for the tuner, which incidentally also leads to good screening, it is necessary for the main chassis to consist of two sections so that the tuner can be slung between them. With a large receiver the construction often takes the form of a large and rigid chassis with a cut-out for the tuner. In this case, there is no justification for this course, and the main chassis consequently takes the form of two narrow chassis joined together at back and front by cross-strips.

In the tuner the layout of components has been chosen primarily for electrical reasons. The gang condenser is immediately above the switches so that the leads between them can be as short as possible, and the valves are placed as close to the gang condenser as they can be in order to keep the grid leads short. Incidentally, it was mechanical considerations which led to the choice of the Tungsram VP2D for the RF stage, for the valve is one of the few battery RF pentodes with a top-grid connection.

It is instructive to consider what changes would be needed to accommodate a top-anode type of valve and how it would fall short of the requirements. In the first place, the valveholder would have to be moved into the aerial-coil compartment, and in the second the anode connection to the valve would have to run from the top of the valve to the primary switch in the middle compartment. This lead would be at least six inches long and it would almost certainly be necessary to screen it. This would cause little trouble on medium and long waves, but on short waves the extra capacity of the screening would be harmful. The use of a top-grid valve is a distinct advantage in reducing the length of leads.

In the case of apparatus which lies outside the tuner the length of leads is of much less importance because of the lower frequencies at which the circuits operate. Care has been taken, nevertheless, to get the first IF transformer as close as possible to the frequency-changer valve for experience shows that a long anode lead to such a valve can be a cause of parasitic oscillation. Trouble of this nature is, of course, much less likely to occur with battery valves than with mains types on account of their lower efficiency. It is considered advisable, however, not to run any avoidable risks.



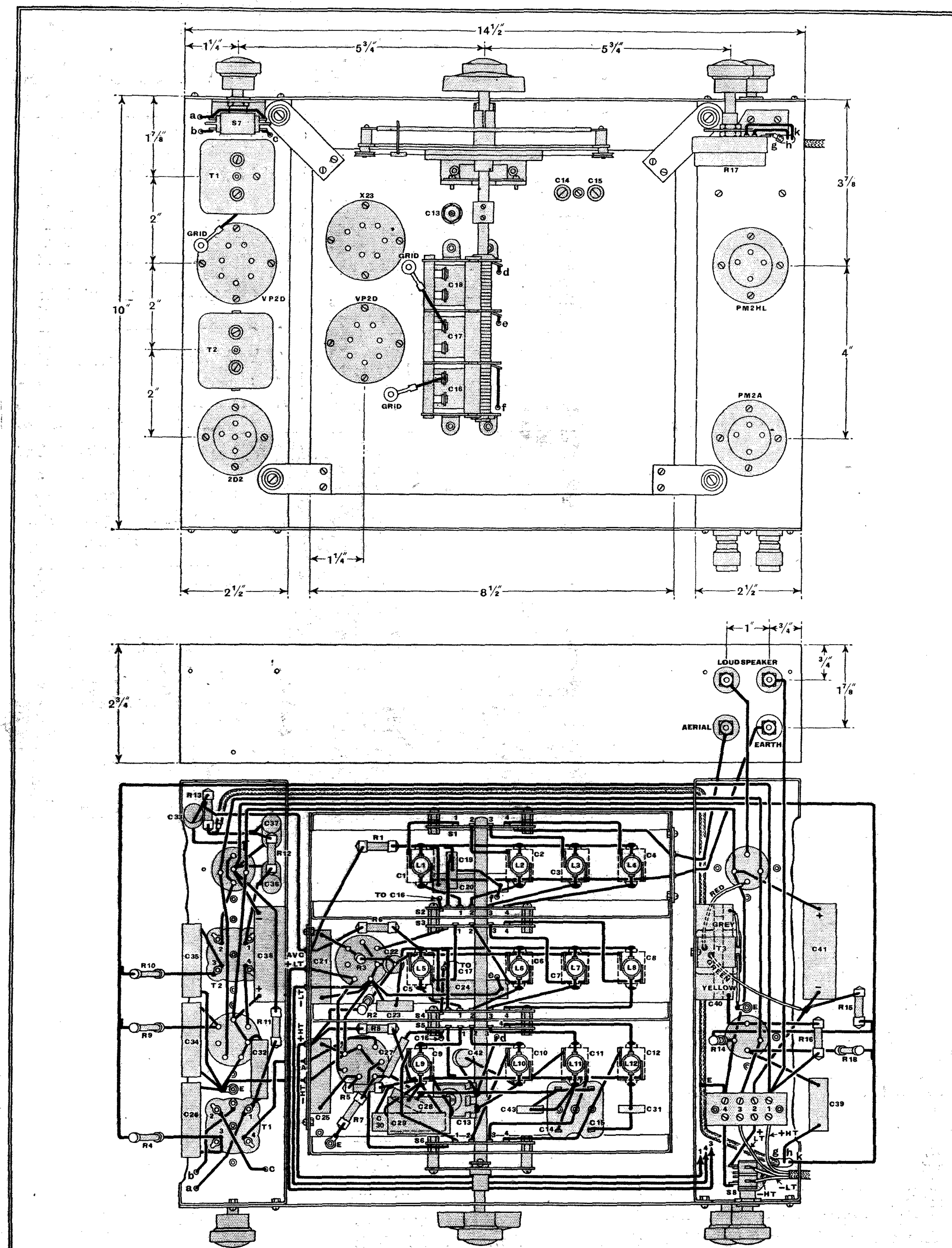
In this front view of the receiver the IF amplifier is clearly visible on the right.

With the construction adopted the components of the IF amplifier fall naturally into place and give quite short leads. The only really long connections are those between the detector and AF amplifier, and they are unimportant at this point because screening can be used without harmful effect.

Turning now to operation and adjustment. The receiver is designed to operate with an HT supply of 120 volts, but a higher voltage can be used with some advantage if the higher current is tolerated. At 120 volts the total current consumption is about 14 mA., so that it is advisable to use a medium- or large-capacity battery. The LT supply should be an accumulator as the current is 0.9 ampere at 2 volts. A capacity of some 20 A.h. is advisable.

The loud speaker is not unimportant, for

ALL-WAVE BATTERY SET—ASSEMBLY AND WIRING DETAILS



Full-size blueprint of the above wiring diagram is available from the Publishers, Dorset House, Stamford Street, London, S.E.1. Price, 1s. 6d., post free.

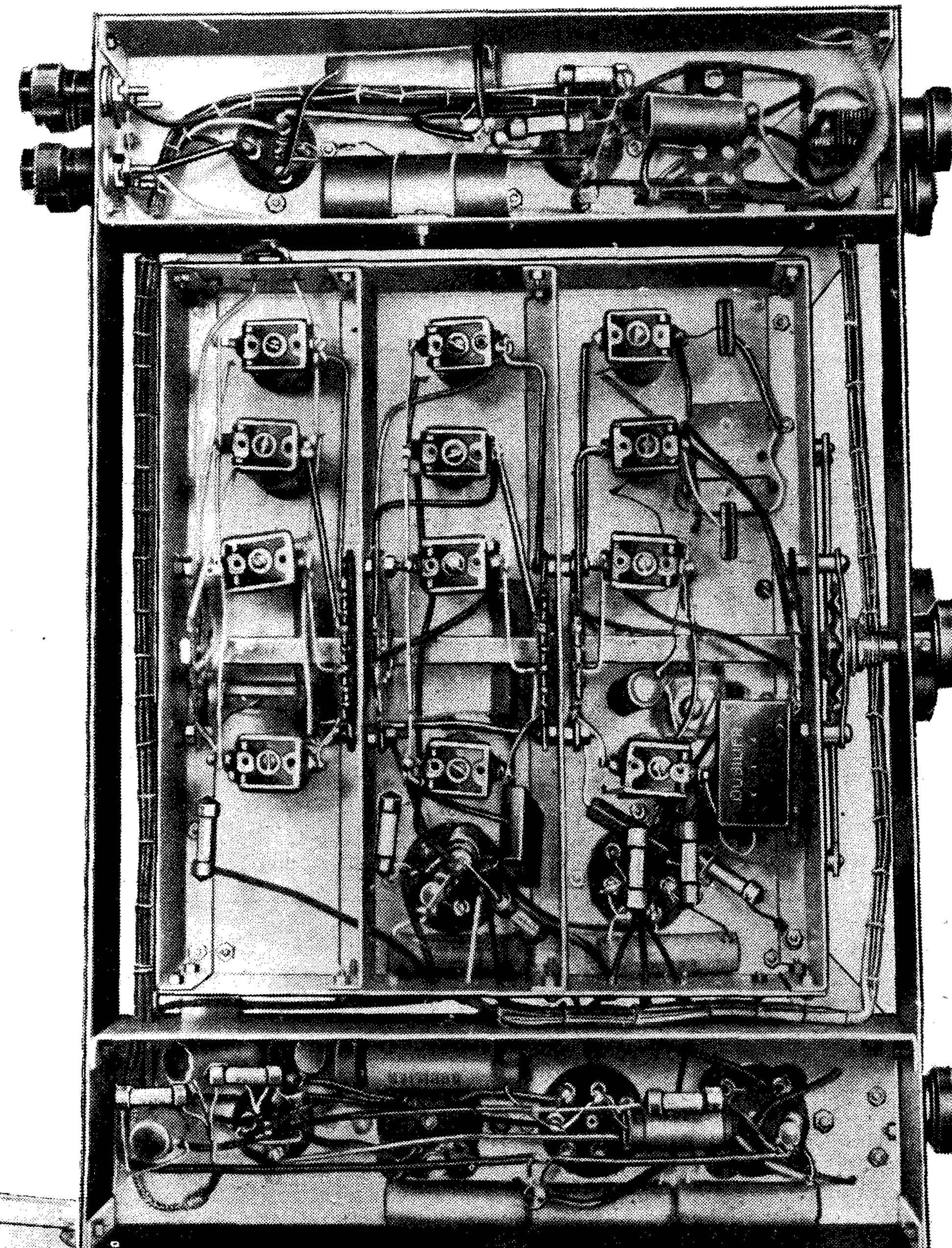
All-wave Battery Set—
upon its efficiency the volume obtainable largely depends. It should have a transformer giving a load of 7,000 ohms to the output valve, and it will naturally be of the permanent magnet type. A speaker such as the Goodman's 10in. Auditorium model is eminently suitable.

The first step in adjustment is to line-up the IF amplifier to 465 kc/s. A modulated test oscillator should be used and set to 465 kc/s. With its output connected to the grid of the IF valve, adjust the two trimmers in the second IF transformer for maximum output. Then transfer the oscillator output to the grid of the frequency-changer and adjust the trimmers in the first transformer with the selectivity switch at maximum (turned clockwise). Then check over all four IF trimmers starting from the detector and working backwards to the frequency-changer.

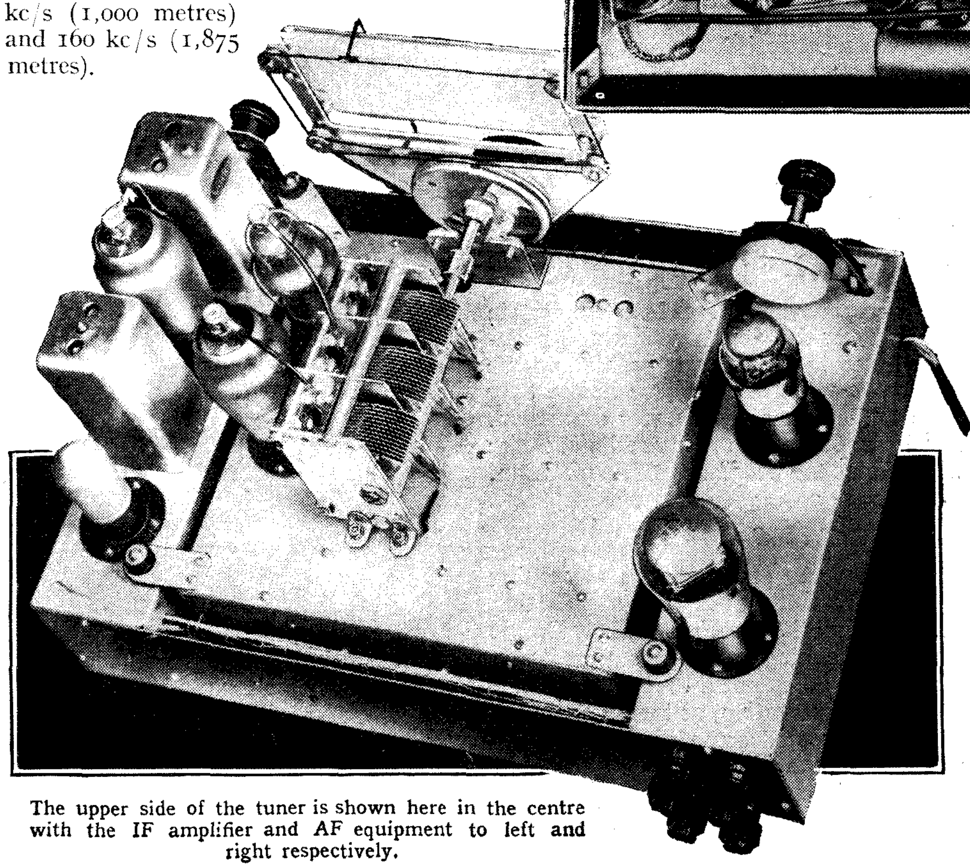
Ganging

The next step is to adjust the ganging with the oscillator joined to the aerial and earth terminals. Start on the medium waveband with the oscillator at 1,400 kc/s. Set the variable condenser so that the dial reading corresponds (1.400 kc/s is 215 metres) and tune in the oscillator signal on the two signal-frequency trimmers and the oscillator trimmer C11. Then set the test oscillator to 600 kc/s (500 metres) and the receiver condenser to suit and tune in the signal on the padding condenser C14 only. Then go back to 1,400 kc/s and repeat the adjustments already made at this frequency.

The procedure on the long waveband is exactly the same using the equivalent trimmers for this band and carrying out adjustments at 300 kc/s (1,000 metres) and 160 kc/s (1,875 metres).



All wiring is carried out on the underside of the tuner and main chassis and is quite straightforward.



The upper side of the tuner is shown here in the centre with the IF amplifier and AF equipment to left and right respectively.

On short waves, too, the procedure is essentially the same and adjustments should be made at gang condenser capacities of the same order as on the medium waveband. On these bands, however, two alternative settings of the oscillator trimmer may be found. The correct one is that which has the less capacity in the trimmer. On the other hand, if the test oscillator is swung through the tuning point of the receiver, two settings may again be found. The lower frequency or longer wavelength setting of the test oscillator is the one to use.

On test the receiver functioned very well and proved sensitive and selective enough for most requirements. Good freedom from whistles and second channel interference was found and on all wavebands the set was easy to handle and gave consistent results. The quality of reproduction was surprisingly good in view of

All-wave Battery Set—
the small output valve and proved very pleasing at a volume level suitable for most domestic requirements.

When conditions were suitable American stations were well received in London on short waves in spite of severe local interference. The French and German short-wave stations proved to be consistently good signals, and on medium and long waves a large number of stations were naturally available at entertainment value.

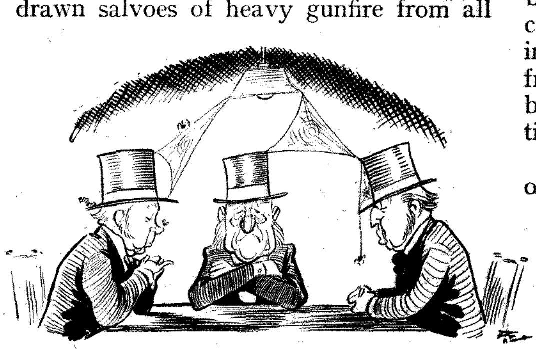
It is regretted that two condensers were omitted from the list of parts and were also not shown on the circuit diagram of Fig. 3. These condensers are a tubular paper condenser C42 of 0.002 mfd. capacity and a mica dielectric condenser C43 of 0.0003 mfd. capacity. The former is connected in parallel with the trimmer C13 and the latter for the medium waveband in parallel with C14.

UNBIASED

BY FREE GRID

Which Way Does *the Current Flow?*

THE remarks which I made the other week about the direction of current flow from an electric eel seem to have drawn salvoes of heavy gunfire from all quarters. Unfortunately for them the attackers do not agree among themselves, and have opened fire on me for opposite reasons, and should, therefore, be engaging each other.



Old technical die-hards

In the first place let me make it quite clear that I'm not doubting the fact that the eel's head is positive and its tail is negative. The only point at issue is whether the current flows from its head to its tail or *vice versa*. Since an eel is no different from any other type of electric battery let us simplify matters by transferring the argument to our old friend, the HT battery. The question before the House is, Does the current flow out of the positive or the negative terminal of an HT battery?

Before you all commit technical suicide by shouting that it flows from the positive let me ask you to pause and think what such a statement means. Surely if it is true it means that the current chases across from the positive anode of a valve to its negative cathode in opposition to the great truth which we learned at our mother's knee that electrons are given off by the hot negative cathode and flow across to the positive anode.

Some of the old technical die-hards among you are, I must admit, very ingenious in your arguments, for I have a letter before me in which the writer, obviously one of the old school of electrical thought, tells me that the *electronic* current which flows from the cathode to the anode is quite separate and distinct from the *electric* current which flows in the opposite direction. The electrons flowing from cathode to anode, I am told, form a bridge by means of which the real electric current crosses the vacuum in the valve; in other words, positive particles coming from the HT battery clamber over the backs of the electrons! Surely a revolutionary thought.

Now I fully realise that these few words of mine are bound to bring forth a fresh broadside from the other camp, and I would like to say that I do not speak without authority in these matters, as in addition to my own reputation as a scientist, which is unimpeachable, I can quote chapter and verse from other sections of *The Wireless World* in defence of my views, and I greatly doubt if my opponents have any foundation at all for their arguments, apart, of course, from hoary old traditions and musty textbooks.

I am, therefore, fully prepared to back up my opinions in public debate, and the other side are at full liberty to rope in any of the "big shots" they can get to speak on their behalf. There are certain people I could mention who would probably agree to speak in opposition to me as a matter of principle even before they were told of the subject under discussion. No doubt one of the many radio societies will offer us the hospitality of its platform.

Critics Silenced

I AM sorry to say that several carping critics have endeavoured to suggest that when visiting the Manchester Show I must have been looking on the wine when it was red to such an extent that it impaired my powers of observation, as turnstiles, in the ordinary accepted sense of the term, do not exist at the City Hall. I regret that numbered among my critics are one or two eminent men of science, and their ill-advised attack on me implies a lack of reasoning power on their part which is unfortunately all too common among such people when they attempt to apply their minds to ordinary mundane matters.

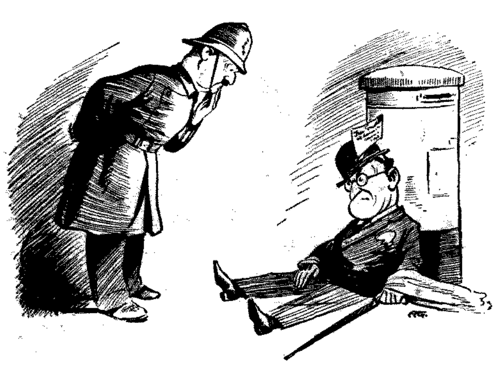
I was, as I usually am, one of the earliest visitors to the Show on the opening day. After the unfortunate *contretemps* at the turnstiles, the management naturally breathed a sigh of relief at my good-naturedly waiving any claim for compensation for injuries received, but, being business men, they realised that if a similar accident occurred to someone else it was extremely unlikely that he would be of as an accommodating nature as myself. The result was that workmen were summoned and the offending turnstiles removed forthwith. I hope that after this explanation my critics will have the common decency to apologise for their unworthy thoughts.

Television Troubles and the G.P.O.

IF you notice cars and trolley-buses chasing each other across your television screen, says a writer in one of our great daily journals, you should complain to the G.P.O. about it. Personally speaking, when this sort of thing happens in the case of my own set I always find it best to take a couple of aspirins and retire to bed for a few hours. In any case, I have no faith in the G.P.O.'s alleged helpfulness in these domestic crises owing to an unfortunate experience I had a little while ago.

I had spent a very tiring evening doing research work in a friend's laboratory and had the misfortune to run into a thick fog on the way home, and as a result I completely lost my bearings. With great presence of mind I scribbled my name and address on a page torn from my pocket book and after attaching it together with a stamp to my hatband, I propped myself up against the nearest pillar box to wait the coming of the postman at the next collection time.

I suppose that, overcome by weariness, I must have fallen asleep as the next thing



The postman failed to collect.

I remember was being awakened by the approach of a policeman in the grey hours of dawn, and I found, to my dismay, that the postman must have ignored me when he made the final collection. So much for the much-vaunted service of the G.P.O.

Letters to the Editor

The Editor does not necessarily endorse the opinions of his correspondents

Frequency Tests

WITH reference to Mr. Voigt's letter in your October 13th issue with reference to broadcast frequency tests, I would like to report that I have heard such tests broadcast during the latter part of September from, I believe, the Stagshaw transmitter. These tests, which took place about 10 a.m., consisted of a series of separate frequencies, starting from 50 c/s or below, and were about ten in number.

Each frequency lasted about half a minute with about the same interval between, rather after the style of the test film used by the RCA service engineers. No announcements were made.

Ambleside, Westmorland. ROBERT C. BELL, Service Engineer.

Amateur Exclusiveness

JUDGING by the Editorial of *The Wireless World* for October 20th, experienced amateurs—a fraternity that boasts of its comradeship throughout the world—are taking up an attitude of what amounts virtually to snobbishness.

Your critics seem to forget that without some infusion of new blood into transmitting circles the movement must eventually die out. Nevertheless, the "old hands" show an extraordinary tendency to discourage the beginner. I have listened-in to two local transmitters planning to "freeze out" a newly licensed amateur by ignoring his calls.

H. J. BENTLEY.
Leicester.

British Sets Overseas

I HAVE read with interest the article by "Heptode," "Return From Malaya," and also the replies by various correspondents. Fifteen years ago American sets and components were practically unobtainable in this colony, and only British goods were on the market. To-day this has been completely reversed, and American manufacturers are, and have been for some time, flooding the market. I am a serviceman of some fifteen years' standing, and own and operate one of the most up-to-date workshops in this colony. I have handled nearly all makes and types of receivers, and can say that hardly 30 per cent. of American receivers are built for tropical use. Among the few British sets that are under my care are two three-valvers that in the course of years have needed only valve replacements. "Heptode," in comparing American sets with the British set mentioned by him, has done so only on the basis of results obtained, and not on actual value for money, which, I think, is what counts in the long run. The prices of British sets compare favourably with American, and the purchaser of British instruments has the additional guarantee of superior workmanship, superior components and superior design.

I must also take "Diallist" up for his campaign against the British Valve Muddle. I have nothing to say against his demand for a simplification and unification of valve types and bases, but please don't hold the Americans up as models of restraint. The utmost confusion exists in an immense range of valves manufactured by some twelve manufacturers, not four or five, as he once stated. The American Valve Muddle involves me in an outlay of £3 a year to keep abreast of its development, and this money I spend in manuals and books that mark the progress of the industry in America.

Lastly, but not least, let me congratulate you on the excellence of your journal. I have been a regular subscriber for some years, and have built for my own use, from British parts, the "Imperial Short-Wave Six" and the Three-band Quality 7-valver. Carry on the good work.

Lourenço Marques, Portuguese E. Africa. A. J. IMRIE.

Ghost Images

I SHOULD like to draw attention to an article which appeared in the August issue of *Radio-Craft*, which may shed some light on the peculiar form of ghost image mentioned by Mr. West in your issue of October 13th.

The author of the article suggests that ghost images are due to reflected waves, of comparable magnitude to the direct wave, arriving a fraction of a second later than the direct wave and thus causing two images. As the reflected wave has its own side components and may have any phase with respect to the direct wave, it is quite possible for a reflected wave travelling 1,000ft. or more to cause a distinct double image, and, due to a difference in phase, cause a black line to be repeated as a white line, or vice versa. The reversal in phase which Mr. West says is not constant may be due to some peculiar action or change in the reflecting body, which may be a reasonable-sized metal object or even a large tree moving in the breeze. Mr. West must also bear in mind that the trouble can be set up by a fault in the aerial system causing a condition of unbalance and reflection.

HAROLD W. DAWES.
London, S.W.9.

Five-metre Skip Distances

WITH reference to the article on "Long-distance 5-metre Communication" in the issue of October 13th, your contributor, H. B. D., seems to have obtained a wrong impression of the explanation of the bulge in the curve at 1,200 miles. Reference to the original article by Pierce in QST shows that the "bulge" is due to the super-position in one curve of two sets of data, one comprising reports from East Coast stations and the other from stations lying farther west. As the latter stations were experiencing a longer skip distance the bulk of the reports from this area is concentrated at distances around 1,200 miles. The higher ionization density over the Eastern states accounts for the main peak in the curve. Addition of the two sets of reports naturally results in a double-peaked curve.

The observation of skip distance on the high frequencies, particularly on the 14-Mc/s and 28-Mc/s amateur bands, has been a normal part of the radio research work at this laboratory during the past summer, and sufficient data have been collected to show that electronic densities in the abnormal E layer of over one million electrons per cubic centimetre have been of frequent occurrence.

Unfortunately, the data collected are very incomplete, and a much larger number of reports will be needed before even a rough idea of the distribution of the ionization can be obtained. May I, through the hospitality of your columns, appeal to those of your readers who have such data available to send me details of all stations worked or heard on "short skip" on 14 Mc/s or 28 Mc/s during the summer months? As many details as possible should be given, complete identification of the station and the exact time at which it was heard or worked being the most important points. All such reports will be gratefully acknowledged.

L. G. STOODLEY (G8DM).
The Physical Laboratory, University College, Southampton.

Intermodulation and Harmonic Distortion : Last Shots

IN order to terminate our controversy with "Cathode Ray" on the subject of intermodulation as rapidly and decently as possible, we will merely conclude:—

(a) We stand by all our conclusions and arguments of our last letter.

(b) We can only regret that "Cathode Ray" has found our acoustical terms "too much" for him. The subject is certainly very confusing, and we have written him personally to explain the matter in detail.

M. V. CALLENDAR, M.A.,
G. F. CLARKE, B.Sc.
Research Dept., Pye Radio, Ltd. Cambridge.

HAVING considered the explanation referred to by Messrs. Callendar and Clarke, I agree that the masking figures given in my letter of June 30th were wrong, due at least in part to a somewhat misleading explanation in the work quoted; and I regret the error. At the same time, I would point out that as I had some doubts about these figures I remarked at the time: "I want to make clear that I am not necessarily backing these figures."

With regard to the term *Sensation Level*, this is, in my opinion, an unnecessary and misleading term; a hybrid, measured in objective units above a subjective starting line. In the newly published I.R.E. book, *Standards on Electroacoustics*, containing definitions of technical terms, it is nowhere mentioned.

I also stand by my original contention, viz., that the harmonics commonly specified—second and third—contribute a relatively small part of the offensiveness of distortion, whereas intermodulation products, commonly ignored, are of major importance. Nobody appears to have been able to explain my original simple experiment satisfactorily on any other basis.

In concluding, I would like to thank Messrs. Callendar and Clarke for drawing attention to the necessity for taking account of the phenomenon of masking in considering the subject of distortion.

"CATHODE RAY."

Television Topics

VISION-FREQUENCY AMPLIFICATION

MOST television receivers employ one stage of VF amplification, and resistance coupling is adopted between the detector and this valve and again between this valve and the CR tube. Unfortunately, stray capacities cause the response to fall off as the frequency is increased, and with plain resistance coupling it is necessary to use a low value of resistance if a reasonably flat response curve is to be secured. This means low gain and, sometimes more important, a severe restriction of the undistorted output of the valve.

It is, therefore, the general practice to adopt correcting methods which tend to offset the effects of the circuit capacity and so permit the use of higher values of resistance. Four different methods of correction are analysed by E. W. Herold in *Communications*,[1] and the optimum conditions for all are given in a form which lends itself admirably to design purposes. In general, the circuit values which give the best frequency response curve are not the same as those which are most suitable from the point of view of time delay. The "optimum" conditions, therefore, represent a compromise between the two requirements.

High-frequency Correction

The circuits investigated are shown in Fig. 1, starting with the plain resistance coupling and ending with a fairly complex network embodying two correcting coils. Table I gives the design figures based on a smooth response curve falling to 90 per cent. of the low-frequency response at the "cut-off frequency" f_c. Frequency, capacity, inductance and resistance are, of course, in cycles per second, henrys, farads and ohms respectively.

The design starts with the required frequency f_c and the circuit capacity C, which is the total of all capacities in shunt with the coupling. It includes the output capacity of the VF valve, the input capacity of the CR tube, the input capacity of the sync separator, the input capacity of the DC restorer, as well as wiring capacity in a typical case. Unless extreme care is taken, it may reach as much as 50 $\mu\mu$F., but if direct coupling is used to the tube and the sync separator is fed from a different point it may be only one-half this figure or even less.

Knowing f_c and C, R can be calculated directly from the figures of the first column for X_c. These figures are indicative of the merit of the circuit from the point of view of gain, since R is proportional to X_c and gain is proportional to R, being, in fact, equal to the product of R and the mutual conductance of the valve.

Suppose $f_c = 2$ Mc/s and $C = 50$ $\mu\mu$F., then with resistance coupling, Fig. 1 (a), $R = 0.48/6.28 \times 2 \times 10^6 \times 5 \times 10^{-11} = 0.48/0.000628 = 765$ ohms, so that with a valve having a mutual conductance of 6.0 mA/v. the gain is only 4.6 times. With the circuit of Fig. 1 (b), which is probably the most widely used, the resistance becomes $1/0.000628 = 1,590$ ohms, and with the same valve the gain is 9.55 times, a considerable improvement. The inductance required is $0.37\ CR^2 = 4.66 \times 10^{-5}H = 46.6\ \mu H$.

Still better results are secured with Fig. 1 (c), R becoming 1,990 ohms and the gain 11.95 times. L is now 75 μH., and C3 becomes 15 $\mu\mu$F. This capacity includes the self-capacity of the coil, perhaps 5 $\mu\mu$F., so that this must be allowed for and the added capacity need only be about 10 $\mu\mu$F.

The best circuit of all is that of Fig. 1 (e), for R becomes 2,860 ohms, and the gain is 17.2 times. L1 is 49 μH. and L2 is 213 μH. In practice the objection to this circuit is that the capacity must be split into two parts in certain proportions. For a total capacity $C = C_1 + C_2 = 50$ $\mu\mu$F., C_1 must be 17 $\mu\mu$F. and C_2 33 $\mu\mu$F. It is not always possible or convenient to arrange matters so that the stray capacities fall naturally so that C_2 is double C_1. More often they fall more nearly in the proportion demanded by Fig. 1 (d).

Incidentally, this circuit, although slightly inferior to (c), has the advantage of giving a much lower response at frequencies higher than f_c. In other words, it cuts off more sharply. The advantage of this is that the circuit also acts as a filter, so that it will reduce any tendency

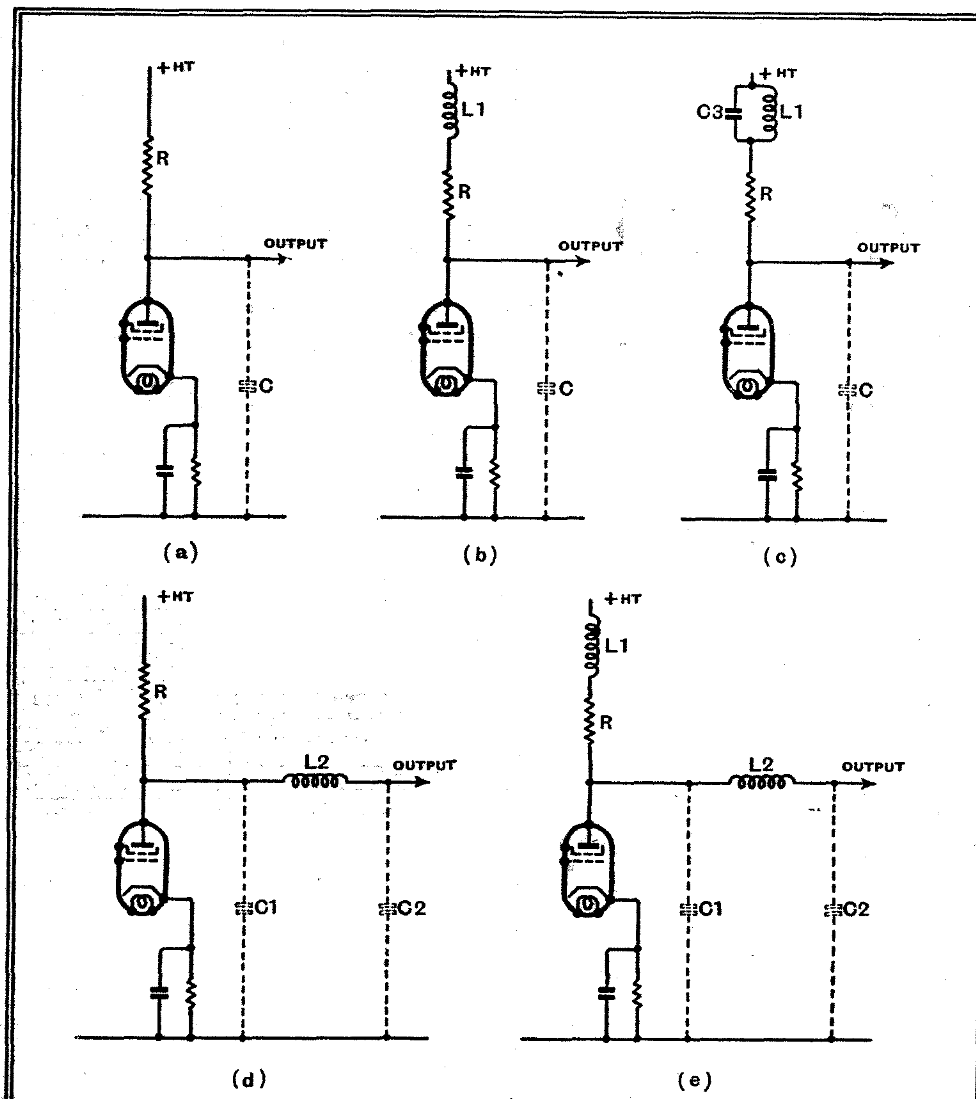


Fig. 1.—Methods of coupling the VF amplifier to the CR tube are depicted in these diagrams. Plain resistance coupling is shown at (a) and with a simple form of correction at (b). A slightly more complex corrector is given at (c), and (d) and (e) show different types of network. As explained in the text, the last is capable of the best performance.

[1] August, 1938.

Television Topics—
to the feed-back of IF harmonics from the leads to the tube. Currents of intermediate or higher frequency should not, of course, be present in the VF valve, but in practice they often are owing to the difficulty of obtaining a high degree of filtering before it. This advantage of a filtering action at high frequencies is also present with the circuit of Fig. 1 (e).

for if they are not the response curve is affected. If the capacities are in the wrong ratio, for instance, the response may fall off too early and then rise afterwards to form a peak just before the cut-off frequency.

Actually, of course, when the circuit has been designed, its performance should be checked by measurement, for then any irregularities due to variations in the circuit constants can be smoothed out by their practical adjustment. In general, however, such irregularities are quite small, and the imperfections will normally be tolerable if care is taken over the initial assessment of the capacities used in deriving the other values.

TABLE I.

Circuit.	$X_c = 6.28 f_c CR$	Delay Error.	L_1	L_2	C_1	C_2	C_3	C
a	0.48	$\frac{0.005}{f_c}$	—	—	—	—	—	C
b	1.0	$\frac{0.003}{f_c}$	$0.37\ CR^2$	—	—	—	—	C
c	1.25	$\frac{0.008}{f_c}$	$0.38\ CR^2$	—	—	—	0.3 C	C
d	1.23	$\frac{0.008}{f_c}$	—	$0.56\ CR^2$	0.2 C	0.8 C	—	$C_1 + C_2$
e	1.8	$\frac{0.009}{f_c}$	$0.12\ CR^2$	$0.52\ CR^2$	0.34 C	0.66 C	—	$C_1 + C_2$

From the point of view of performance this last circuit is unquestionably the best, but it certainly requires more material than the others, for two coils are needed. These need not be expensive, however. In practice it is quite important that the capacities be close to the correct values,

More About Car Radio

THE technical reviews of car radio receivers published in our issue of October 20th was restricted to sets shown at the recent Motor Exhibition. As this did not include all the equipment now available, a brief description of others not represented at the show will be given.

There are some interesting features in the new Pye car radio receiver. It employs a 5-valve superheterodyne circuit having one RF stage fitted with a low-noise RF pentode. The frequency-changer and IF amplifier are conventional, apart from the fact that all tuned circuits have high-Q iron-cored coils.

Its special feature is the inclusion of an output limiting circuit, which can best be described as a volume compressor. It enables a higher mean level of output to be obtained without overloading the last stage on deep modulation. Thus the softer passages of music which might be drowned by the normal noises of a car in motion are maintained at a good level of audibility.

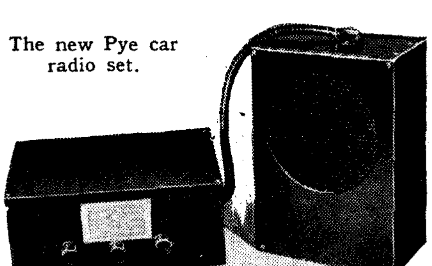
The set is of two-unit construction, one part contains the set and the other the loud speaker and vibrator-type HT supply unit. An input filter in the receiver limits ignition noise, and only in exceptional cases are spark-plug suppressors required. The set covers medium and long waves; it costs 15 guineas.

What must surely be unique among car radio receivers is the Princely Model 106, for it includes a short-wave range in addition to the medium and long wavebands. This all-wave car radio set is a 7-valve, plus rectifier, superheterodyne, and on the short waves covers a range of 16 to 50 metres. The medium and long wavebands have normal coverage.

It includes two RF stages before the frequency-changer, and two IF amplifiers follow, while the output stage is push-pull, giving a maximum of nine watts undistorted output.

A vibrator and full-wave rectifier, which is housed, together with its smoothing equipment, in the loud speaker unit, provides the HT supply. The loud speaker is a large 8in. diaphragm model. This set costs 25 guineas.

The new Pye car radio set.



In all there are six receivers in the Princely range, the cheapest costing 7 guineas. Even this is a superheterodyne, and has five valves, including a full-wave rectifier which works in conjunction with an HT vibrator. It is a self-contained unit with the tuning and volume controls on the set.

Of the other sets mention must be made of Model 102, as this includes push-button tuning, the system employed being a mechanical one with the six station-selector buttons on the receiver unit. A manual tuning control is also included. It is a four-valve (plus rectifier) superheterodyne and costs 9 guineas.

Push-button tuning is adopted in the latest Crosley Roamio car radio receiver. The choice of any five stations can be had with this set, and the selection at any time changed for others. The push-button tuning system is mechanical, and all the controls, including the alternative manual tuning scale, are included in the set. Remote control is not adopted.

The circuit is a four-valve superheterodyne arrangement, and a fifth valve, in conjunction with a vibrator, supplies HT. It is built as a single unit with self-contained loud speaker, and the price is 10 guineas. It covers the medium waveband only, and can be used on 6- or 12-volt batteries.

Television Programmes

Vision 45 Mc/s Sound 41.5 Mc/s

An hour's special film transmission, intended for demonstration purposes, will be given from 11 a.m. each week-day.

THURSDAY, NOVEMBER 3rd.

3, "Cast Up by the Sea," a Stephen Leacock melodrama. **3.30,** British Movietonews. **3.40,** 187th edition of Picture Page.

9, Cabaret. **9.25,** 188th edition of Picture Page. **9.55,** Gaumont-British News. **10.5,** News.

FRIDAY, NOVEMBER 4th.

3-4.30, "Cyrano de Bergerac," a play by Edmond Rostand with Leslie Banks in the name part.

9, Foundations of Cookery, Marcel Boulestin begins a new series. **9.15,** "So Ended a Great Love"—feature film with Paula Wessely. **10.45,** News.

SATURDAY, NOVEMBER 5th.

3, C. H. Middleton, "In Our Garden." **3.15,** The Hogarth Puppets. **3.25,** Cartoon Film. **3.30,** Cabaret. **3.55,** British Movietonews.

8.20, Ice Hockey match between Earls Court Rangers and Wembley Monarchs, at the Empress Hall, Earls Court. **9,** "Order to View"—a revue. **9.35,** Gaumont-British News. **9.45,** Ice Hockey O.B. continued. **10.10,** Eyes and No Eyes—A visual definition bee. **10.25,** News.

SUNDAY, NOVEMBER 6th.

8.50, News. **9.5,** Cartoon Film. **9.10,** Theatre Parade—Excerpts from the Vaudeville Theatre Show "Goodness, How Sad!" by Robert Morley.

MONDAY, NOVEMBER 7th.

3-4.30, Television version of Somerset Maugham's suburban comedy "The Breadwinner."

8.50, Your Television Set—No. II. How to get the best from your receiver. **9,** "Dark Highlights"—An All-coloured Cabaret. **9.40,** National Sporting Club boxing from Empress Hall, Earls Court. **10.20,** News.

TUESDAY, NOVEMBER 8th.

3, Revue. **3.35,** Gaumont-British News. **3.45,** Picture story No. 1,—"The Seventh Man" by Robert Gibbings. **3.55,** Cartoon Film.

9, Talk by Lord Hailey. **9.10,** British Movietonews. **9.20,** Somerset Maugham's "The Breadwinner." **10.50,** News.

WEDNESDAY, NOVEMBER 9th.

2.25, The Lord Mayor's Show—O.B. **3,** "Contrasts." **3.10,** Cartoon Film. **3.15,** "The Last Voyage of Captain Grant," a serialed narrative of the Arctic.

9, Speaking Personally—Ann Bridge. **9.10,** Eric Wild and his Band. **9.30,** Cartoon Film. **9.35,** Gaumont-British News. **9.45,** "The Viceroy of Peru," adapted by Harold Bowen from "Le Carrosse du Saint-Sacrement." **10.15,** News.

Random Radiations

By "DIALLIST"

Comprehensive

THE question of guarantees for wireless sets has always been a vexed one. As matters stand most firms give a three-months' guarantee for the set, excluding its valves, and a few a guarantee, with the same exception, for twelve months. Recently I came across an advertisement offering sets under a comprehensive twelve months' guarantee which covered not only the receiver itself, but also its British-made valves. I know some people whose valves I wouldn't care to guarantee for that length of time, however good they were! In one household that I visit the radiogram is at work for at least 10 hours a day, or say the best part of 4,000 hours a year. I know others, too, where sets or radiograms are pretty constantly in operation at all times when the home stations are on the air. And I suppose that, taking it by and large, the average number of hours of daily use that the receiver gets nowadays isn't much short of four, or say 1,200 to 1,500 a year.

A Vexed Question

THERE is one rather unsatisfactory aspect where the receiver and the valves are separately guaranteed. A smoothing condenser, let us say, becomes a casualty within the guarantee period, and its demise results in the power rectifier valve meeting with an untimely end. The set is returned for repairs under the guarantee and the faulty condenser bank is duly replaced free of charge. Not so the valve. The set maker refers the victim to the valve manufacturer and his guarantee. When the latter is approached he replies that the valve went west not through any defect which it developed, but because it was subjected to an overload; but how the overload was caused does not concern him, the only relevant fact is that it occurred. And I suppose that if a valve developed a defect which caused the breakdown of other components, you would be entitled under the dual guarantee to a free replacement of the valve, but not of the parts wrecked by its misbehaviour. It seems to me that to be quite fair and satisfactory, guarantees should cover untoward happenings such as these.

A Maintenance Scheme

WIRELESS dealers, I hear, have been putting their heads together to evolve a maintenance scheme for receiving sets. The idea is that the set owner should pay an annual sum of about thirty shillings for a receiver pure and simple, or about two pounds for a radiogram. In return for that he would receive a fixed number of visits during the year from a trained and fully equipped service man, who would make any necessary adjustments and clean and generally check over the apparatus. All defective parts, including the valves, would be replaced free of charge. The set owner would, in fact, know exactly where he stood. A very good idea, I think, and one likely to catch on with wireless users. What I particularly like is a suggestion that the scheme should apply to sets bought on the hire-purchase system, an appropriate extra weekly or monthly charge being, of course, made. Too often, as matters are, one comes across folk who can only just afford the instalments on a set bought by hire purchase and are completely swamped if a breakdown calling for expensive repairs occurs outside the guarantee period.

Progress!

THE United States has, of course, always been so far ahead of us in radio that we've been hard put to it even to keep Uncle Sam's coat tails in sight through the dust of his flying footsteps. Whenever I open an American paper I eagerly scan the radio advertisements in order to know what new things we may expect here in a few years' time. I was particularly thrilled by one which appeared in a recent issue of the "New Yorker." Here it is:

"A STARTLING NEW MYSTERY.

"Wire-less Self-Powered Radio.

"NO Electrical Connections—NO Ground Wire—NO Aerial Wire. Weighs only 15 lb. complete. Portable, Compact. . . . $13\frac{1}{4} \times 7\frac{1}{2} \times 7\frac{1}{2}$ inches.

"Ideal for Automobiles, Boats, Lawns, Golf Courses. . . . Simply set it down—and Press the Button (No waiting for tubes to heat).

"Beautiful self-contained Concert Tone (*sic!*), **Automobile Type, Dynamic Loud-speaker. . . .**

Price only 35 dollars. . . ."

From the accompanying illustration which depicts an angler, complete with waders and fishing rod, holding up the *startling new mystery*, one gathers that America has at last discovered the portable. Meantime there seems to be a magnificent chance for any of our manufacturers who may have unsold stocks of ancient portables lying about to get a bit of their own back by dumping them across the Herring Pond.

Volume Controls

A READER—I deduce from certain remarks that he is a radio service-man, though he doesn't actually tell me so—has an interesting suggestion to make with regard to volume controls. He would like to see them connected across the secondary of the output transformer. His argument is that if this were done there would be no need for fiddling adjustments of the volume levels of built-in and extension loud speakers, that the volume control itself could be robustly made and that remote control would be made easier. He suggests that overloading of the output valve could be prevented by amplified AVC, whose presence would make it impossible for the user to advance the manual volume control too far. I am afraid that it wouldn't work out quite so simply as that. Many who use extension loud speakers want them to run either more loudly or more softly than the one in the set. And it mustn't be forgotten that the extension terminals are not infrequently used for the connection of head telephones if there is a deaf member of the family circle. There would also have to be a switch for cutting out the suggested kind of AVC: otherwise the set might not be of very much use on the short waves.

Student Life

FROM the Director of W2XAD and W2XAF I hear that these stations are making quite a feature of the broadcasts dealing with education in America, which began on November 1st. There are four of these broadcasts each week in English and one of these at least should be of more than usual interest. Each week there will be a programme dealing with undergraduate life, the items being provided mainly by the students themselves. American students are at least as lighthearted as those of other countries and I foresee some good fun.

THE WIRELESS INDUSTRY

MILNES Thermo-generators for accumulator charging, or for supplying LT to a broadcast receiver direct, are described in a booklet just issued by Milnes Electrical Eng. Company, Church Street, Bingley, Yorks. The generators function on the thermo-pile principle and are operated from any gas supply. A new vibratory HT unit designed for working with the generators is also described.

The Whiteley Electrical Radio Company inform us that the W-B Morse Key, reviewed in our issue of September 22nd, has now been withdrawn from the market.

A new catalogue of "Precision" test equipment, including universal meters with resistances of 20,000 and 1,000 ohms per volt, is available from L. A. MacLachlan and Company, Strathyre, Scotland.

THE NEW HOME OF RELIANCE RESISTANCES

DESIGNED specifically for the production of wire-wound and composition variable resistances, the new premises of The Reliance Manufacturing Co. (Southwark), Ltd., at Sutherland Road, Walthamstow, London, E.17, house all the processes involved with the exception of wire-drawing. An up-to-date bakelite moulding plant with electrically heated platens and the latest type of oil-driven presses has been installed, and the hydraulic accumulator supplying the presses stands on a concrete foundation 10ft. thick. More than 300 tons of reinforced concrete have been used in laying the 6,000 sq. ft. of working floor space.

NEWS OF THE WEEK

FINANCIAL STRESS?

B.B.C. Adjusts Expenditure-Revenue Ratio

BROADCASTING HOUSE is getting distinctly panicky over the financial position, and sweeping economy measures are projected to adjust expenditure and revenue, especially in regard to television.

The fact is that the reserves have melted away like morning dew before the summer sun, and the Corporation can find no adequate solution of its problem immediately. What it is doing in the meantime is overhauling the comparatively minor items of expenditure, such as staff expenses (travelling and incidentals) and programme outlay on the sound-boadcasting side. It is watching the sixpences and shillings—on the principle that the pounds will take care of themselves.

It is realised that it is impossible to cut down on artistes' fees; but the B.B.C. can engage, and is engaging, fewer artistes.

Hundreds of thousands of pounds will be wanted during 1939 on account of capital expenditure; but only mere hundreds can be saved by the present economy measures. The hard facts are that receiving licences now number nearly nine millions, and the steepness of the curve is rapidly lessening. Reserve funds have been drawn upon to the margin of safety.

R.A.F.C.W.R.

Training Begins

SINCE the formation of the Royal Air Force Civilian Wireless Reserve, at the end of August, more than 3,000 applications for membership have been received by the Air Ministry from amateur wireless telegraphists throughout Britain, and of this number 700 have already been enrolled.

Members of the reserve received their first general exercise last Saturday, October 29th. This was radiated from a Royal Air Force transmitting station to some 200 reservists scattered throughout Great Britain who have been organised under twelve regional controllers.

A button badge has been designed and approved for the Organisation. It is a shield, surmounted by the eagle of the R.A.F.; in the centre is a double-bladed axe, with lightning radiating from it, on a background of Air Force blue with the letters R.A.F.C.W.R. beneath.

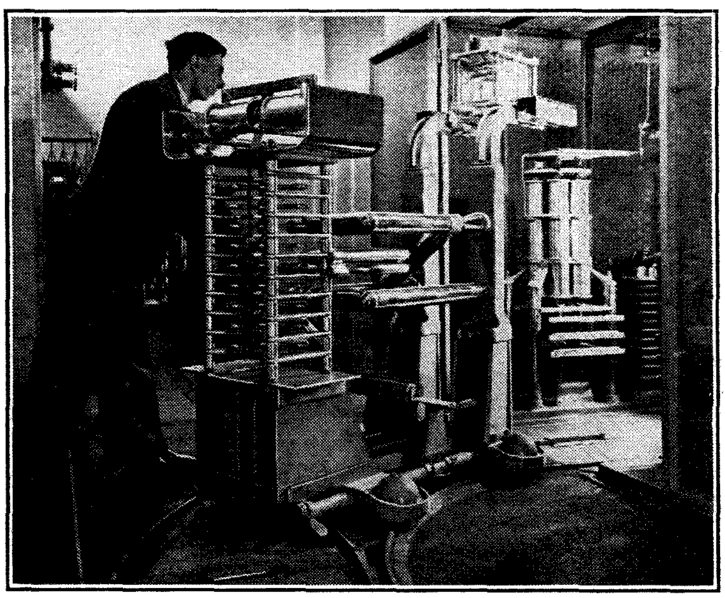
DAVENTRY'S TUNING COILS

Methods of Wave Changing at the Empire Station

THREE methods are employed for the frequent changes in wavelength necessary at the B.B.C. Empire station at Daventry.

One of these, which is purely experimental, is in use in one of the 20-kW transmitters using high-power screen-grid valves. This transmitter is fitted with continuously variable inductances by which the wavelength can be continuously adjusted between 13 and 50 metres. be rotated through 180 degrees and the tuned circuit brought into contact with the spare valves.

In the most recent transmitters installed at Daventry, the B.B.C. has reverted to the plug-in type of coil. As was depicted in *The Wireless World* a few weeks ago, the coil units are run into position on rails. The trucks conveying these units for the final stage of the transmitter carry, in addition to the main anode tuning inductance, the feeder coupling coil and associated tuning condenser as well as the grid circuit inductance.



DAVENTRY'S PLUG-IN COILS. One of the plug-in coil units being wheeled into position on the rails. The overhanging projection on the right carries the grid tuning circuit. In the centre are the two large tubular turns of the main anode inductance between which is the feeder-coupling coil.

Whilst the tuning operation is in progress, the power of the transmitter is drastically reduced by a special switch.

Rotary Switching

Another system of wave changing employs a rotating turntable on which is fixed four sets of tuned circuits. Any one of these pre-tuned wavelengths may be brought into circuit by a contacting arrangement. The transmitter power supply having been switched off, the contacts above the circuit rise about 6in., thereby disconnecting, from the two water-cooled valves, the circuit no longer required. The turntable is then rotated ninety degrees, and the contacts descend on the new tuned circuit and all is ready for the power to be switched on again.

A second pair of valves are provided diametrically opposite the others, so that in the event of a failure the turntable can

TELEVISION O.B.S AFTER DARK

THE success of the recent television transmission from the Carlton Cinema, Haymarket, has prompted a big drive for more O.B. material from the West End after dark. Technically, these transmissions offer no serious problem except in regard to lighting. The use of the telephone circuits to link up with the nearest tapping point on the Post Office television cable has proved a complete success for distances up to one-and-a-half miles. The specially selected lines used on these occasions do not pass through the telephone exchange, but from a direct link between the O.B. unit and the television cable.

BRUSSELS AND THE B.B.C.

Upholding British Interests

SIR NOEL ASHBRIDGE, the B.B.C.'s Controller of Engineering, will attend the Brussels Wave Plan Conference of the International Broadcasting Union, which opens on November 7th. With him—also upholding the interests of British listeners—will be Mr. L. W. Hayes, of the B.B.C. Engineering Information Branch, who has attended practically every European radio conference during the past fifteen years.

The Conference, which will establish another European wavelength plan similar to those of Geneva and Prague, is not expected to modify the British wavelengths.

The British Post Office representatives will be Colonel Angwin and Mr. H. G. C. Welch.

FROM ALL QUARTERS

Tribute to Sir John Reith

WHEN Sir John Reith left Broadcasting House he expressed a wish, in terms almost amounting to a command, that the staff should not contribute towards any formal presentation. This wish has been respected. There are, however, ways of circumventing the most uncompromising obstacles. The B.B.C. Club has now persuaded Sir John to accept a memento of his thirteen years' presidency. The choice of memento will be announced in due course.

Imperial Airways Radio Officers

A THREE-YEAR agreement has been concluded between Imperial Airways and the Radio Officers' Union covering all radio officers engaged on Imperial Airways routes. This provides for rates of pay commencing at £4 10s. per week, rising by 5s. annual increments to £6 5s. in the eighth year. Radio officers on the Empire Air Mail services are to receive 8s. a day while away from their base, and those on European services an extra payment of a penny per ten miles while flying. Provision is made for an annual leave of twenty-one days.

First Orkney Transmitter

IN the issue of October 20th we referred to GM3TR as the first amateur transmitting station to be authorised in the Orkney Islands. Mr. James Twatt, of the Marconi Development Department at Chelmsford, Essex, writes saying: "On April 2nd, 1936, I was granted a licence to transmit under the call-sign G6ZC from 26, Willowburn Road, Kirkwall, Orkney, but unfortunately my almost immediate removal to Chelmsford prevented the station from being put into operation at that

News of the Week—

address." To be correct, we should, therefore, have said that GM3TR was the first authorised amateur station to transmit in Orkney.

Television in Australia ?

ALTHOUGH it may be a long time before television becomes a public entertainment in Australia, there is no doubt about the interest focused on such a possibility. This is evidenced by the interest shown in the recent exhibition of two G.E.C. television receivers and photos of the B.B.C. television service by the British General Electric Company, Pty., at Sydney. Television reception was simulated by projecting on to the screen of one of the receivers, from a hidden source, a sub-standard motion picture film.

Encouraging Radio Research

A PRIZE of Rm.10,000 has been created in Germany and will be awarded, for the first time this year, for the most interesting radio research.

Indian Peoples' Sets

Two Indian firms in Madras have offered to sell wireless receivers for Rs.30 (£2 5s.) and Rs.60, for provincial and all-India receptions respectively. Mr. V. V. Giri, Madras Minister for Industry and Labour, is testing the sets himself, and, if they prove to be satisfactory, a company will probably be floated with the financial assistance of the Government.

Scophony Representative to Visit U.S.A.

CONSIDERABLE interest has been shown in the Scophony large-screen television developments by some leading American radio and film interests. With this in mind Mr. S. Sagall, of Scophony, Ltd., is leaving this week for America. He will endeavour to arrange for a Scophony exhibit at the World Fair.

Roumania Tackles Electrica Interference

AN energetic campaign against man-made interference has been started in Roumania. An order has been issued that all owners of electrical apparatus capable of causing interference with radio reception must notify the authorities within thirty days. Failure to comply with this order will mean the confiscation of the apparatus.

German Broadcast Developments

NEW stations in Pomerania and Saarbrücken, a new Berlin Deutschlandsender transmitter, as well as relay stations at Hanover and Dresden, are the extensions of the broadcasting service now under way in Germany.

General Ferrié Memorial

THE town of Draguignan, in the South of France, has honoured the memory of its distinguished son, General Ferrié, the wireless valve pioneer, by naming its principal college "Collège Général Ferrié."

"The Technique of the Radio Play"

THIS is the title of the paper to be read by Mr. Cyril Wood, late of the B.B.C., at the meeting of the Royal Society of Arts, John Street, Adelphi, London, W.C.2, on Wednesday next, November 9th, at 8.15 p.m. Applications for tickets should be made to the secretary.

French Broadcasting

THE policy and management of broadcasting in France is being examined by a special commission. It is understood that alarming and false news during the recent crisis looms largely on the agenda.

Safety in Numbers

POLSKIE RADIO is now transmitting simultaneously on four short wavelengths, viz., 19.84, 22.00, 25.55, and 26.01 metres. Announcements are in Polish, English and Spanish.

Germany's Voice

ON a letter recently received from Berlin was the postmark "Der Deutsche Kurzwellensender die Stimme der Heimat" (The German Short-wave Station is the Voice of the Homeland).

Italy's SW Power

THE two 100-kW short-wave transmitters at Prato Smeraldo, near Rome, which were referred to last week, were put into operation on Monday, October 31st.

Tokyo-Rome Radio Telephone

A NEW radio-telephone service between Rome and Tokyo was recently inaugurated. The great circle distance between these two cities is approximately 6,000 miles.

Televisio-photography at a 100 miles

MISS ELIZABETH COWELL, the television announcer, has just received an excellent portrait of herself taken from a receiving screen at Cinderford, Forest of Dean, Gloucestershire, more than a hundred miles from the transmitting station.

Vatican Radio

A STAMP recently issued by the Vatican State showing pictorially the Vatican City and gardens includes in the drawing the masts of the Papal broadcasting station.

Wireless in Finland

DESPITE the fact that a wireless licence in Finland costs 9s. (which in relation to the wages paid is dearer than the English licence), the popularity of wireless in this Northern Republic continues to increase. The latest licence figure of 259,458 reveals the fact that there is one receiver to every fourteen inhabitants. Swedish sets are the most popular, with those of German manufacture second and English receivers taking a poor third place in popularity.

Short Waves at Olympia

Two *Wireless World* receivers, the "AC Short-wave Three" and the "Battery Short-wave Three," are to be seen on the stand of the International Short-wave Club at the Woman's Fair, which opened at Olympia yesterday, November 2nd.

R.M.A. Change of Address

THE Radio Manufacturers' Association has moved to new offices in 59, Russell Square, London, W.C.1. Telephone: Museum 4031-2. It is also announced that Mr. Garry Allighan, *Evening Standard* radio critic and official publicist of the R.M.A., has left the Association following the abolition, by mutual consent, of the position.

Radio and the Fishing Fleet

IN view of the significance of radio communication at sea, the Norwegian organisations of fishermen have sent the Government a petition asking for the abolition of import duties on foreign transmitting and receiving equipment for small craft. The Government is also requested to spend 150,000 kroner on reconditioning the commercial radio telephony transmitter at Aalesund. During the past year a number of small transmitter-receivers have been installed in fishing craft in Norway, and now fifty-five vessels of the fleet attached to this northern town, Aalesund, have been fitted with radio equipment.

Hire Purchase

A BOOK recently published under the self-explanatory title of "The Hire Purchase Act, 1938: Its Meaning and Effect," by H. C. Crane, constitutes a valuable guide to all traders concerned with any branch of "easy payment" selling. The book costs 3s. 6d. (by post 3s. 9d.), and is issued by The Trader Publishing Company, Ltd., Dorset House, Stamford Street, London, S.E.1.

BROADCAST PROGRAMMES Features of the Week

THURSDAY, NOVEMBER 3rd.

Nat., 6.40, Extracts from "Goodbye, Mr. Chips." 8.30, The Mediterranean—Spain. 9.25, Television at Work, a commentary during the transmission of Television's "Picture Page." 10.35, "Reverie," B.B.C. Theatre Orchestra.

Reg., 6.0, The Richard Crean Orchestra. 8.0, The Kentucky Minstrels. 9.0, Darts Championship of the Air.

Abroad.

Munich, 7.10, "Die Vielgeliebte," operetta (Dostal).

FRIDAY, NOVEMBER 4th.

Nat., 6.25, The English Family Robinson. 8.10, "Remembrance," an Armistice Play by Ralph de Pomerai. 9.45, Ladies' International Fencing Championship.

Reg., 8.0, "What Happened at 8.20?" 9.30, Dance Cabaret from The Grand Hotel, Torquay.

Abroad.

Paris PTT and Marseilles, 8.30, Gabriel Fauré Concert from the Conservatoire.

SATURDAY, NOVEMBER 5th.

Nat., 3.55, Rugby League International, Wales v. England. 8.0, "Music Hall," including Evelyn Laye and the Two Leslies. 10.0, "The Gunpowder Plot," a reconstruction of the events which have given us Guy Fawkes' Day.

Reg., 6.45, A visit to Lambeth Walk. 7.35, "Franz Liszt," a musical biography. 9.0, American Jam Session, a special programme of swing stars, relayed from America.

Abroad.

Hamburg, 7.10, "Lysistrata," operetta (Lincke).

Bordeaux, 8.30, "Mireille," opera (Gounod).

SUNDAY, NOVEMBER 6th.

Nat., 3.30, Jewish Ex-Service Men's National Remembrance Service from the Horse Guards' Parade. 5.0, "Twenty Years After," recorded reception of talk from South Africa by General J. C. Smuts. 6.10, Abridged version of Shakespeare's "The Winter's Tale." 9.35, "Rivers of Europe," I—The Danube, Walford Hyden and his Orchestra.

Reg., 5.30, Spelling Bee, Dons v. Journalists. 5.55, Relay from Switzerland. 7.10, "Musical Comedy," well-known melodies. 9.5, Sunday Concert, Handel's "Acis and Galatea."

Abroad.

Berlin Deutschlandsender, 7.10, "Carmen," opera (Bizet).

Saarbrucken, 7.10, "Gipsy Love," operetta (Lehár).

MONDAY, NOVEMBER 7th.

Nat., 7.0, "Monday Night at Seven," 8.10, Snooker commentary. 9.40, Italian Music.

Reg., 6.0, Rugby Steam Shed Band. 8.20, Songs of the British Isles. 9.30, Rhythm Classics. 9.50, 10.25 and 10.55, Eclipse of the Moon, O.B. from Mill Hill Observatory.

Abroad.

Lille and Toulouse, 8.30, Symphony Concert including William Walton's new Symphony.

TUESDAY, NOVEMBER 8th.

Nat., 7.30, An inquiry into Social Distinction—Manners and Customs. 8.0, Star Gazing, featuring Jessie Matthews. 9.40, Famous Fusses No. II—The Waltz.

Reg., 7.30, "Stop Dancing," 8.30, The Under Twenty Club. 9.45, Speed.

Abroad.

Brussels I, 6.30, "La Serva Padrona," opera (Pergolesi).

WEDNESDAY, NOVEMBER 9th.

Nat., 12.15, The Lord Mayor's Show. 7.0, "You Shall Have Music," 7.45, "The World Goes By," a radio magazine. 8.15, Queen's Hall Symphony Concert. 9.20, The Prime Minister at the Lord Mayor's Banquet.

Reg., 3.30, Soccer Commentary, England v. Norway. 7.30, A Newcomer to Viewing. Howard Marshall gives the first of six talks on television and how it works. 7.45, The Arcadian Follies from the Alexandra Theatre, Hull. 9.20, Queen's Hall Symphony Concert.

Abroad.

Radio Paris and Brussels I, 8.30, Franco-Belgian Exchange Concert.

Lille, 8.30, "The Three Waltzes," operetta (Oscar Straus).

How to Understand Frequency Curves

Amplifier Characteristics and Loud-Speaker Reproduction

By "CATHODE RAY"

NO doubt the readers whom I usually have particularly in view—the comparative beginners—were a bit out of their depth in parts of my recent articles on tone control. When one goes to an oculist to have one's eyes tested he sums up his findings by a few marks on a prepared diagram. Although this conveys nothing at all to you and me, the optician to whom one takes it evidently understands it at a glance, for with no other information he proceeds to make a pair of spectacles to compensate for the eye defects. In the same way the defects of a sound-reproducing system can be expressed by means of a diagram, and those of us who are constantly using such diagrams may be apt to forget that their message is, so to speak, in code, and therefore its meaning is not necessarily obvious to the uninitiated.

Just as the oculist uses prepared diagrams on which to plot our visual characteristics, and the dentist has the same facilities for keeping a record of what he has done and is likely to have to do with our teeth, those concerned with sound reproduction buy standard sheets on which to plot their diagrams. Fig. 1 shows one of these. I suppose I can assume that everybody knows what a graph is. So the general idea of expressing information (for example, the relation between a baby's age and its weight, or the season of year and the sales of ice-cream) by means of a line (technically known as a curve, even if it be straight) on such a diagram is well enough known. The scales deserve some comment, though.

Where Uniform Scales Fail

The horizontal scale is of frequency, better known to musicians as pitch. Musicians identify particular frequencies by such obscure and uninformative terms as A flat and C sharp minor, and cannot even agree among themselves concerning exactly what frequency any one of these signifies; moreover, each denotes a number of widely separated frequencies. Scientific people indicate exactly what they mean by specifying the number of vibrations, cycles, or air waves per second required to produce a note of any particular pitch. The natural impulse is to mark these numbers along a uniform scale, so that 0 to 100, 100 to 200, and 5,000 to 5,100 all occupy the same length of scale. Frequency scales of this sort can be seen by looking up technical papers of about fifteen or more years ago. But musicians, unscientific though they be in most matters, led the technicians in recognising that the true measure of frequency change is not the frequency difference, but the ratio of the two frequencies. Thus the three examples given above all differ by exactly 100 c/s, but to the ear 5,000 to 5,100 represents a very slight—hardly perceptible—step in frequency; 100 to 200 is equal to the difference between a man's and a woman's voice, while 0 to 100 is really an infinitely large difference—all the difference between sound and no sound. So it would be a very unfair distribution to give them all equal lengths of scale. The slice from 100 to 200 is what the musicians call an octave—the higher frequency is double the lower. Now an octave gives the same impression of a step-up in frequency in whatever part of the whole scale it is located. Thus 200 to 400 is another octave, and should be allowed the same length of scale as 100 to 200, just as in a piano all the octaves occupy the same length of keyboard. The mathematicians' name for the same thing is a logarithmic scale, and they value it very highly for such purposes as slide rules. So although in Fig. 1 it may look a rather unnatural and complicated type of scale, it is really just the same as a number of things of familiar everyday use.

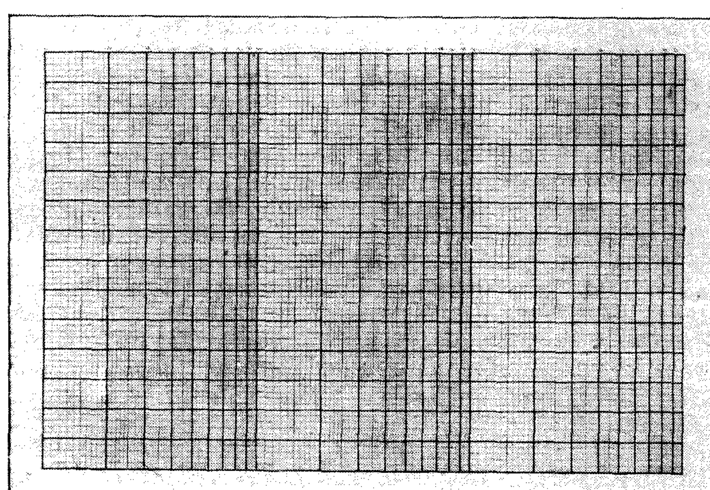


Fig. 1.—The usual type of curve sheet used for plotting frequency characteristics. The reasons for the peculiar scales are explained here.

The Vertical Scale

So much for the horizontal scale. The vertical scale indicates the relative strength of the sound (or electrical signal corresponding to it) at any frequency. If it is measured in units of air pressure, or in volts, or in watts, similar objections apply to a uniform scale as those just raised concerning the frequency scale. The attitude of the ear to loudness is much less definite than it is to frequency, so that first of all it is less sensitive to small changes and, secondly, there is more difficulty in finding out what it understands as *double* the loudness; but at least it can be said that the logarithmic scale is much more natural than the uniform. If, then, one wants to mark the strength in volts, or in the number of times amplification, one adopts the same sort of scale as for frequency. But as telephone engineers had already been accustomed to using a unit which, when marked at uniform intervals, actually constituted a logarithmic scale—just as octaves can be marked uniformly along the frequency scale—radio and sound engineers copied them, and their curve sheets are generally printed with uniform vertical scales, on the understanding that they will be used for this special unit, the decibel, which is one-third the size of an octave of power and one-sixth of an octave of voltage. So when you see a rise of 6 decibels you know that it is double the voltage or four times the power.

Now that these special scales are understood to be adopted because they correspond most closely to the relative impressions made on the ear—whether in pitch or loudness—we can go on to get some idea of what different shapes of curves actually mean in terms of quality of reproduction. This is knowledge that grows by experience, so that a trained listener can sketch approximately the frequency characteristic of a system without making any actual measurements; conversely, by looking at a frequency characteristic curve he can tell what sort of tone is given.

How to Understand Frequency Curves—

The commonest mistake of the beginner is to over-estimate the importance of small rises or falls. It looks very nice to see a perfectly straight level line right across the sheet (like Fig. 2(a)), and somebody who has an amplifier with such a characteristic is prone to lift up his voice in boasting over his neighbour whose amplifier's characteristic is like Fig. 2(b). One thing to be said about this is that if each has a loud speaker that reproduces the high notes less strongly than the low, then (b) is a better curve than (a), and the boasting, if any, should be reversed. The next thing is that in actual fact the irregularities in output of the very best loud speaker are far greater than those of Fig. 2(b), which are relatively negligible, and even if a perfect loud speaker were invented, irregularities of 10 db. or even more are introduced by the acoustics of the room. The third thing is that, although a change in output of 1 db. can instantly be detected when it is imposed on a continuous note, it is very doubtful that the most sensitive listener could definitely distinguish the difference between amplifiers (a) and (b) when used alternately to reproduce any ordinary programme. While if there is no standard of comparison at all, it is difficult to judge the relative level of any part within 6 or 8 db.!

Why Strive for Perfection?

On the other hand, departures of a few decibels cannot always be ignored, for two reasons. One is that the output of an amplifier is limited by the highest peak, and, if some small part of the scale is somewhat exaggerated, though perhaps not enough to upset the balance of tone, it may restrict the general volume. The other is that while 2 db. droop in the bass, for instance, may be tolerable in one item such as a transformer or a stage of amplification, if there are a number of similar items in the chain of reproduction the total effect may be serious.

Now for some examples; and to make room for a fair selection of them they are printed in Fig. 3 with only skeleton scales to indicate the limits. Perfection is represented, of course, by curve A—assuming that it is a characteristic of the entire system and not just of a part. Real perfection in a part may require some departure from the level in order to compensate for unavoidable characteristics of another part. B is a *good* loud speaker characteristic, and shows that the most that can be claimed is a fairly level general average extending over most of the audible scale. C is typical of a reasonably good amplifier; the tendency in practice is for the extremely low and high frequencies to droop, and by comparison with B it can be realised that such a small droop is negligible. But D, although no worse than many systems in use, could easily be distinguished by ear from C. Reproduction would lack both depth and brilliance. The deep plonks of the double bass would be weakened and apparently raised in pitch, while sounds such as brushing of cymbals would be muffled. Speech, though probably still apparently distinct, would be more of a strain to listen to. But the general balance would not be as bad as one might judge from the curve. Reproduction would just lack reality and be typical of "canned music."

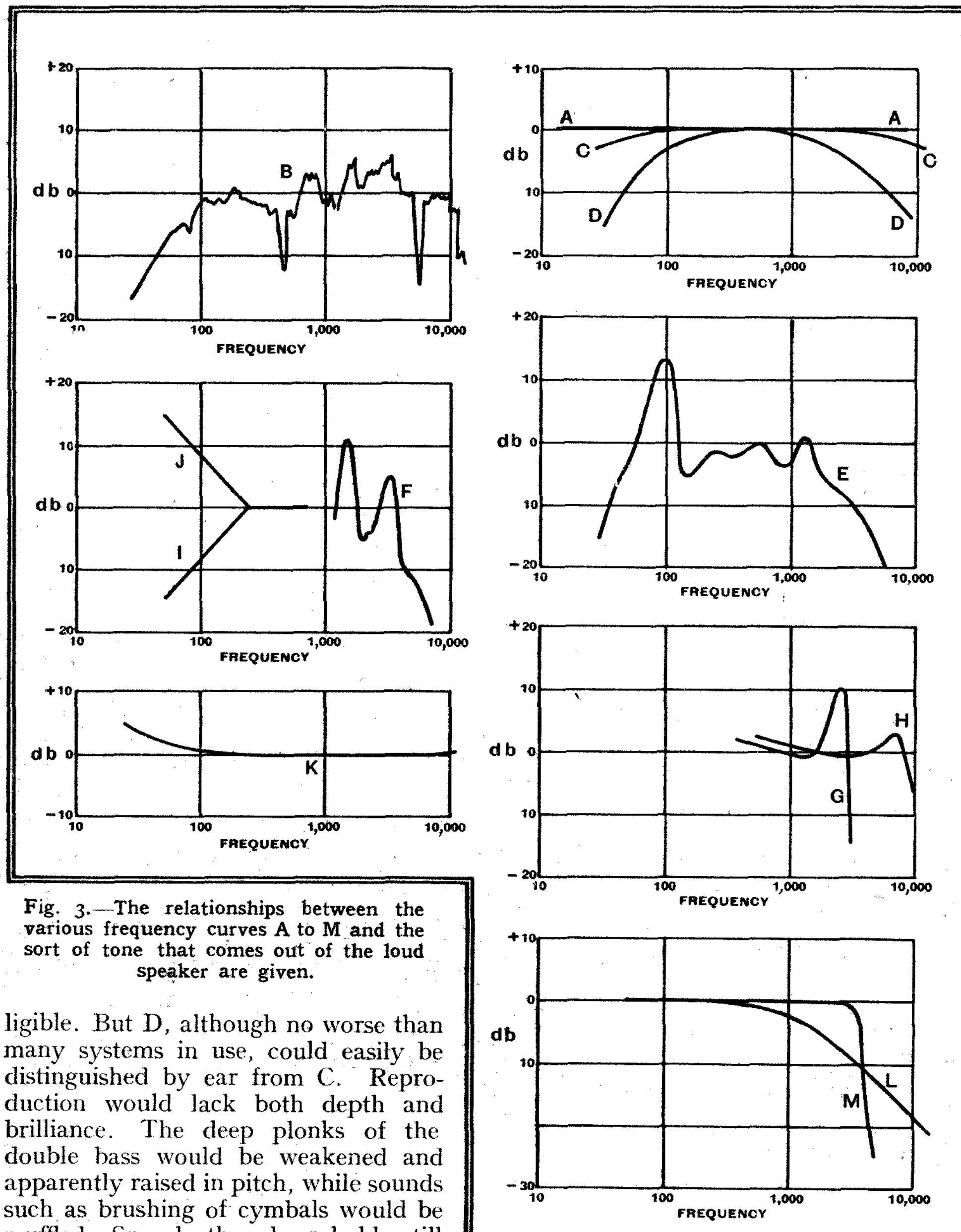


Fig. 3.—The relationships between the various frequency curves A to M and the sort of tone that comes out of the loud speaker are given.

Neglecting minor irregularities of the loud speaker, the overall characteristic of a typical table model receiver is as shown by E. Real bass is lacking, and a semblance of bass is given by a severe resonance around 100 c/s and by cutting the treble by means of the tone control. One can tell the resonant bass from true bass because it all comes out on one note; this is very noticeable when listening at a distance; sometimes the only thing that can be heard is a thump every time this note is played. In conjunction with the deficient treble speech sounds throaty, and in extreme cases may be hard to follow.

One reason why tone controls are so often set to cut off the high notes is that a common fault of cheap loud speakers is a treble something like F—one or more violent peaks and a great lack of really high-note reproduction. This sounds so harsh and edgy that people prefer to muffle it down. These loud-speaker defects must be borne in mind when considering the characteristics of other parts. Then there is the gramophone pick-up. Some have a rise in the bass, though whether that is a true rise, or depends on measurement on records with abnormally wide tracks carrying it beyond linear limits, is not always clear. Most of them have a peak at the top end followed by a fairly sudden cut-off. G is a bad example; bad because the sharp peak will cause unpleasant exaggeration of upper-middle notes, together with pronounced scratch of the same pitch; and bad because the highest frequencies on the record, giving naturalness and brilliance, will be lost. H is quite a good example. In fact, a theoretically perfect pick-up

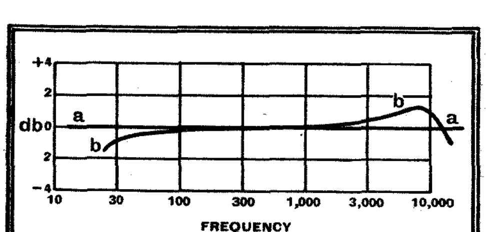


Fig 2.—Is the perfect amplifier any better than the nearly perfect?

How to Understand Frequency Curves—
would have to be tone-controlled to something like this, because higher frequencies are not recorded, but do exist as scratch. Limitations of records impose a bass characteristic shown by I, and this necessitates an amplifier characteristic J to compensate.[1]

The radio tuning circuits are likely to produce a steady droop towards the high-note end, and in typical receivers this is usually offset up to a point by allowing the pentode output to develop some excess of high notes.

Assuming now that the loud speaker is the best that money can buy, that the room in which it is heard is not abnormal, and that the radio or gramophone parts are reasonably flat, we turn to a few more possible amplifier curves.

If one had not seen the foregoing curves, K might have looked to have a useful degree of bass boost with which to combat such effects as gramophone record and loud-speaker loss. But comparison with J and B shows that it doesn't go very far.

How does one distinguish between L, which can be got by connecting a condenser across something in the amplifier, and M, which requires a specially designed filter? The difference in tone is difficult to describe in words, or even to recognise unless certain conditions exist such as adjacent-station whistles. M enables these to be cut out very completely, while retaining as much as possible of the valuable high notes. When the noise or interference to be cut out is not of a definite pitch, but is merely a general mush, curve L may be preferable, as it removes a large part of the noise while retaining at least a remnant of all the wanted high tones. Moreover, it is *very* much easier to provide.

Judging by Ear

When listening critically to reproduction, with a view to finding the possible causes of imperfection, look out for woolly tone lacking crispness and easy intelligibility of weak speech (L); the same combined with a tub-thumping pseudo-bass (E); a metallic pretence of brilliance that is painful at loud volume (F); a lack of thrilling depth in music (though quite tolerable speech) (I); absence of glaring faults, but general mediocrity, easily recognisable as reproduction rather than reality (D). These are the commonest faults. Those associated with loud speakers are the most baffling; for instance, E sounds as if there is too much bass and yet not enough; raising or lowering the bass by means of tone control only makes matters worse. Similarly for the high tones in F. So it is most important to start with a good loud speaker; other defects that are likely to occur can usually be compensated successfully.

Peaks due to resonances are most easily detected by going into another room (or even another house!) and noting if a few island tones are left standing up after all the rest have been submerged by the distance. And when doing all this it is most important to take account of the nature of the programme. I have just mentioned that a set that makes music sound thin may be perfectly satisfactory for speech. Speech should certainly be considered, for it is a valuable clue to the too-common E type of reproduction. But one should hear an orchestral programme, preferably played in the local studio, and including plucked double basses, drums (tympani for the low notes, side-drums for the high), violins, triangle and cymbals. These should be listened to separately, and then as part of the general array of sound from lowest to highest. It is surprising how the characteristics of a given set of equipment apparently change right round when a different programme comes on. Some of these surprises can be forestalled by experience, but even the expert often has an eye-opener when he has applied his instruments and got an actual measured characteristic.

[1] See "Tone Control" articles, *The Wireless World*, Sept. 15th and 22nd.

NEXT WEEK'S ISSUE

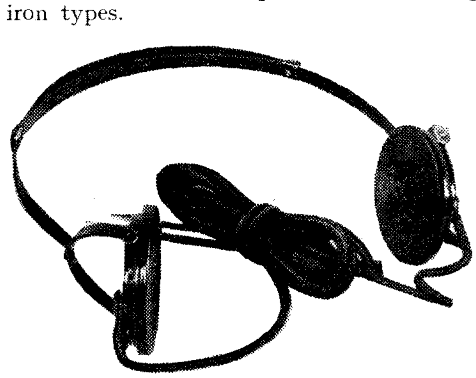
The appearance of the **SPECIAL VALVE NUMBER** of *The Wireless World* is now looked forward to as an important annual event. In the enlarged issue of November 10th will be included a comprehensive

VALVE DATA SUPPLEMENT

with classified and tabulated lists, giving characteristics and base connections, of over 1,000 British and American valves. In addition to the normal features of the journal, special articles on valve topics will be published.

Lightweight Crystal Headphones

THE Rothermel-Brush type "B" headphones weigh only 3½ ounces, including head-band and cords. They are a little over 2in. in diameter and only $\frac{5}{16}$in. in thickness. In spite of their small size they are remarkably efficient, particularly at the higher frequencies and in the middle register where comparison is possible they show an 8 to 10 db increase over representative moving iron types.



Rothermel-Brush type "B" lightweight headphones.

Between 250 and 10,000 cycles, the output is aurally uniform, and the maintenance of the response in the top is a quality which has not previously been available in headphones. Below 250 cycles the output tails off rapidly, but the phones still show some response at 50 cycles.

Their light weight should commend these phones for use in aeroplanes, and there should be less interference with the compass, as there are no magnets and only a light steel head-band.

A single bi-morph crystal is clamped at three corners, and the fourth drives the thin composition diaphragm directly. The case is of pressed aluminium, and the cap is turned over at the edge to form a complete seal. Snap connectors take the place of the usual terminal screws.

The price of the "B" type phones is £3 15s., and the makers are R. A. Rothermel, Ltd., Canterbury Road, London, N.W.6.

News from the Clubs

Bradford Experimental Radio Society
Headquarters: 66, Little Horton Lane, Bradford.
Hon. Sec.: Mr. S. Hartley, 7, Blakehill Avenue, Fagley, Bradford.

On November 8th a lecture and demonstration will be given by Mr. Beaumont, chief engineer of Ambasasdor Radio, the subject being "Commercial Receiver Design with a Special Reference to Short Waves."

Dollis Hill Radio Communication Society
Headquarters: Braintcroft Schools, Warren Road, London, N.W.2.
Meetings: Alternate Tuesdays at 8.15 p.m.
Hon. Sec.: Mr. E. Eldridge, 79, Oxgate Gardens, London, N.W.2.

On October 18th Mr. Walters, of Belling and Lee, lectured on "Interference Suppression." At the next meeting on November 15th Mr. A. Turner will continue his talk on "S.W. Transmitters and Receivers."

Croydon Radio Society
Headquarters: St. Peter's Hall, Ledbury Road, S. Croydon.
Meetings: Tuesdays at 8 p.m.
Hon. Sec.: Mr. E. L. Cumbers, 14, Campden Road, S. Croydon.

At the October 18th meeting Mr. B. R. Bettridge, of the Marconiphone Co., spoke on "Recent Developments in Radio and Television." In the course of his lecture he demonstrated a new cathode-ray tube.

Forthcoming Events.

November 8th.—Demonstration by Mr. Stuart Davis of his latest high-quality apparatus.
November 15th.—To be announced later.
November 22nd.—"Amphion," of the *Croydon Advertiser*, will lecture on "The Man Behind the Baton."
November 29th.—A lecture entitled "Sound in the Cinema," by Mr. W. J. Bird.
December 6th.—A guest lecturer will be provided by the British Sound Recording Association.
December 13th.—A musical evening through the medium of gramophone records will be given by Mr. H. G. Salter, the vice-president.

Exeter and District Wireless Society
Headquarters: Y.W.C.A., 3, Dix's Field, Southernhay, Exeter.
Meetings: Mondays at 8 p.m.
Hon. Sec.: Mr. W. J. Ching, 9, Sivell Place, Heavitree, Exeter.

On October 17th members were conducted over the Corporation's electricity headquarters by Mr. L. Cornish, who opened the proceedings with a short talk describing the history of the city's electrical undertaking.

Scarborough Short Wave Club
Headquarters: Club Room, Gladstone Lane, Scarborough.
Meetings: Monday evenings.
Hon. Sec.: Mr. P. B. Briscombe, 48, Fieldside, Northstead, Scarborough.

The club is holding a special meeting at the St. Alma Hotel, West Street, at 8.15 p.m., on November 7th, when there will be a ciné film dealing with the 1938 National Field Day. The Club has its own transmitter, the call sign being 2BXX.

PETO-SCOTT SUPERHET

IN the Peto-Scott advertisement in last week's issue the price of Model 902 7-stage battery all-wave superhet should have been given as £4 17s. 6d. for cash, or 6s. deposit and 18 monthly payments of 6s.

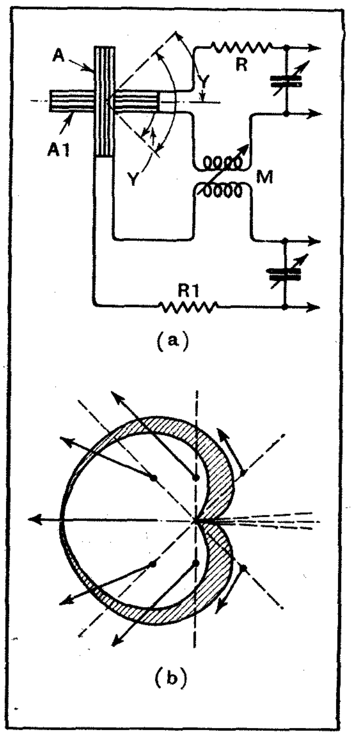
Recent Inventions

Brief descriptions of the more interesting radio devices and improvements issued as patents will be included in this section

DIRECTIONAL SYSTEMS

IT is usual to depend upon variations in the amplitude of an incoming signal, e.g., upon a maximum or minimum of sound, to give an indication of direction. By contrast the invention is concerned with a system in which the direction of a received signal is determined by the phase-relation of currents produced in the receiver, any change in direction being accompanied by corresponding changes of phase.

As shown in the Figure (a), two crossed frame aerials A, A1, both



Direction-finding system depending on phase differences in two frame aerial circuits.

tuned to the signal frequency, are coupled together at M, equal resistances R, R1 being included in each circuit. It is then shown mathematically that if the reactance of the mutual coupling M is made equal to the resistances R or R1, a change in the direction of the incoming signal will not alter the amplitude of the current in either circuit, though the phase-vector of the current in one circuit will rotate in one direction through an angle Y equal to the change of signal direction, whilst the phase-vector in the other circuit will also rotate through the same angle Y, but in the opposite direction. The total change in phase is thus double that of the change in signal direction.

By adding the voltage pick-up from a non-directional aerial a "phase-cardioid" is produced, which, as shown shaded in the Figure (b), gives a deeper or more clear-cut directional response than the usual heart-shaped "amplitude" curve, which is shown unshaded. The method is capable of various applications, particularly for direction-finding, and in the radio navigation of aircraft.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of J. Plebanski). Convention date (Poland) September 9th, 1936. No. 488611.

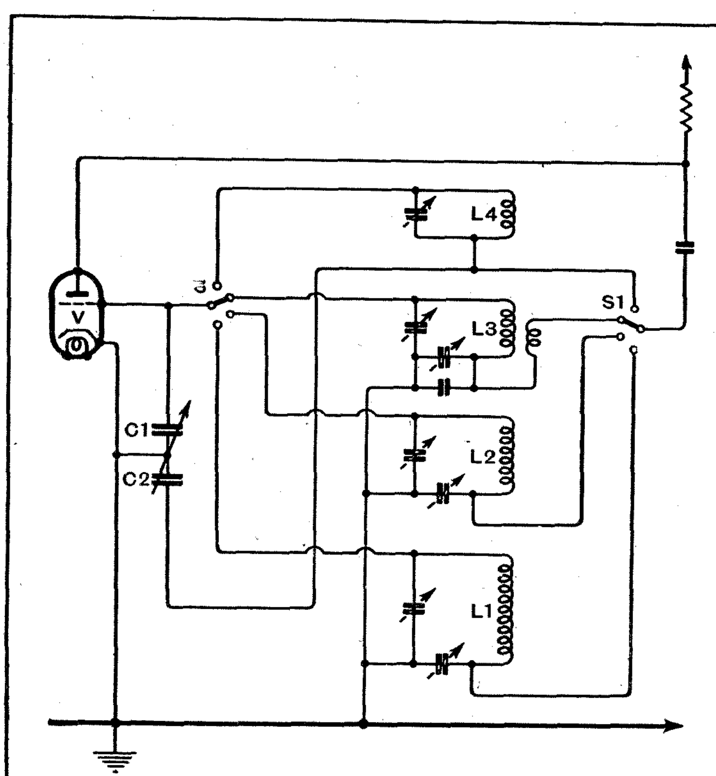
o o o o

ALL-WAVE RECEIVERS

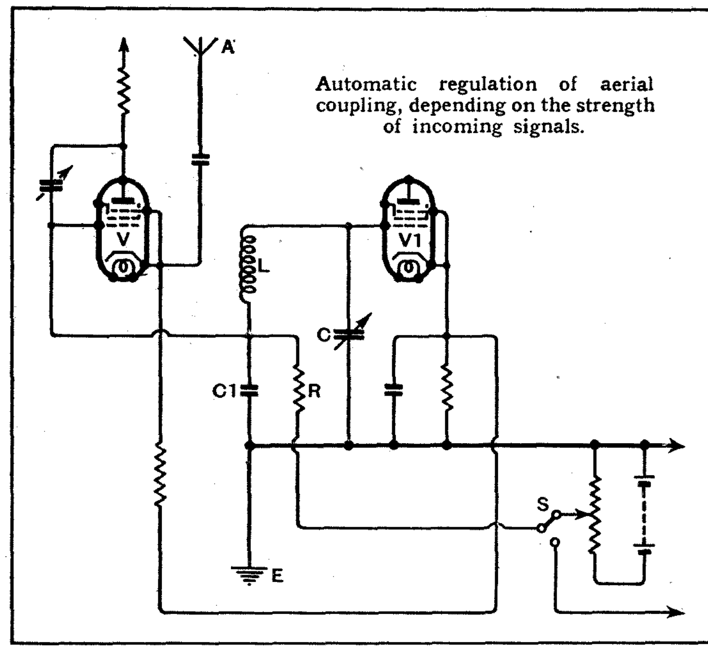
IT is difficult in an all-wave superhet to secure satisfactory operation of the local oscillator valve on the ultra-short waveband, if the ordinary type of back coupling is used. To overcome this defect the local oscillator valve is automatically converted to the well-known Colpitts circuit as and when the set is switched over to receive ultra-short-wave signals.

The inductances L1, L2, L3, for the long, medium, and short waves respectively, are earthed through condensers as shown, and one or the other is brought into operation, as required, by the four-pole selector or wave-change switches S, S1. The main tuning condenser is formed in two sections, of which C1 is connected between the grid of the valve V and earth. One end of the ultra-short wave coil L4 is permanently connected to earth through the other section C2 of the condenser. Accordingly, as this coil is switched in, the valve V begins to operate as a Colpitts oscillator, in order to handle the high frequencies concerned. At the same time, the circuit capacity is decreased, since the two sections C1, C2 of the main tuning condenser are now effectively in series across the coil L4.

G. Hayes. Application date February 11th, 1937. No. 487700.



Multi-band superheterodyne oscillator circuit.



Automatic regulation of aerial coupling, depending on the strength of incoming signals.

AUTOMATIC VOLUME CONTROL

FOR the reception of distant stations, it is desirable that the aerial should be connected to the first valve through a coupling which provides a high gain, so as to ensure the best possible signal-to-noise ratio. For a near-by station, however, such a coupling would naturally tend to overload the input valve.

In general, AVC systems operate by regulating the gain of one or more of the valve amplifiers, and therefore do not hold the input signal voltage at its optimum value, as does the arrangement shown in the Figure.

The aerial A is connected to earth at E through the input circuit of a pentode valve V in series with a condenser C1, the latter being common to the tuned input circuit L, C of the first radio-frequency amplifier V1. The effective aerial coupling therefore depends upon the "transconductance" of the valve V, and this in turn is controlled by the amplitude of the incoming signal, through the bias applied to it *via* a resistance R from an AVC rectifier (not shown) located at a later stage in the chain of amplification. The automatic control can be switched over at S to allow manual control when desired.

Hazeltine Corporation (Assignees of N. P. Case). Convention date (U.S.A.) October 14th, 1936. No. 487641.

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

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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

Editorial Comment

Valve Data; 1938

ONCE again we present *The Wireless World* Valve Data Supplement and once again it is larger than ever. Since these yearly supplements were started in 1927 they have continually grown in size and now over 1,000 different valves are listed in the 20 pages of tables. The number of different valve bases is fortunately not yet equal to the number of valves, only fourteen being listed.

Of these fourteen, seven are in common use in this country, but there are no fewer than 144 ways of connecting them! All told, 187 base connections are listed for the 14 bases. If we have not yet reached the condition of a different base for every valve, we are approaching the state of every valve having different connections!

In part the enormous number of valves on the market is due to the valves of different makers bearing different type numbers, consequently, although they may actually be interchangeable in a set they must be counted as different types. Secondly, there are in reality three ranges—British, American and Continental.

Apart from the question of type numbers there is within these three ranges a reasonable degree of standardisation. Complete uniformity can hardly be secured without stifling development, and some of the new valve bases, which at first sight seem superfluous, do offer technical advantage. If a base results in shorter internal connections to the electrodes, the input resistance on short waves is raised. As these are improvements which could probably be obtained in no other way the general inconvenience of a new base is technically justifiable.

Another point which has been criticised is the lack of uniformity of filament and heater ratings. At first sight, conditions here seem chaotic, but there is actually a reason for the various ratings. After the early days battery valves settled down to a standard rating of 2 volts, which is still universal for both British and American valves.

When indirectly heated mains valves were first introduced they were intended for operation with their heaters in parallel from an AC supply, and an arbitrary standard of 4 volts was adopted in this country and 2.5 volts in America. After some years car radio started in America and as the cars in that country have 6-volt accumulators, the range of 6.3-volt valves was produced. It was soon found that they were as satisfactory for AC working as the 2.5-volt type, and they consequently replaced the latter.

The same thing happened in this country, but as most British cars have 12-volt batteries, the British range was rated at 13 volts. A certain lack of standardisation was apparent, however, for some firms adopted a current rating of 0.3 ampere, whereas others decided upon 0.2 ampere. Just as in America the valves were used in AC/DC sets and the heater power was found insufficient for all types. Consequently, similar valves with the standard current rating but of higher voltage appeared for AC/DC operation and with the standard voltage, but higher current rating for car radio. These valves never became popular in AC sets, the 4-volt type being retained for these.

Among mains valves, then, the 4-volt and 13-volt are the standard British types for AC sets and car-radio, with the 13-volt and higher voltage types for AC/DC sets. In America the 6.3-volt type is now standard for all three applications, but there are higher voltage specimens intended purely for AC/DC operation.

In this country 6.3-volt types are now to be found and represent some attempt to come into line with American practice; again, however, different makers have adopted different current ratings and even bases. In general, the 6.3-volt 0.3-ampere valves are of American characteristics and have the American Octal base, while the 6.3-volt 0.2-ampede side-contact valves follow Continental practice.

When the 6.3-volt valves were first introduced in this country it was hoped that standardisation had begun, and that the other types would soon disappear. This hope has not been realised, and it seems probable that it never will be now.

Valve Input Resistance

ITS IMPORTANCE AT WAVELENGTHS BELOW 10 METRES

By M. G. SCROGGIE, B.Sc., A.M.I.E.E.

THE low input resistance of valves working on ultra-short wavelengths becomes a factor of dominant importance, severely restricting amplification and impairing selectivity. How these ill-effects can be minimised by selection of the most suitable type of valve and by design of the associated circuits is explained in this article.

IN most circumstances the amount of amplification obtainable from a valve depends on the amplification factor and internal anode resistance of the valve and on the nature of the intervalve coupling used. As an example, a stage of AF amplification using a triode valve with an amplification factor of 40, coupled to the next stage by a 1 to 3 transformer having an input impedance large compared with the valve's anode resistance, would give an amplification of nearly 120. Another example: a stage of RF amplification using a pentode valve with an amplification factor of 3,000, an anode resistance of 1 megohm, and a tuned anode coupling with a dynamic resistance of 50,000 ohms, would amplify $\frac{3,000 \times 50,000}{1,050,000}$, or 143 times. The mutual conductance of this valve is 3 milliamps per volt, and when the coupling impedance is, as usual with RF pentodes, *small* compared with the internal anode resistance, it is usually enough to reckon the amplification as the mutual conductance in *amps* per volt multiplied by the coupling impedance (in this case $0.003 \times 50,000$, or 150).

The input impedance of the valve, between grid and cathode, is generally of minor importance; in fact, it is often allowable to regard it as so nearly infinite as to have negligible effect. But as the frequency of the signal with which the valve has to deal is raised this factor grows in importance until it swamps the other considerations just mentioned. This state of affairs usually sets in at frequencies greater than about 30 Mc/s (wavelengths less than 10 metres). So the television waveband is among those concerned.

When one is accustomed to input resistances of the order of a megohm it is a bit startling to come across values of only a few thousands of ohms. In the television waveband the input resistance of an ordinary valve is of the order of 10,000 ohms, and in the amateur 5-metre band about 5,000 ohms. Sometimes it is considerably less. This comes in parallel with any coupling impedance, and as the resultant of a number of impedances in parallel must be lower than the lowest of them there is naturally not much inducement to attempt really high values of coupling impedance. To illustrate this, Fig. 1(a) shows the essentials of a tuned anode stage of amplification. At resonance the tuned coupling is equivalent to a relatively high resistance, which can be called R_C. The internal anode resistance of the valve can be denoted by R_A, the grid leak by R_G, and the input resistance of the following valve by R_I. The capacities of these items are left out of account, being regarded as included in the tuning capacity; and the blocking condenser usually has a negligible impedance at the signal frequency. So far as the signal is concerned, then, the effective coupling is as shown in Fig. 1(b). If we were considering a low-resistance valve, the signal produced by the voltage Vg on the first grid could be represented by a voltage generator in series with R_A and equal to μVg; but in a pentode valve it is simpler to regard it as a current generator in parallel with everything and equal to GVg, G being the mutual conductance. The signal voltage applied to the second valve can then be calculated by multiplying GVg by the effective coupling resistance, consisting of all four resistances in parallel. This can be called R, as in the still further simplified diagram (c). Supposing, first, that it is a medium- or long-wave circuit, and R_I is, for the sake of argument, 1 megohm, as are also R_A and R_L. The whole lot in parallel, R_C apart, are thus a third of a megohm, which is considerably higher than any practical value of R_C. So R_C, the coupling impedance, being the lowest, is the main factor controlling the amplification. If it is, say, 75,000 ohms, then R works out at 62,000.

Unavailing Efforts

Contrast the situation on ultra-short waves, where R_I may be 5,000 ohms. Whatever is done to increase the efficiency elsewhere cannot avail to bring the total effective value, R, even up to the 5,000 ohms. The amplification being proportional to GR, the importance of the input resistance is evident.

The same sort of argument applies to the coupling between aerial and first valve.

The practical results of this are severely restricted amplification and selectivity. In fact, as the frequency is raised, a point is reached where with a given valve no amplification at all is possible. Television is not so seriously affected as might be supposed, for, owing to the necessity for very poor selectivity in order to cover the whole wide band of vision modulation, the effective coupling resistance R would have to be quite low in any case. That is why, in order to achieve a useful amount of amplification, the other factor G—the valve's mutual conductance—is made as high as possible. But for reception other than television the low value of R is very troublesome.

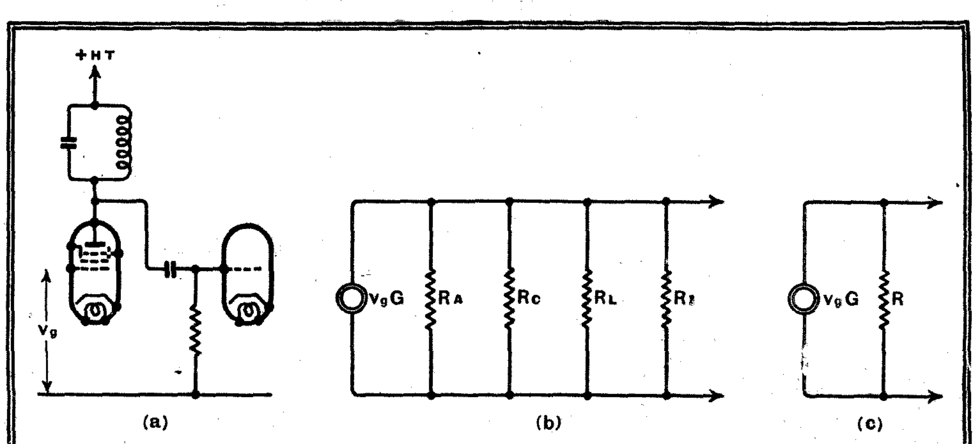


Fig. 1.—A high-frequency coupling between two valves, shown in its essentials at (a), can be represented by four resistances in parallel (b), comprising the equivalents of first valve output resistance, tuned circuit dynamic resistance, grid leak resistance, and second valve input resistance. The same applies to an aerial-to-valve circuit, if R_A is taken to represent the loading effect of the aerial. By combining these four resistances, they can be represented by a single resistance (c).

What exactly is the cause of this calamitous falling off in resistance? There are actually several

Valve Input Resistance—
causes, the relative importance of which are still being debated by the specialists. There is the loss in the capacity of the grid and its lead-in wire, valve pin, socket, etc. This capacity forms an increasing proportion of the whole tuning capacity as the frequency is increased, so it is important that it should be low-loss, and hence valves for ultra-short waves are sometimes made with ceramic bases and are usually mounted in sockets of similar material. Another cause of low resistance is that the time taken by the electrons to cross the inter-electrode space inside the valve is an appreciable part of one cycle of oscillation. At 6 metres the time occupied by a whole cycle is a mere fifty-millionth of a second, so that time allowed for the electrons to move does not leave room for much hesitation on their part! For reasons which have been explained from time to time[1] the effect of any appreciable delay is equivalent to a reduced input resistance. This has commonly been regarded as the main culprit in pulling down the input resistance, and it may be so at least in some valves, but a leading investigator[2] has changed his mind as a result of more thorough research, and now ascribes from one to two-thirds of the blame in typical European amplifier valves to still another cause—the *inductances* of the electrodes and their leads, in conjunction with their capacities. In particular, the inductance of the cathode lead is liable to be a serious contributor to reduced input resistance. The connection between cause and effect may not be entirely obvious, but the evidence seems to be well founded. It tends also to emphasise the necessity for guarding against adding still further to the losses by using unnecessarily long leads external to the valve.

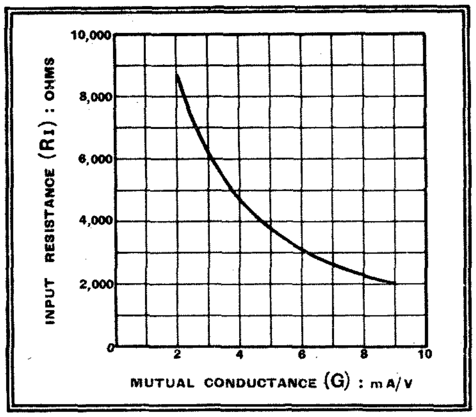


Fig. 2.—Relationship between mutual conductance, G, and input resistance, RI, of a SP41 valve as the grid bias is varied.

Rapidly Falling Resistance

Although the exact nature and disposition of these various causes of low input resistance are very interesting to the valve designer, the valve user is obliged to adjust himself to the fact. It is interesting to note that the input resistance for short waves is approximately proportional to the *square* of the wavelength, and hence falls off very rapidly.

Coming, then, to the practical aspect of the matter; how can low input resistance, or at least its bad effects, be avoided? Broadly, there are two ways open to the set designer: selection of a suitable valve, and circuit design. It has already been mentioned that amplification depends mainly on the product GR, and we have seen that at very short wavelengths R depends mainly on RI, the valve input resistance. Now it is no use increasing the mutual conductance, G, of the valve, if its RI falls correspondingly. Unfortunately that is just what tends to happen. Consider a typical modern RF pentode, the Mazda SP41. The G can, of course, be adjusted by varying the grid bias, and in this particular example very high values are reached when the bias is small. A curve connecting G and RI (Fig. 2) shows that as the one goes up the other goes down, and the tendency is for the two effects to cancel out so far as amplification is concerned. Fig. 3 shows the stage gain as a function of grid bias, assuming two typical values for the tuned coupling resistance inclusive of RA and RG. These values are inevitably lower than in long-wave practice. It is seen that amplification does not fall in anything like the same proportion as G, and up to a point G shows a tendency to remain constant, due to the compensating rise in RI. Up to that point grid bias adjustment is chiefly a selectivity control.

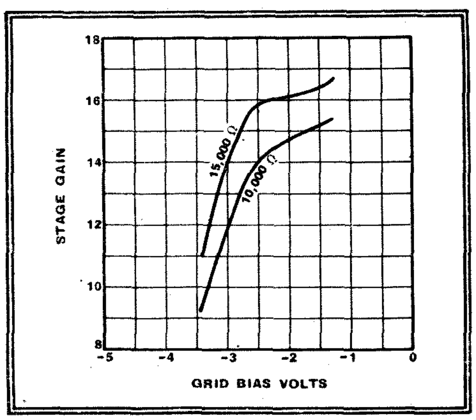


Fig. 3.—How the stage gain obtained with the SP41 depends on grid bias, assuming two typical values of tuned circuit resistance. As the bias is reduced the selectivity drops, even over the range giving approximately constant gain.

What is true of different adjustments of a single valve is largely true of different designs of valve. An improvement in RI is usually offset by a loss in G, and vice versa. Where selectivity is wanted one naturally decides in favour of high RI. A large net improvement can be obtained, however, by abandoning ordinary valve construction. From a consideration of the various causes of low input resistance it can be seen that what is wanted is very small spacing to reduce electron transit time, very low inter-electrode capacity (which if it is not to clash with the preceding feature means small electrode area, as well as short well-spaced leads), low dielectric loss, and short leads. All of these requirements are met as far as possible in the Acorn style of construction, which yields a most valuable tenfold increase in input resistance while retaining normal mutual conductances. Unfortunately these valves are exceedingly difficult and expensive to make and are very fragile. Valve makers agree in hating them.

How the New Valves Help

So various attempts have been made to obtain at least a portion of the benefits of the Acorn within the scope of reasonable manufacture. It does not seem likely that a close approach to the Acorn characteristics will be obtainable without radical departures from normal valve construction; but some advances have been recorded. For example, the "E" series featured by Mullard and Tungsram employ the side-contact base, permitting shorter internal leads. Also the electrode construction is unusually compact. It is claimed that the valves have input resistances intermediate between ordinary valves and Acorns. The British octal base sponsored by Mazda is also claimed to result in an improvement, due to the shortening and increased spacing of internal leads. Low input resistance is desirable not only in the RF amplifier, which may be optional, but above all in the frequency changer, which is essential (in a superhet). The Osram X65 triode-hexode is claimed to be an improvement on the earlier X41 and X31 as regards input resistance.

The second field of attack is outside the valve, and here again the lengths and dispositions of the leads must be carefully

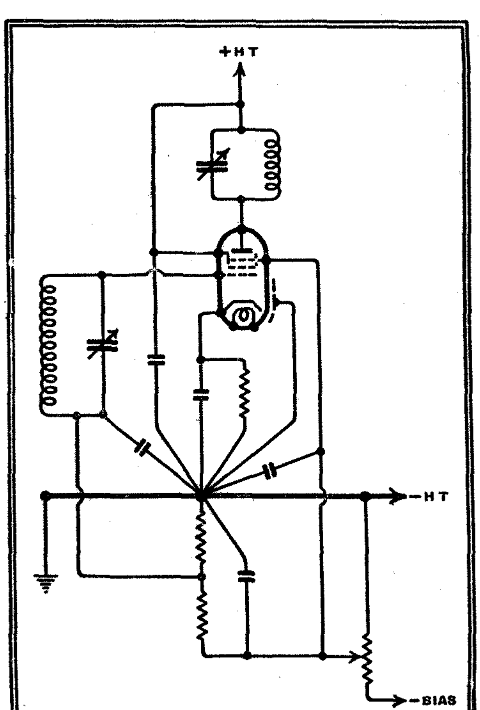


Fig. 4.—Example of a stage of short-wave amplification indicating point connection of all return leads to earth.

[1] E.g., in "Grid Loss at Ultra-high Frequencies," *The Wireless World*, October 23rd, 1936.

[2] M. J. O. Strutt. (See *Proc. I.R.E.*, August, 1938.)

Valve Input Resistance—

considered, and the newer types of valve base may be helpful in this respect. The need for a valve-holder with as little dielectric material as possible, and that of low-loss characteristics, is obvious. The leads, including those such as cathodes and screens that are often wrongly looked upon as "dead" to RF currents, should be as short and direct as possible, through blocking condensers where needed, to a single "earth" point. This is suggested in circuit diagrams such as Fig. 4. The return from the suppressor grid, etc., should be taken to "earth" and not to cathode.

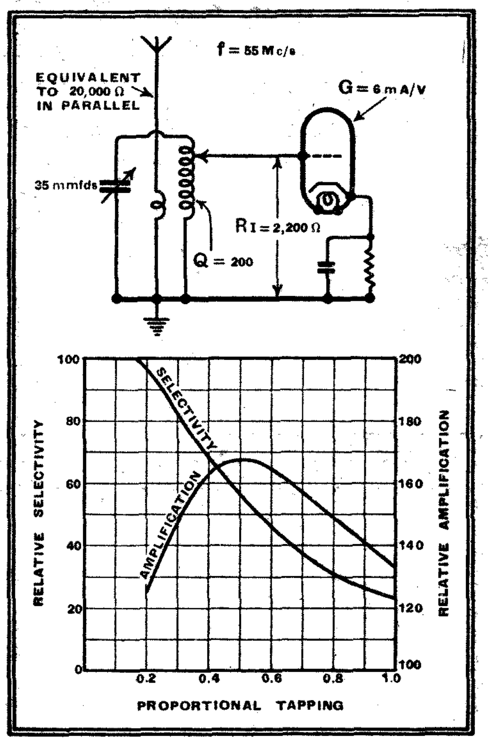


Fig. 5.—An example of how the performance of a stage can be improved, when the valve input resistance is very low, by tapping the valve across only a portion of the tuned circuit. The vertical scales are only relative.

Another possible expedient, particularly when the best selectivity is desired, is tapping down the tuned circuit. In this way the sharpness of the tuned circuit is improved, and with it the signal voltage developed across it, which *may* more than compensate for the reduction due to the step-down to the valve. Consider, for example, the valve having the characteristics shown in Figs. 2 and 3, and suppose it to be operated at 6 mA/V (−2.3 volts grid bias) which seems to be about the most favourable setting. Its input resistance R1 is then 3,300 ohms at 45 Mc/s, and, assuming the frequency-squared law previously mentioned, this would fall to 2,200 ohms at 55 Mc/s (5.4 metres). An efficient tuned circuit might have a Q, or "magnification," of 200; and its dynamic resistance, assuming a total capacity of 35 m-mfds., would be 16,000 ohms. Suppose this circuit is employed between aerial and valve, and that the aerial connection is equivalent to a parallel resistance of 20,000 ohms. Allowing for this, the tuned circuit is 8,900 ohms—still well above the input resistance of the valve. Connecting the valve across the whole tuned circuit therefore would load the tuned circuit excessively. Fig. 5 shows how selectivity and amplification would be affected by tapping the valve input across only a portion of the coil. A half-way tap would not only give more than 2½ times the selectivity but also double the amplification. A considerable further increase in selectivity and only a moderate loss of amplification could be obtained by tapping slightly below half.

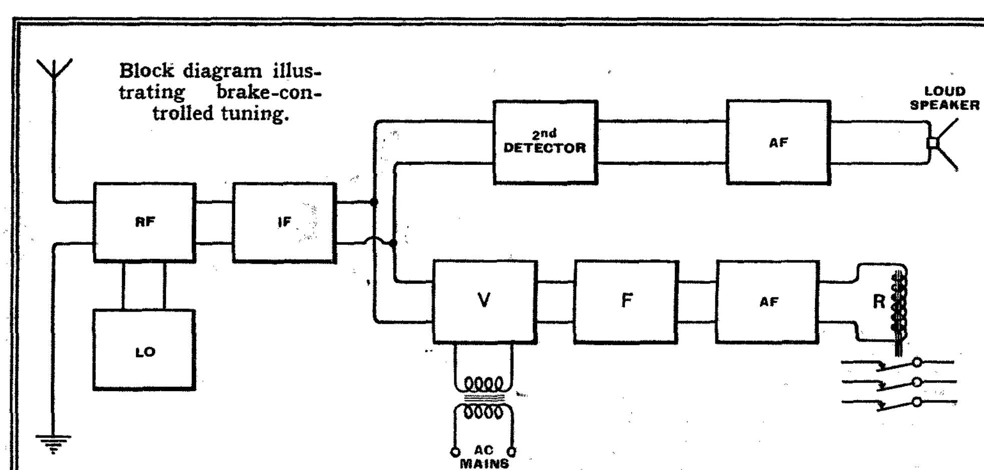
Summarising: the input resistance of valves falls off very rapidly as the frequency increases, and in the ultra-short-wave region becomes of dominant importance. Where very low selectivity is required (as in television) this does not matter very much so long as the valve has a very high mutual conductance. Where high selectivity and amplification are wanted, the most effective way of avoiding input resistance losses is to use Acorn valves. Alternatively some of the newer types of valves offer a measure of improvement at a much lower cost. And the best can be made of the valves available by attention to high-frequency leads, making them short and direct, bringing all by-pass connections to a common earth point, and by choice of a suitable tapping ratio between tuned circuit and valve.

Frequency Control

TUNING WITH THE HELP OF THE MAINS

ALTHOUGH press-button control is very much to the fore just now, there are other methods of approaching the problem of "easy" tuning which may still be said to possess certain merits of their own. It is one thing, for instance, to select a given station by pressing the right button, and another to feel confident that it will always come through "dead in the centre" of the band-pass circuits.

The visual tuner represents the first aid to dead-centre tuning once AVC made it difficult to trust to the ear alone. A later development is one in which an automatic check or "brake" is applied to the control shaft as the circuits reach the true point of resonance, so that the listener is helped by his sense of touch. In both cases the necessary "control" current is usually supplied by the signal, through a highly-selective circuit, so that it comes sharply into action at the right moment.



Block diagram illustrating brake-controlled tuning.

But signal currents are a relatively weak source of energy, particularly when it comes to operating an automatic tuning-brake, and the latest suggestion is to tap off a little extra juice from the supply mains to do what is required. The idea is shown in the diagram (Patent 490272) which shows the "skeleton" circuit of a superhet receiver fitted with brake-controlled tuning assisted by the mains.

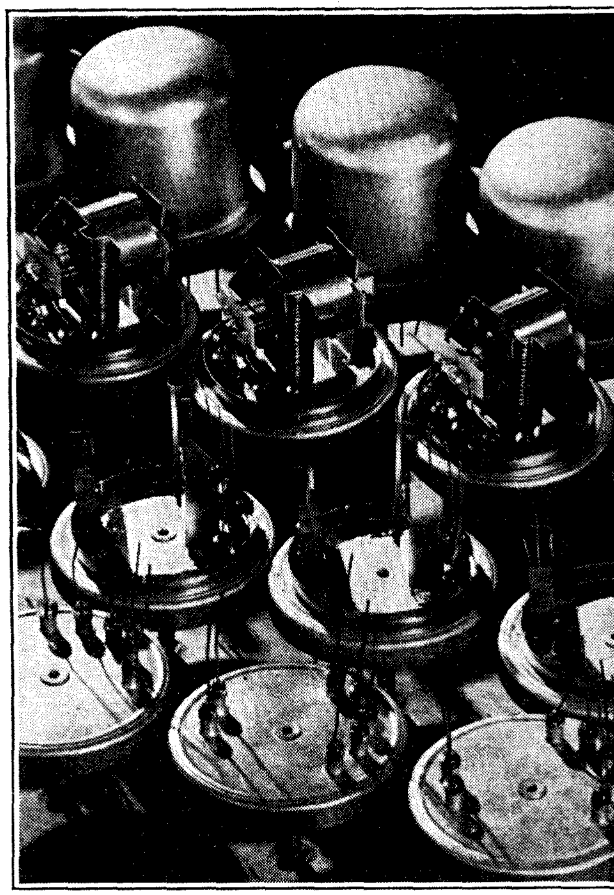
Incoming signals, after being combined with local oscillations from LO, are passed through one or more IF stages, a second detector, and one or more AF amplifiers to the loud speaker, in the ordinary way. Branched off from the IF stage is a valve V which is modulated by the AC mains frequency through a transformer T. The modulated output is coupled to a highly selective filter F, so that only a narrow band of frequencies can pass to a relay R, which applies an automatic brake to the tuning spindle at the right moment.

Although shown for the sake of clearness as a branch circuit, the valve V is, in fact, the ordinary IF amplifier of the set, whilst the filter circuit F is included in the usual band-pass coupling between the IF valve and the second detector. A pair of delay-action diodes are used to keep the mains-modulated frequency out of the signal channel, until such time as the carrier-wave of the incoming signal reaches its peak. At that moment the narrow band of modulated current, supplied from the mains, is allowed to pass through the filter circuit and apply the automatic brake to the tuning-shaft. In so doing, it opens a switch and automatically puts itself out of action until the listener decides to change over to another station.

Steel Valves

By WOLF E. FELIX

NEW GERMAN PRODUCTIONS COMPARED WITH GLASS AND EARLIER METAL TYPES

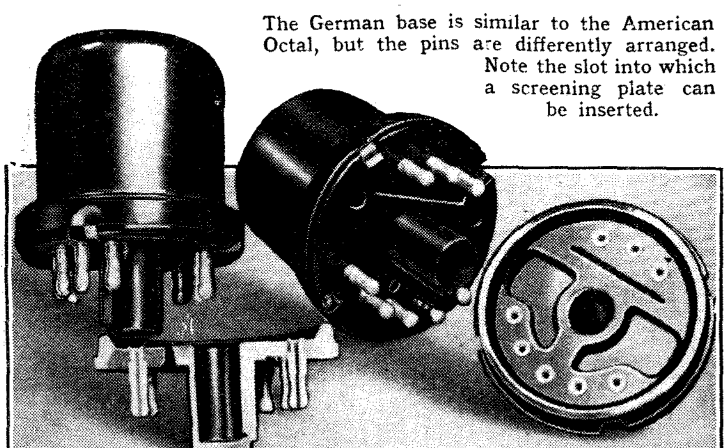


JUST before the recent Berlin Show Telefunken brought out a new series of valves which aroused considerable interest. The group embraces 13 types characterised by the letter "E," and is called the "harmonic series." This name, which rather puzzled foreign visitors, was chosen because the different units of the series are adapted to work together in such a way as to provide optimum performance with a minimum of tubes. The heater voltage is fixed at 6.3 volts. The RF and IF tubes can, therefore, be run in parallel from AC mains, or from the storage battery of a motor car, or in series from DC mains. This is a step towards standardisation and reduction of types as the special DC and car-radio types have now become unnecessary. Heater current for these tubes is uniformly fixed at 200 milliamps, which is a considerable reduction as compared to previous Telefunken tubes.

The most interesting feature of the new tubes, however, is their inner structure, which departs from conventional standards in several respects. With the exception of the output and rectifier valves, for which the glass bulb is preferable, and of the tuning indicator tube where it is indispensable, the valves of the E series have a steel envelope. It would be wrong, however, to assume that the new Telefunken productions are imitations of the "metal tubes" which were put on the market some years ago in the U.S.A. The use of metal for the outer envelope of transmitting and receiving tubes is an old idea which did not—to the knowledge of the writer—originate in America. The problem of providing an effective seal between glass and metal was solved in the U.S.A. by separate insulation of the lead wires with individual glass beads sealing "Fernico" eyelets—one for each wire. While this was a very important contribution it was unfortunate that advantage was not taken of the opportunity to do away with other fundamental disadvantages of the old glass tube, which are far more important than the use of glass for the envelope, and which are caused by the conventional system of fixing the inner parts or electrodes by means of a comparatively narrow glass tube pinched at the top to hold the wires and produce a vacuum-proof seal. As everyone experienced in the handling of valves knows, it is not the glass bulb which generally suffers from the effects of shock and vibration, but the inner metal structure. This is partly due to the modern tendency towards reduced inter-electrode spacing and the considerable length of the electrode supports. The claim that metal tubes are inherently more rugged than glass tubes is justified only in so far that a certain improvement in the method of fixing the electrodes had actually taken place. No material change had, however, been effected in the design of the electrodes themselves, which retained the shape and disposition usual with glass tubes and were, therefore, liable to the same sort of mishaps.

THE author suggests that the robustness of the earlier type of all-metal valve is more apparent than real; he goes on to describe the horizontal electrode assembly of the new German Telefunken steel valves, which, it is claimed, provides greater rigidity, lower inter-electrode capacity and higher mutual conductance.

The German base is similar to the American Octal, but the pins are differently arranged. Note the slot into which a screening plate can be inserted.



Where, then, are the advantages of the metal envelope to be found if its obvious immunity from breakage is ignored? In the first place, steel has the advantage over glass that it not only constitutes an enclosure for the vacuum but also a screen against electromagnetic and electrostatic fields. It therefore serves a dual purpose, while the glass tube necessitates separate screening which may either consist of a separate shield or of a metal coating connected to one of the socket prongs. As output and rectifier valves need no screening, there is no point in giving them a metal envelope. On the contrary: as these tubes give off considerable heat a metal casing would actually be undesirable. That is one of the reasons why, for these special purposes, the metal tube has not made much headway in America, and glass tubes are preferred. The new Telefunken E series, for the same reason, consists of steel and glass tubes, according to the purpose of each type.

Short Lead-in Wires

The second advantage of the steel valve —which could, however, also be arrived at by new methods of glass design—consists in the novel method of arranging and sealing the lead wires. With the old glass tube, these wires run closely parallel for a considerable distance in the lead-in tube, then converge to form the "pinch" and separate again to reach the various points

Steel Valves—

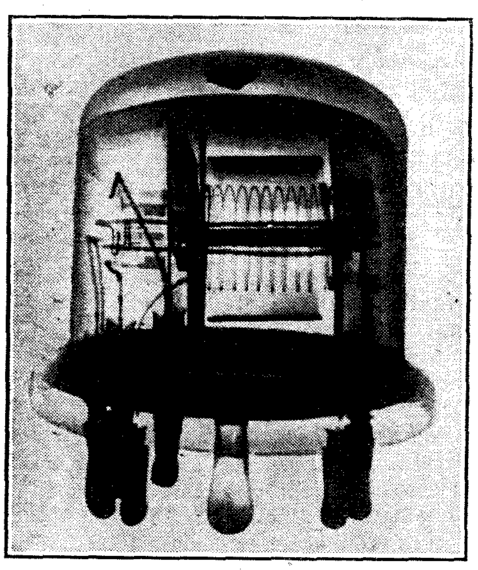
of connection inside the tube. The wire lengths are considerable, as the pinch is quite a distance from the valve base, and, furthermore, the electrodes project well above the pinch. The grid lead is introduced at the top of the whole system, necessitating lengths of external screened lead to connect with the corresponding point of the circuit. The entire system is by no means completely rigid and so is affected by vibration and shocks; it is also characterised by considerable inter-electrode capacities. Some of these disadvantages were reduced in the American metal valve by the elimination of the "pinch" and shorter connections between electrodes and tube base. The main drawback however—the length and non-rigidity of the active system, remained materially as it was in the glass tube.

Horizontal Electrode Assembly

The fundamental innovation in the new Telefunken steel tube consists in the horizontal disposition of the entire active system on a strong steel base plate, allowing rigid mounting at both ends by means of short U-section metal struts welded to the base plate. As both ends of the electrodes are now equally close to the base, and as the lead wires run straight down from their connecting points to the base prongs, all lead wires have been reduced to a fraction of their former length and are, moreover, spaced well apart. The long and sometimes wobbly structure characteristic of the present-day valve, often necessitating the addition of resilient mica spacers for support in the upper part of the glass or metal tube envelope, has completely disappeared. The extreme rigidity of the new structure is immediately apparent. The importance of this feature consists not only in the reduction of breakdowns and of vibration effects, such as microphonic noises, howling, etc., but also in the possibility of bringing the different electrodes yet nearer together, thereby improving the electrical performance of the tube, without risking an increase in the percentage of rejects or defects. The sealing of the lead wires in the base plate is effected in the usual manner by glass beads in Fernico eyelets and the steel envelope is welded to the base plate, as are the electrode supports. As a consequence of the horizontal arrangement of the inner structure the tubes are shorter than the American metal valves, the diameter being slightly greater.

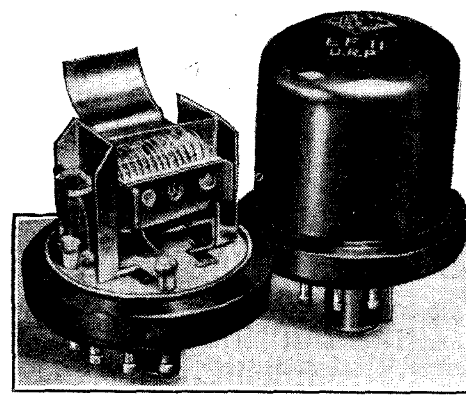
Another advantage of the new arrangement, due to the reduced length of, and great distance between, the lead wires, has resulted in exceptionally low inter-electrode capacities. These allow of a very marked improvement in short-wave performance as compared with previous types of ordinary broadcast receiving tubes. Yet another new departure is the abolition of the grid cap on the dome of the tube and the disposition of the grid connection alongside the others on the tube base. This not only does away with an important source of breakdown, the precariously located grid cap being one of the worst causes of trouble, but it gives the designer far greater freedom for the layout of his wiring and the arrangemnet of his coil assemblies, while reducing the length of the critical grid connections. Provisions are made on valve base and socket for the insertion of a little screen plate separating the leads which require screening from the others. The base is similar to the American octal base; however, there are three prongs in one group and five in the other, separated by the slot for the screen plate, which has the additional advantage of increasing the insulation resistance between the two groups of prongs. The base is so designed as not to lower the performance of the active parts in any direction whatsoever. The glass tubes of the series are also equipped with the new base.

It is not without interest to observe the great difference between the methods of launching a new type of valve in America and Germany. In the U.S.A. metal valves were introduced rather precipitously as a combative measure in the fight for market supremacy between great private business concerns. Engineers were hardly ready for mass production on a really big scale and alarming percentages of rejects were at first experienced, putting the entire idea in jeopardy. On the other side publicity was loud and assertive. Glass tubes were described as obsolete and metal tubes—in spite of the similarity of their electrode assembly—as immeasurably superior. The public was induced to demand metal tubes because sets would be improved by using them in preference to glass tubes. Disillusion followed very soon and metal valves suffered a setback which led to a relative advance of the glass tube. All this had very little to do with the actual technical merits of the case.



X-ray photograph of Type ECH11 frequency-changer. The triode oscillator section, on the left, is screened from the other electrodes by the left-hand support. The pumping tube is seen below the base plate, between the two groups of pins.

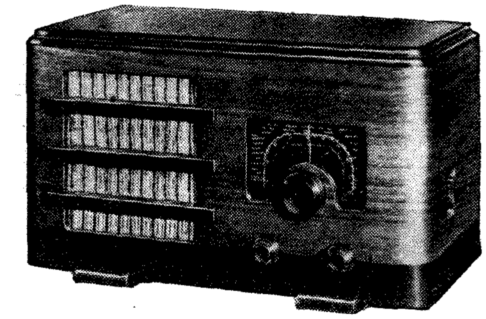
In Germany the valve and set makers got together and decided to bring out no new tubes for an entire year, devoting the time to laboratory development and manufacturing experiments. The result consisted in ripe new designs which were agreed by all concerned to ensure an improvement of sets and a reduction of costs for both the interested parties. The new tubes were first introduced on a small scale for car radio use, and valuable experience gained in manufacturing them. The industry then decided to introduce the steel tubes in this year's receivers, but limited their use to the higher price classes. The cheaper mass-production sets retain the old glass tubes. Production of the new tubes was therefore increased gradually, not by leaps and bounds, and difficulties could be completely avoided. "Ballyhoo" was strictly vetoed and the public was not told that old tubes were now obsolete and should be replaced by new ones. On the contrary, it was pointed out that the new valves would not be of any immediate interest to the listening public, but that they would enable designers in future to build better sets for the same price. Sensationalism was thus replaced by conscientiousness, precipitation by thoroughness and commercial egotism by purposeful industrial co-operation. This method should prove more economical, safer and better in the long run and it will certainly tend to increase the confidence and good will of the public towards the industry.



RF pentode, Type EF11, with anode opened out to show inner electrodes. The channel-section support on the left acts as a screen for the leading-out wires.

New Cossor Set

DESIGNED for operation on AC or DC mains between 200 and 250 volts, the recently introduced "universal" Cossor receiver, Model 45, is a "straight" single-



stage TRF set with an RF pentode detector and pentode output. Medium and long broadcast wavebands are covered; the set, which is fitted with an 8in. speaker, costs seven guineas.

NEWS OF THE WEEK

GLASGOW BROADCASTING HOUSE

Studio Acoustics

THE B.B.C.'s new studios and simultaneous broadcasting centre in the West of Scotland, situated in Hamilton Drive, Glasgow, is to be opened officially on Friday, November 18th.

The acoustic treatment of the studios is of particular importance, the three orchestral and two drama studios being perhaps the most interesting of the nine included in the layout.

In the orchestral studios wood panelling ½in. thick is used in the form of a dado held just clear of the walls. Above the dados are blankets of rock wool 1in. thick arranged either in panels or horizontal strips alternating with plaster surfaces. Panels of acoustic felt are fixed to the ceiling. The wood panelling absorbs energy at lower frequencies due to resonance, while rock wool and acoustic felt absorb mainly the higher audible frequencies.

The required reverberation time for the different frequencies is secured by correctly proportioning the areas covered by the different materials. Of the two drama studios one is almost completely acoustically dead, the walls and ceiling being covered with rock wool and the floor completely carpeted. The other studio has a reverberation period of 0.3 second brought about by the introduction of a dado of lath and plaster 4ft. high and a normal lath and plaster ceiling.

SIX O'CLOCK NEWS ON SUNDAYS

SUNDAY is considered by Fleet Street as a bad day for news, but this thought is not deterring the B.B.C. from introducing a Regional news bulletin at six o'clock on Sunday evenings in the near future. The 8.50 news will then be confined to the National wavelengths.

INDIAN RADIO GROWING

EVIDENCE of the growing interest in Indian radio is illustrated by the figures for customs revenue on wireless apparatus which stand at £7,350 for the month of August, 1938; during the same month last year the amount totalled only £4,050. Licences also showed an exciting increase, numbering 57,864 at August 31st; 10,664 more than last year.

The trade received considerable impetus during the rapidly moving political events of the international crisis when All-Indian Radio put on an extra news service and rebroadcast B.B.C. news and other transmissions connected with the situation.

LONDON TRANSMITTERS' SHORTCOMINGS

Increasing Regional Range ?

B.B.C. engineers have, from the opening of the London National and Regional transmitters at Brookmans Park, been somewhat anxious over the Air Ministry's limitation of the height of the masts to 200 feet.

It was felt that, in view of this embargo, there was nothing much to hope for in the way of extending the range of the transmitters. At last, however, steps are to be taken to ascertain what can be done, not only to give the Regional transmitter a greater range, but also to produce an aerial of anti-fading design.

Some short masts are in course of erection, and it is hoped that experiments with a more elaborate aerial system will result, at least in a useful extension of effective range.

PATENT DISPUTE

THE House of Lords, by a majority of three to two, dismissed the appeal in the patent dispute between Electric and Musical Industries, Ltd., and Lissen, Ltd., on which there has been prolonged litigation—actually sixty-three days.

E.M.I. appealed against the judgment of the Court of Appeal (which had reversed the decision of the Chancery Court) that their letters patent relating to a distortionless system of amplification were invalid and ordered them to be revoked.

MASSED TELEVISION DEMONSTRATION

FOR the first time television came under the critical eye of a gathering of eminent photographers when a mass demonstration was staged at the Dorchester Hotel, London, last week on the occasion of the Royal Photographic Society's Festival Dinner.

Mr. Beverley Nichols, from the television studio at Alexandra Palace, responded to the toast "The Guests." After which a cabaret show performed at Alexandra Palace was received.

The thirty-seven sets were fed from a special aerial distribution system, and special mains arrangements were necessary to provide the required 11 kW without blowing the hotel fuses.

TELEVISION FROM THEATRES

B.B.C. television cameras will be installed at St. Martin's Theatre on November 16th for televising the play, "When We Are Married," in its entirety. A super emitron will work from the dress circle and two other cameras from the orchestra stalls. Control will be effected from the scanning van outside the theatre. Lighting will be suitably augmented and scenery brought nearer the footlights for the benefit of televiewers.

On November 24th the first act of the Jack Hulbert-Cicely Courtneidge show, "Under Your Hat," will be televised from the Palace Theatre; an emitron in one of the stage boxes will cover the set and candid close-ups will be obtained in the foyer and dressing-rooms.

FROM ALL QUARTERS

Foreign Broadcasts from London

MAJOR TRYON, Postmaster-General, in reply to a question in the House of Commons last week, said that it was proposed to continue the present broadcast news service in French, German and Italian. Apart from these medium-wave transmissions and the short-wave broadcasts in Spanish, Portuguese and Arabic, no additions were contemplated.

Wireless Reserve in Eire

AMATEUR wireless enthusiasts in Eire are anxious to form an organisation similar to the Civilian Wireless Reserve in this country, and a special committee of the Irish Radio Transmitters' Society has been formed for this purpose. The *Irish Radio News* suggests that it will be closely linked with the Army Signal Corps.

Television Forecast

THE Chief Engineer of the B.B.C., Sir Noel Ashbridge, in delivering the Thomas Hawksley lecture at the Institute of Mechanical Engineers in London last week, said that it may be readily anticipated that sound broadcasting and television will ultimately merge. He pointed out that the nature of the country within the service area of future television transmitters might restrict the range.

Radio Normandie Tests

THE new Radio Normandie transmitter at Louvetot has been making daylight tests on 274 metres.

P.O. Wireless Progress

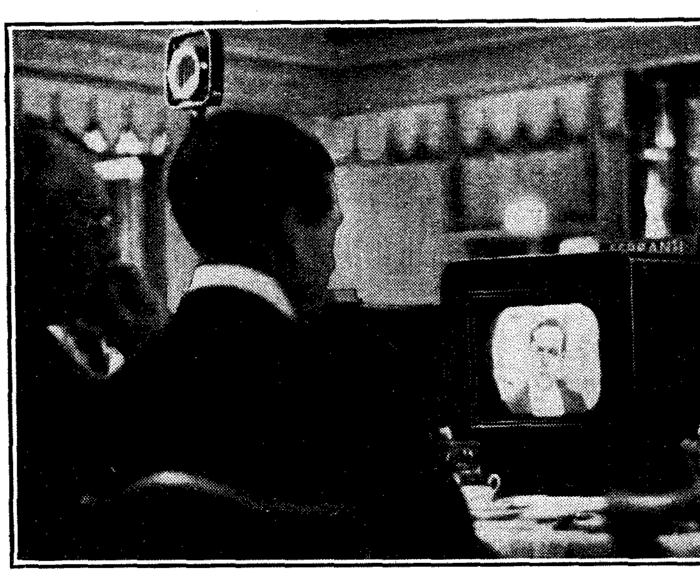
SPEAKING on November 2nd at the Inaugural Meeting of the Wireless Section of the I.E.E., Mr. A. J. Gill reviewed the more important developments in radio engineering carried out by the Post Office Engineering Department during the past year or so. He stated that the ultra-short-wave equipment for telephonic links at short distances, on which work has been proceeding for the past few years, has now reached an entirely reliable stage. For ranges up to 40 miles a transmitter for unattended operation, providing an unmodulated output of 1 watt, has been developed.

Burndept Reunion

A REUNION dinner for officials and employees of the original Burndept Company and its subsidiaries, which were formed before 1928, is being arranged for Friday, January 20th, 1939. Will members of the works or office staff (either male or female) who wish to attend please communicate with Mr. H. W. Higgs, c/o 73, Madeira Avenue, Bromley, Kent.

Modern Insulating Materials

AN Exhibition of ceramic and other low-loss insulating materials, illustrating their applications in many fields, is to be held by the United Insulator Company at the Hotel Great Central, Marylebone, London, N.W., from November 14th to November 18th.



H.R.H. THE DUKE OF KENT presided at the first television dinner which was given at the Dorchester Hotel by the Royal Photographic Society. His Royal Highness is seen watching Mr. Beverley Nichols, who responded to the toast from a television studio at Alexandra Palace, six miles away. (The viewing screen in this picture has not been retouched).

Letters to the Editor

The Editor does not necessarily endorse the opinions of his correspondents

Amateur Experimenters

AS one of the amateur transmitters conducting the "rather pathetic" experiments of 5 metres, mentioned by "Etheris" on page 366 of *The Wireless World* of October 27, may I be permitted to make a few comments and ask a few questions?

On page 380 of the same issue, "Ethacomber" discusses the mechanism of the transmission of 56-Mc/s signals over distances of several thousand miles. Are we to assume that the Post Office have the answers to all the problems suggested by this article? I wonder if "Etheris" read the very admirable article by W. A. Scarr in the September *T. and R. Bulletin*, with the title, "What Have We Learnt About 56 Mc/s"? This article gives rise to quite a number of questions which it is probable would be unanswered or incompletely answered by the Post Office engineers.

I am probably correct in saying that the Post Office have not attempted to send 56-Mc/s signals over distances in excess of a hundred miles or so, as reliable communication over such a distance would be very improbable, but much work has been, and is being, done by amateurs taking regular observations over such distances. The National Bureau of Standards in the U.S.A. has on several occasions acknowledged with thanks the results of regular observations made by amateurs on 56 Mc/s. Many things have been discovered by "stumbling" amateurs in the past, as "Etheris" will discover if he reads Chapter 2 of Ladner and Stoner's "Short Wave Communication," and who can say what the enthusiastic (even if ill-equipped) amateur experimenters on 56 Mc/s may not discover in the future? Had the Post Office waited till they knew "pretty well all about it" the radio-telephone services, etc., would probably not yet be established, for improvements are still being made.

A final word: the A.R.R.L.'s "Radio Amateur's Handbook" is read with respect by many a professional.

E. J. WILLIAMS, B.Sc. (G2XC).
Portsmouth.

Car Aerials

MR. F. R. W. STRAFFORD deserves most cordial thanks for the service he has rendered in publishing (*The Wireless World*, October 20th) results of measurements on aerials in circumstances in which it is difficult to foretell the signal pick-up. This letter is written in the hope that he may be persuaded to disclose still more experimental results. In particular, the picture which he presents to illustrate the pick-up by the under-chassis aerial (Fig. 4) does not appear to me convincing. From this picture he deduces that "in no circumstance does any improvement ensue if one passes the midway position towards ground." Was this result confirmed by experiment? On different reasoning I am led to the conclusion that the signal pick-up would increase the closer the under-chassis aerial is to the *ground*.

I am hesitant to explain my reasoning without any knowledge of whether my conclusions find any support from experiment. Briefly, however, the point is that the car body should be regarded as the aerial, notwithstanding that it is connected to the earth terminal of the set and correctly so, because the set is within it. The under-chassis aerial then acts mainly as a capacity earth, though, of course, the down-lead portion also acts to increase the signal pick-up.

Presumably car aerials should be judged also by considerations other than signal pick-up and appearance. Is any data available to show whether the under-chassis aerial gives as steady a signal as a roof aerial when the car is travelling over rough roads?

W. B. LEWIS.
Cambridge.

Comparing Performance

FROM time to time someone urges that all manufacturers should give sensitivity figures for their receivers; but the difficulty with the present system of expression is almost insuperable from a sales point of view. It is practically impossible to explain to a non-technical customer the "micro-volts input for milli-watts output" business.

What is wanted is a simple round figure for catalogue purposes which will give a direct comparison. I think this could easily be obtained by using the reciprocal of the micro-volts sensitivity and one million. Thus a set with 10 micro-volts sensitivity would be advertised "sensitivity 100,000" while a large set would sound much more impressive listed with a sensitivity of 4,000,000 than it does merely given as "sensitivity ¼ of 1 micro-volt."

Once this system is adopted it would be an easy matter for manufacturers to agree(?) to an arbitrary classification of sensitivity for different purposes, and thus give the uninitiated some idea of the set to suit their particular need. Something, perhaps, on the lines of the following (but not, of course, the actual values given):—

	Sensitivity Required.
For home stations (locals) only	1,000
For home stations and more powerful foreigners	50,000
For good foreign reception	200,000
For world-wide reception	1,000,000 and over.

When this counsel of perfection eventually prevails it will no longer be necessary to explain to a disgruntled purchaser of a 9-guinea "All-World" receiver that it is not possible to get Australia at any time of the day. Who knows, perhaps the more honest firms may give the figures for each of the wave ranges covered: perhaps not!

SALESMAN.

ALL-WAVE BATTERY SET

IT is regretted that an error occurred in the practical wiring diagram of the tuner of this receiver. In the oscillator section the earthing contact of the switch was shown joined to the oscillator positive HT line. It should, of course, be joined to the earth bus-bar which joins the padding condensers.

BROADCASTING HOUSE, GLASGOW, will be officially opened next week. There are ten studios housed in the new premises. Part of the control room is seen in the picture

Club News

Exeter and District Wireless Society

Headquarters: Y.W.C.A., 3, Dix's Field, Southernhay, Exeter.
Meetings: Mondays at 8 p.m.
Hon. Sec.: Mr. W. J. Ching, 9, Sivell Place, Heavitree, Exeter.

At the meeting held on October 24th Mr. F. Thorn demonstrated several new season's sets. On November 28th the Society will visit the showrooms of the Exeter Gas Light and Coke Co.

Ashton and District Amateur Radio Society

Headquarters: Commercial Hotel, 86, Old Street, Ashton-under-Lyne.
Meetings: Alternate Wednesdays.
Hon. Sec.: Mr. K. Gooding, 7, Broadbent Avenue, Ashton-under-Lyne.

A library has been formed and several members have presented books. The subscription to the Society is 6d. per meeting; free morse instruction is given provided that members bring their own headphones. Arrangements are being made to give slow morse practice over the air on a frequency of 1,870 kc/s every Thursday evening at 11 p.m. The following programme has been arranged:—

November 27th.—Visit to the local radio relay station.
December 17th.—Visit to the B.B.C. transmitting station at Moorside Edge.

Leicester Amateur Radio Society

Headquarters: Winn's Café, Granby Street, Leicester.
Meetings: Alternate Tuesdays at 8 p.m.
Hon. Sec.: Mr. T. Cribb, 55, Knighton Drive, Leicester.

The following programme has been arranged:—

November 15th.—Mr. R. Goddard will demonstrate his home-constructed cathode-ray test gear.
November 29th.—Lecture by a representative of Everett, Edgcumbe, Ltd., entitled "Measurements in the Radio Field."

Isle of Man Radio Society

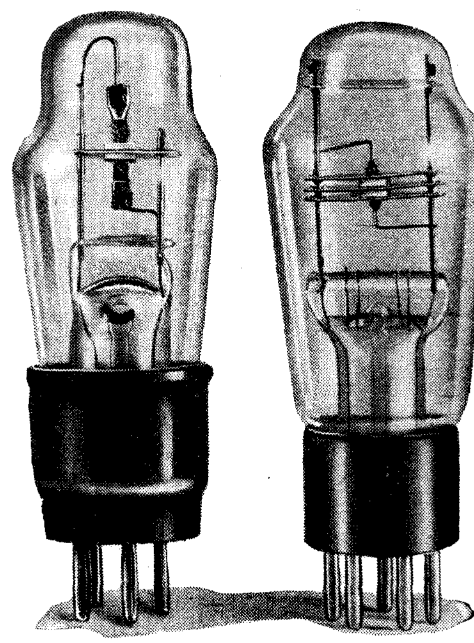
Headquarters: 6, Stanley Place, Victoria Road, Douglas.
Hon. Sec.: Mr. W. Lawson, 13, Second Avenue, School Road, Onchan.

The following programme has been arranged:—

December 6th.—A paper supplied by Crompton Parkinson. The subject is not yet known.
January 3rd.—Lantern lecture by a representative of Ediswan on "The Cathode-Ray Tube and its Applications."

Crystal Band-Pass Filters

Part II.—METHODS OF MOUNTING CRYSTALS



By E. L. GARDINER, B.Sc.

IN the last article the characteristics of quartz crystals were discussed and the author now goes on to deal with the method of mounting. It is shown that some conventional ways introduce undesirable characteristics and an evacuated holder is described.

ANY mechanical damping or friction upon the surfaces of the crystal will reduce its electrical response. If the crystal were to be tightly clamped, it might be destroyed altogether. It is necessary to apply the electrical potentials to two electrodes which are either in contact with the principal surfaces of the crystal or separated therefrom by a very small gap of a few thousandths of an inch, which must be constant if the performance is to be reliable. Any considerable movement of the crystal may lead to microphonic effects, or set up noises in a receiver. The ideal holder would therefore hold the crystal rigidly, without the slightest constraint, making uniform electrical contact with its surfaces. It would allow no movement of the crystal other than free mechanical vibration (which accompanies the piezo-electric oscillations), and would work in any position without being affected by changes of temperature or atmospheric pressure. In fact, its design would be an engineering nightmare of the first water!

The usual type of holder found satisfactory for oscillating or transmitting crystals may be termed a box type, and is sketched in Fig. 5. The crystal is placed in a box of insulating material, such as bakelite, and lies upon a metal plate which forms one electrode. The box should fit the crystal closely, but not tightly. A second electrode either rests upon the upper surface of the crystal with light pressure due to its own weight or a light spring, or alternatively is held at a small distance from it with the help of a fine-threaded screw adjustment. This kind of holder is effective when the crystal is oscillating strongly, under considerable RF energy. It is thought to take up an equilibrium position clear of the box and electrodes, being cushioned therefrom by a layer of compressed or rarefied air produced by the vibrating crystal itself. At such high frequencies the viscosity of air is considerable, and it will not be able to flow away from the crystal during the period of each oscillation. Whether or not this effect is responsible, box-type holders of refined design have proved satisfactory in transmission.

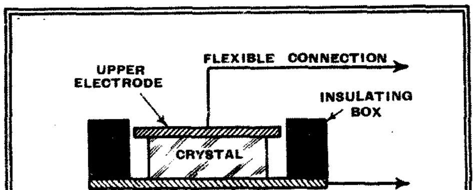


Fig. 5.—The essentials of a conventional box-type crystal holder are shown in this drawing.

Applied to reception, however, holders constructed on such lines were found very imperfect. Crystal noises were common, while the measured resistance of the crystal from day to day was a variable factor, depending upon its position in the holder, and making exact filter design impossible. In addition, the mechanical damping upon the crystal was excessive, leading to poor piezo-electric response.

Non-Linear Response

It is often supposed that the effect of holder friction upon a crystal is strictly comparable to an increase in the effective resistance of the crystal. At high values of applied potential this may be nearly true, but when low values of potential corresponding to weak radio signals are applied to the crystal this relationship breaks down. A property of resistance is that the law (Ohm's law) connecting voltage and current through it is linear. Thus if the crystal possesses pure resistance, its response would be proportional to applied voltage under all conditions. It is found, however, that in a holder which applies friction to the crystal no current may flow at low values of potential, the crystal refusing to oscillate. At a certain critical potential this frictional effect is overcome, and the crystal commences to respond.

For a time, however, the relation between current and potential is non-linear, and measurements carried out by the research staff of Marconi's Wireless Telegraph Co. at Chelmsford show it to be of the form indicated in Fig. 6. There will be seen to be a threshold of potential over which the response is either absent or non-linear, and which will reduce the response to weak radio signals. A good holder design must reduce this defect to a minimum, eliminating it if possible. When testing crystal-gate communication receivers the writer has often noted a lack of response to very weak or distant signals, which on occasions have vanished on

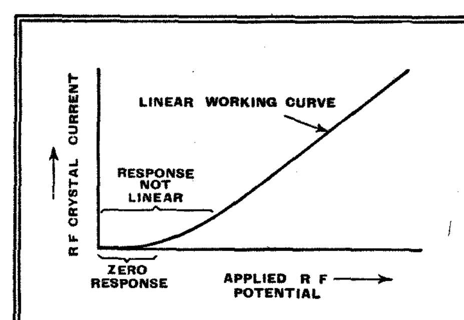


Fig. 6.—It is found that the use of an imperfect holder makes the response non-linear, as shown by this curve.

switching in the crystal, while stronger signals have not been reduced materially in strength by it. There can be little doubt that mechanical damping in the crystal holder is responsible for this defect, which limits the usefulness of the filter in distant reception where its high selectivity would be most valuable; and that an improved design or holder is called for.

Extensive experiments have shown the advantages of two new departures in holder construction. The first of these relates to the electrodes. It is difficult to get the best electrical characteristics unless the electrodes are actually in contact with the crystal, or very close to its surfaces. The former, however, tends to cause friction, while the latter is not easy to ensure from a simple and inexpensive holder. A solution has been found by

Crystal Band-Pass Filters—

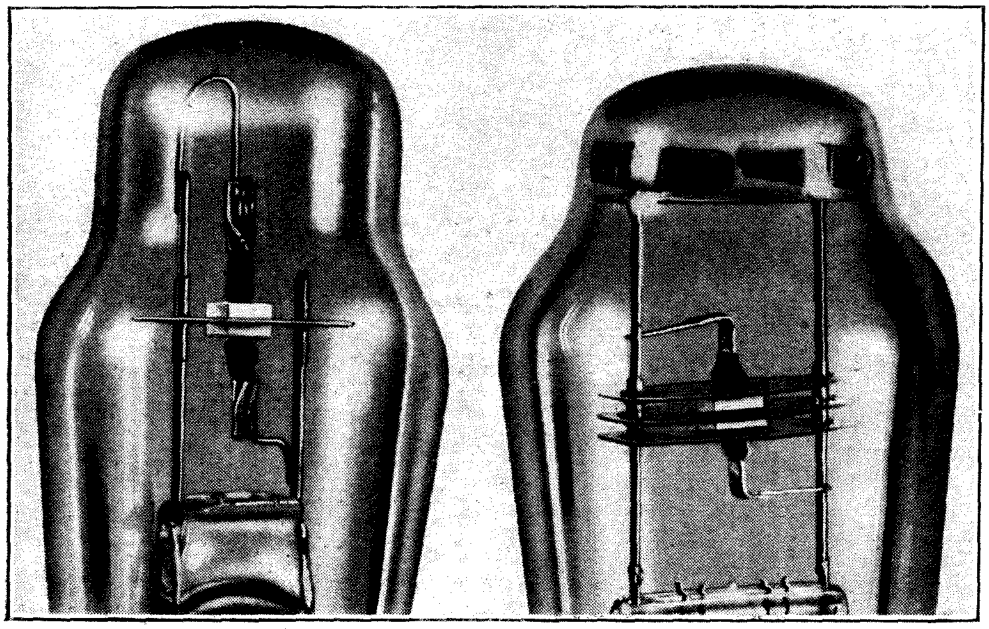
coating the active surfaces of the crystal with a thin film of silver, or other conducting metal, which now becomes the electrode. This method has previously been used on occasions for transmitting crystals, and is not claimed as entirely new. Applied to resonators it results in a high degree of constancy, and a small improvement in efficiency compared to a carefully adjusted gap holder, while it is much better than a poorly adjusted one.

If the metal coating is thin it has a negligible damping effect upon the crystal, while its effect upon the frequency is small, and easily allowed for. It now only remains to make contact to the metallised surfaces, which can be done by means of a light wire brush, and also to support the crystal. A light pad of wire gauze will do this with very little restraint. In the case of large crystals used at comparatively low frequencies it may be satisfactory to support the bar upon knife-edges, which may be of cork, about the central nodal region. It is found also that a metallised crystal may be used with advantage in the box-type holder, with a small air gap between the electrodes and metallised surfaces, and that less variations in performance then occur.

A second improvement is produced by enclosing the crystal in an evacuated container. The vacuum need not be very high, and must not reach the region at which ionisation by the applied potentials might occur. About one centimetre of mercury is suitable. The removal of air damping raises the effective Q of the crystal by as much as three times in some cases, showing that the viscosity of the air causes appreciable friction at high rates of vibration. The crystal is, of course, also isolated to a large extent from temperature changes, and is unaffected by humidity of the air or by dust. The Marconi Company have designed a holder combining these two features with other improvements,[1] in which a metallised crystal is supported by fine wire brushes in an evacuated bulb not unlike a valve, and fitted with a standard valve base.

For the first time this holder gave consistent performance, the measured damping of the crystal being practically constant over long periods, while it is sufficiently robust to pass safely through the post. A photograph of two such crystals is shown. They are manufactured under licence by the Piezo Crystal Co., of 21 Old Queen Street, London, W.1, and will be found most valuable to those interested in accurate scientific work employing crystals, or wishing to construct band-pass filters of the highest performance and reliability.

For many purposes, such for example, as broadcast reception, it is doubtful whether an evacuated holder is essential, and it has been found possible to produce an improved box-type holder which is much less expensive. This consists of a moulded steatite case, having metallised electrodes, and used preferably with a metallised crystal. By refinements in construction it has been found possible to maintain a small and constant air gap under production conditions, and the unit is quite satisfactory unless it be subjected to intense vibration while in use, when the evacuated type would be selected. Since the crystals are small, this moulded holder containing a pair of matched crystals can be small enough to fit comfortably inside a normal IF transformer can, and it becomes possible to design a band-pass filter which occupies no more space than a conventional IF coupling.



The method of mounting the crystal *in vacuo* is clearly shown in this photograph.

[1] Patent No. 477,344 (Application).

"Single Signal—and Why"

THE author of the above article, published in our issue of September 29th, 1938, writes: "The word 'decreases' in line 33 on p. 286, should read *increases*. A similar correction should be made to the word 'decreases,' which appears four lines lower down. When these corrections are made, it will be found that the explanation given in the text no longer reads on to Figs. 5 (*a*) and 5 (*b*). If, however, the reference to Fig. 5 (*a*) in the text be corrected to read 'Fig. 5 (*b*),' and the reference to Fig. 5 (*b*) be corrected to read 'Fig. 5 (*a*),' the explanation will be found to be in order.

"These necessary corrections have, I regret to say, brought to light one more error. In the second column on page 286, the word 'above' on line 21 should read 'below.'

"All of these errors are dependent on the first error which occurs in line 33 in the first column. All the drawings shown in the figures are quite correct, and the captions and lettering relating to them need no alteration.

"Finally, in order to remove any doubt which readers may have as to the correctness of the theoretical discussion given in the article, I should like to remark that the corrections which I have given above do not in any way affect the soundness of the conclusions reached or of the explanation as a whole."

Television Programmes

Sound 41.5 Mc/s Vision 45 Mc/s

THURSDAY, NOVEMBER 10th.

3, "Villa for Sale," a comedy. **3.25,** Gaumont-British News. **3.35,** 189th edition of Picture Page.

9, Cabaret, including Walsh and Barker. **9.40,** British Movietonews. **9.50,** 190th edition of Picture Page. **10.20,** News.

FRIDAY, NOVEMBER 11th.

10.30, O.B. from Whitehall of Armistice Day Cenotaph service.

3, O.B. from Whitehall of the scenes around the Cenotaph, with descriptive commentary by Thomas Woodrooffe.

9, "The White Château," a play by Reginald Berkeley. Cast includes Antoinette Cellier and A. R. Whatmore, with co-operation from members of the 53rd (London) Medium Brigade R.A., T.A., and the 7th Bn. the Middlesex Regiment, T.A. **10.30,** News.

SATURDAY, NOVEMBER 12th.

3, Punch and Judy. **3.5,** Cartoon Film. **3.10,** Cabaret. **3.50,** Gaumont-British News.

9, "Ladies Only," an All-Women Revue with book, lyrics and music by Joan Stevenson. **9.35,** British Movietonews. **9.45,** Golf demonstration by Ernest Bradbeer. **10,** Film. **10.20,** Pianoforte solos by Clifford Curzon with the B.B.C. Television Orchestra. **10.40,** News.

SUNDAY, NOVEMBER 13th.

8.50, News. **9.5,** Music Makers. **9.15,** Cartoon Film. **9.20-10.50,** "The White Château" (as on Friday at 9 p.m.).

MONDAY, NOVEMBER 14th.

3-4.30, "General John Regan," a comedy by G. A. Birmingham.

9, Starlight. **9.10,** British Movietonews. **9.20,** News Map IV—Palestine. **9.40,** Cartoon Film. **9.45,** Fantastic Garden. **10.15,** News.

TUESDAY, NOVEMBER 15th.

3, Eric Wild and his Band. **3.20,** British Movietonews. **3.30-4,** "Viceroy of Peru," a one-act play by Prosper Mérimée.

9, The Comedian Harmonists. **9.15,** Cartoon Film. **9.20,** C. H. Middleton. **9.35,** Gaumont-British News. **9.45,** Re-View, including Queenie Leonard and Patricia Burke in songs and scenes from by-gone shows. **10.15,** News.

WEDNESDAY, NOVEMBER 16th.

3, West End Cabaret. **3.30,** Gaumont-British News. **3.40,** Talk.

9, Speaking Personally, Ian Hay. **9.10,** Squash Rackets Demonstration. **9.25,** Cartoon Film. **9.35,** British Movietonews. **9.45,** Contrasts. **10.15,** News.

The "Wireless World"

VALVE DATA SUPPLEMENT

The 1938—1939 Types

NEW valves are still being produced in great numbers, and *The Wireless World* Valve Data Supplement consequently grows in size every year. Current types of British and American valves are listed, together with their electrical characteristics, operating conditions, and base connections. Valves which are definitely obsolete are not included, but the omission of a specimen should not be taken to mean that it is now unobtainable. Valve makers can usually supply obsolete types as replacements.

Quite a number of the valves included are approaching obsolescence in the sense that one would not choose them in preference to newer types for a new receiver. They are, however, still used in large numbers in existing receivers, and the inclusion of their characteristics is justified on the score of the help it gives to those engaged in servicing.

In general, valves are listed in order of filament or heater voltage. With a few exceptions, 2-volt valves are for battery operation, and 4-volt types for AC mains operation. The 6.3-volt types are intended for AC operation with the parallel connection of heaters or for AC/DC operation with the series connection of heaters. They are also suitable for car radio receivers when a 6-volt car battery is used. The 13-volt range is intended chiefly for AC/DC sets and for car radio with a 12-volt battery. Valves of higher heater voltage rating are designed for AC/DC receivers.

Valves run with heaters in parallel from a single transformer secondary must all have the same heater voltage rating, but the currents can differ. When series operation is adopted, as in an AC/DC set, the valves must take the same current, but the voltages can vary.

The valves listed are classified roughly according to their major uses, but because a valve is included in one section it should not be supposed that its functions are necessarily confined to that one application. An RF pentode, for instance, finds its major application as an RF or IF amplifier as its name would suggest, but it can also be used as a grid detector or an anode bend detector, or a resistance-coupled AF amplifier. The operating conditions for these less common applications are often widely different from those when it is to act as an RF amplifier. To list conditions for all the possible applications of a valve is obviously impossible in view of the enormous number of types now marketed. The conditions given, therefore, are the optimum ones for the purpose for which the valve is primarily intended by its makers.

Frequency-changers

The first section is headed frequency-changers and includes valves primarily intended for this essential operation in a superheterodyne. The chief types are the heptode, octode, triode-pentode, and triode-hexode, and these are essentially two valves in one—comprising mixing and oscillating sections. There are also a few hexodes. These valves require a separate oscillator if used for frequency-changing; where this is their main function they are listed in this section, but where they are primarily intended for use as amplifiers they are included with RF pentodes.

The heptode and octode are essentially alike, but the latter has an extra grid, rather on the lines of an RF pentode. The electrodes are concentric with the cathode, and the two inner grids form the grid and anode of a triode oscillator. The third and fifth grids are screen grids, and the fourth is the signal or control grid.

The triode-pentode consists of a separate triode and pentode in the same glass envelope. The triode is used as an oscillator and the pentode as a mixer with cathode injection. The valve is not very suitable for short-wave operation, and is consequently less commonly used now than it was a few years ago.

The triode-hexode is probably the most widely used frequency-changer to-day. The hexode section has the first grid for the signal input and the second and fourth for screens, while the third grid is for injecting the oscillator voltage. It is normally connected internally to the grid of the separate triode assembly which acts as an oscillator.

Its popularity is due largely to the relative absence of interaction between the signal and oscillator circuits on short waves and to the ease with which the triode circuit can be made to oscillate. In this connection, however, it should be mentioned that some of the latest octodes have neutralising condensers built in to remove the interaction effects.

Screen-grid Valves

Ordinary screened tetrodes and pentodes are not greatly used in broadcast sets now, having been largely superseded by the variable-mu type. They are, however, used for IF stages which are not controlled by the AVC system, and they are also used on occasion for frequency-changing, electron-coupled oscillators, detectors, AF amplifiers, television sync separators, etc. The early types of tetrode can also be used as dynatron oscillators, but the latest kind have pentode-type characteristics and are unsuitable for this purpose.

Quite a number of valves in this category have very high values of mutual conductance, of the order of 6-12 mA/v. These are special television types, and the grid-anode capacity is usually too high for advantage to be taken of the high mutual conductance in other applications.

When a valve is used as a voltage amplifier its gain can be calculated by multiplying its mutual conductance (mA/v) by the parallel value of the dynamic resistance of the tuned circuit and the valve's own AC resistance and dividing by 1,000. When the valve resistance is very high compared with the dynamic resistance the gain is nearly equal to the product of mutual conductance and dynamic resistance divided by 1,000. That is,

$$\text{Gain} = \frac{g\text{Ra}\,\text{R}_D}{(\text{Ra}+\text{R}_D)1{,}000} \simeq \frac{g\ \text{R}_D}{1{,}000} \text{ when Ra} \gg \text{R}_D$$

This equation holds also for other valves. With frequency-changers conversion conductance must be substituted for mutual conductance, and with resistance-coupled amplifiers R_D becomes the coupling resistance in parallel with the following grid leak. The equation does not hold with reactive couplings.

Throughout RF and IF amplifiers variable-mu tetrodes or pentodes are now generally employed. With non-variable-mu valves the mutual conductance tends to remain constant as the grid bias is increased and then rapidly falls to zero, whereas with the variable-mu valve the mutual conductance falls continuously and gradually as the bias is applied. In practice, of course, the mutual conductance with both types falls on increasing the bias, but the change is much more gradual and a much higher bias voltage is needed to obtain the same minimum value with the variable-mu valve.

The practical result is that it is possible to control the amplification within wide limits by varying the grid bias of variable-mu valves without distortion or cross modulation being introduced. This statement must be taken conservatively, of course, for there is naturally a limit to the conditions under which freedom from distortion occurs, and even with variable-mu types trouble will be experienced if the input exceeds a certain figure.

Inter-electrode Capacities

With all valves the inter-electrode capacities are important, but they are especially so in the case of types which are used for RF and IF amplifiers. The input and output capacities usually occur in parallel with the tuned circuits and are only important in that they increase the minimum capacity of these circuits and so restrict the tuning range. It must be remembered that a receiver will require retrimming if a valve is replaced by one having different capacities. In television receivers, of course, the capacities are of the first importance and most definitely limit the gain per stage.

The grid-anode capacity, however, is very important in all types of receiver because it very greatly affects the stability; it does, in fact, place a definite limit to the possible stable gain even with all other couplings eliminated. With a single stage of amplification having identical grid and anode circuits, the limit of amplification is $A = 2/\omega C_{ga} R_D$ when the valve resistance is high compared with the dynamic resistance. With two stages the number 2 in the above equation should be replaced by 1, with three stages by 0.76, and with four stages by 0.67. With R_D in ohms and C_{ga} in microfarads, $\omega = 6.28$ times frequency in Mc/s.

Diode valves are used chiefly as detectors and for AVC purposes. The majority contain two anodes and a common cathode and can provide detection and delayed AVC. In general they can be safely operated at a much larger signal input than the diodes fitted to the multiple diode class of valve and they often have a lower resistance. Westectors are included in this section since they fulfil the same functions as diodes of the thermionic type.

Valves which include one or more diodes in addition to another type of electrode assembly are listed in the section appropriate to the major elements. Thus, the duo-diode-triode appears under the heading of

(*Continued on p.* 432.)

FREQUENCY-CHANGERS

Type.			Heater.		Volts.			Current (mA.).		AC Resistance (MΩ).	Conversion Conductance (mA/V.).	Opt. Osc. Volts (Peak).	Capacities (mmfds.).			Base.	Price.
			Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.				Input.	Output.	Grid-Anode.		
BRIMAR ..	15 A 2 (H)	.. tet.	4.0	0.65	250	100	– 3.0	3.5	2.0	0.3	0.6	10.0	8.0	9.0	0.2	7 B	11/6
	,,	.. osc.			200	—	—	—	—	—	0.75	—	—	—	—		
	20 A1 } (TH)	.. hex.	{ 4.0	1.2 }	250	80	– 2.0	1.4	1.4	0.75	0.65	11.0	7.0	21.0	—	{ 7 B }	11/6
	6P8G }	.. osc.	{ 6.3	0.8 }	150	—	—	—	—	—	—	—	16.0	9.0	3.5	{ A8A }	
	15 D 1 (H)	.. tet.	13.0	0.2	250	100	– 3.0	3.5	2.0	0.3	0.6	10.0	8.0	9.0	0.2	7 B	11/6
	,,	.. osc.			200	—	—	—	—	—	0.75	—	—	—	—		
COSSOR ..	210 PG (H)	.. tet.	2.0*	0.1	150	40	0	0.4	0.8	—	0.45	7.0	14.0	21.5	—	7 A	10/6
	,,	.. osc.			150	—	—	1.1	—	—	—	—	—	—	—		
	210 SPG (H)	.. tet.	2.0*	0.1	150	40	0	0.4	0.8	—	0.45	7.0	15.0	21.0	0.03	7 A	10/6
	,,	.. osc.			150	—	—	1.1	—	—	—	—	—	—	—		
	220 TH (TH)	.. hex.	2.0*	0.2	120	60	0	0.6	1.7	—	0.25	7.0	6.5	23.0	0.04	7 A	10/6
	,,	.. osc.			100	—	—	1.7	—	—	—	—	—	—	—		
	210 PGA (H)	.. tet.	2.0*	0.1	120	40	0	0.4	0.8	—	0.45	7.0	15.0	21.0	0.03	7 A	10/6
	,,	.. osc.			120	—	—	1.1	—	—	—	—	—	—	—		
	41 MPG (H)	.. tet.	4.0	1.0	250	100	– 1.5	2.5	3.0	—	1.5	14.0	15.5	22.5	—	7 B	11/6
	,,	.. osc.			100	—	—	3.0	—	—	—	—	—	—	—		
	41 STH (TH)	.. hex.	4.0	1.15	250	100	– 1.5	3.0	4.0	—	0.6	12.0	6.5	14.5	0.001	7 B	11/6
	,,	.. osc.			100	—	—	2.0	—	—	—	—	—	—	—		
	24 THA (TH)	.. hex.	4.0	1.5	250	100	– 2.0	3.5	5.5	—	0.85	10.0	8.0	14.0	0.001	7 B	11/6
	,,	.. osc.			100	—	—	1.5	—	—	—	—	—	—	—		
	13 PGA (H)	.. tet.	13.0	0.2	250	100	– 3.0	3.5	2.2	—	0.75	12.0	8.0	9.5	—	7 B	11/6
	,,	.. osc.			200	—	—	4.0	—	—	—	—	—	—	—		
	202 MPG (H)	.. tet.	20.0	0.2	200	100	– 1.5	2.5	3.0	—	1.5	14.0	15.5	22.5	—	7 B	11/6
	,,	.. osc.			100	—	—	3.0	—	—	—	—	—	—	—		
	202 STH (TH)	.. hex.	20.0	0.2	250	100	– 1.5	3.0	4.0	—	0.6	12.0	6.5	14.5	0.001	7 B	11/6
	,,	.. osc.			100	—	—	2.0	—	—	—	—	—	—	—		
DARIO ..	BK 22 (O)	.. pent.	2.0*	0.14	135	45	0	0.6	2.5	2.5	0.25	11.3	9.1	14.3	0.07	7 A	10/6
	TK 24 (O)	.. pent.	4.0	0.65	250	70	– 1.5	1.3	3.0	1.5	0.6	11.3	9.0	12.5	0.06	7 B	11/6
	TCH 24 (TH)	.. —	4.0	1.4	250	100	– 2.0	3.0	7.0	2.0	0.75	8.0	8.0	14.0	—	7 B	11/6
	TB 5013 (O)	.. pent.	13.0	0.2	200	70	– 1.5	0.8	3.0	1.5	0.6	11.3	9.0	12.5	0.06	7 B	11/6
EVER-READY	K 80 A (O)	.. pent.	2.0*	0.1	150	70	0	0.95	0.75	—	0.2	13.0	9.9	14.5	0.057	7 A	10/6
	,,	.. osc.			150	—	—	—	—	—	—	—	7.0	6.4	—		
	K 80 B (O)	.. pent.	2.0*	0.12	135	45	– 0.5	0.7	0.7	2.5	0.27	12.3	9.1	13.6	0.07	7 A	10/6
	,,	.. osc.			135	—	—	2.1	—	—	—	—	6.6	8.5	—		
	A 80 A (O)	.. pent.	4.0	0.65	250	90	– 1.5	1.6	3.8	1.6	0.6	12.0	9.0	12.5	0.06	7 B	11/6
	,,	.. osc.			90	—	—	2.0	—	—	—	—	9.4	6.1	—		
	A 36 A (TH)	.. hex.	4.0	1.0	250	70	– 1.5	4.0	6.0	1.5	1.0	29.0	7.4	14.3	—	7 B	11/6
	,,	.. osc.			150	—	—	6.0	—	—	1.2	—	—	2.8	1.8		
	A 36 B (TH)	.. hex.	4.0	1.5	275	100	– 2.5	3.25	7.0	1.5	0.75	11.0	8.0	13.0	—	7 B	11/6
	,,	.. osc.			100	—	—	22.0	—	—	6.0	—	16.5	3.1	3.2§		

REFERENCES.

*	Directly heated filament.	(TD)	Triple-diode.
HW	Half-wave.	(P)	RF Pentode.
FW	Full-wave.	(H)	Heptode.
VD	Voltage-doubler.	(O)	Octode.
MV	Mercury Vapour.	(TP)	Triode-Pentode.
(B)	Class "B" valve.	(TH)	Triode-Hexode.
(Q)	QPP valve.	**	The mains transformer secondary should be tapped for these rectifiers, as with some specimens a lower voltage is needed to obtain the rated output.
(D)	Driver valve.		
(T)	Tetrode.		
†	Per pair in push-pull.		
‡	Under operating conditions quoted.	***	Also available with bayonet-type base.
‡‡	Class A Double Pentode.	††	Special double-triode.
‡‡‡	Double Triode.	†††	Double-pentode
(SA)	Split-anode	§	Each filament
(SD)	Single-diode.	§§	Self-rectifying
(DD)	Duo-diode.		

FREQUENCY-CHANGERS—(*Continued*)

Make	Type		Heater Volts	Heater Amps	Volts Anode	Volts Screen	Volts Grid	Current (mA.) Anode	Current (mA.) Screen	AC Resistance (MΩ)	Conversion Conductance (mA/V.)	Opt. Osc. Volts (Peak).	Capacities (mmfds.) Input	Capacities (mmfds.) Output	Capacities (mmfds.) Grid-Anode	Base	Price
EVER-READY —cont.	C 80 B (O)	.. pent.	13.0	0.2	200	90	– 1.5	1.6	3.8	1.6	0.6	12.0	9.0	12.5	0.1	7 B	11/6
	,,	.. osc.			90	—	—	2.0	—	—	—	—	9.4	6.1	—		
	C 36 A (TH)	.. hex.	21.0	0.2	250	70	– 1.5	4.0	6.0	1.5	1.0	29.0	7.4	14.3	0.1	7 B	11/6
	,,	.. osc.			100	—	—	6.0	—	—	1.2	—	—	2.8	1.8		
	C 36 B (TH)	.. hex.	29.0	0.2	275	100	– 2.5	3.25	7.0	1.5	0.75	11.0	8.0	13.0	—	7 B	11/6
	,,	.. osc.			100	—	—	22.0	—	—	6.0	—	16.5	3.1	3.25		
FERRANTI ..	VHT 4 (H)	.. tet.	4.0	1.0	250	100	– 3.0	2.6	5.1	0.5	0.7	15.0	15.0	16.0	0.3	7 B	11/6
	,,	.. osc.			100	—	—	1.2	—	—	—	—	11.0	9.0	5.0		
HIVAC ..	TP 230 (TP)	.. pent.	2.0*	0.3	150	70	0	4.3	0.8	—	0.325	3.5	9.1	9.7	0.004	9 A	10/6
	,,	.. osc.			100	—	—	2.0	—	0.026	—	—	1.3	1.8	3.2		
MARCONI and OSRAM.	X 22 (H)..	.. tet.	2.0*	0.15	150	70	0	1.0	2.7	1.0	0.35	10–20	12.7	23.7	0.61	7 A	10/6
	,, ..	.. osc.			110	—	—	5.5	—	—	—	—	8.5	6.85	1.6		
	X 23 (TH)	.. hex.	2.0*	0.3	150	60	– 1.5	0.7	1.7	1.0	0.25	6.0	6.3	17.5	0.05	7 A	10/6
	,,	.. osc.			100	—	—	2.1	—	—	—	—	21.5	9.8	4.1		
	MX 40 (H)	.. tet.	4.0	1.0	250	80	– 3.0	2.75	2.0	0.5	0.5	10.0	14.0	16.0	0.1	7 B	11/6
	,,	.. osc.			150	—	—	2.1	—	—	—	—	7.0	4.0	2.0		
	X 42 (H)..	.. tet.	4.0	0.6	250	100	– 3.0	3.5	2.55	—	0.49	25.0	—	—	—	7 B	11/6
	,, ..	.. osc.			250	—	—	3.65	—	—	—	—	—	—	—		
	X 41 (TH)	.. hex.	4.0	1.2	250	80	– 1.5	2.3	2.8	0.75	0.64	12.0	7.0	21.5	0.043	7 B	11/6
	,,	.. osc.			150	—	—	2.2	—	—	—	—	17.0	8.5	3.56		
	X 63 (H) ..	.. tet.	6.3	0.3	250	100	– 3.0	2.9	3.6	—	0.5	25.0	8.6	10.5	0.32	A 8 A	11/6
	,,	.. osc.			—	—	—	2.5	—	—	—	—	7.9	6.2	1.4		
	X 64 ..	.. —	6.3	0.3	250	150	– 6.0	3.25	8.75	1.0	0.31	18.0	6.0	8.5	0.17	A 8 B	10/6
	X 65 (TH)	.. hex.	6.3	0.3	250	100	– 3.0	1.8	4.4	3.0	0.225	10.0	3.5	5.5	0.12	A 8 A	11/6
	,,	.. osc.			150	—	—	4.6	—	—	—	—	10.4	5.5	2.0		
	X 31 (TH)	.. hex.	13.0	0.3	250	80	– 1.5	2.3	1.8	0.75	0.64	12.0	7.0	11.5	0.043	7 B	15/-
	,,	.. osc.			150	—	—	2.2	—	—	—	—	17.0	8.5	3.56		
	X 30 / X 32 } (H)	.. tet.	13.0	0.3	250	80	– 3.0	4.0	2.0	0.2	0.8	10.0	—	—	—	7 B	15/-
		.. osc.			150	—	—	3.0	—	—	—	—	—	—	—		
MAZDA ..	TP 25 (TP)	.. pent.	2.0*	0.2	120	60	– 1.5	0.55	1.0	—	0.25	8.0	6.75	8.25	0.011	8 I	10/6
	,,	.. osc.			80	—	—	2.5	—	0.0133	—	—	8.25	3.5	2.0		
	TP 22 (TP)	.. pent.	2.0*	0.25	150	60	– 1.5	1.2	0.4	1.0	0.5	3.0	9.0	10.0	0.025	9 A	10/6
	,,	.. osc.			100	—	—	0.8	—	0.024	—	—	4.5	6.5	4.5		
	TP 23 (TP)	.. pent.	2.0*	0.25	120	60	– 1.5	0.5	1.0	—	0.25	8.0	7.5	12.0	0.025	7 A	10/6
	,,	.. osc.			80	—	—	2.5	—	0.0095	—	—	13.5	9.0	4.5		
	ACTP (TP)	.. pent.	4.0	1.25	250	200	– 5.0	6.5	2.5	0.9	0.7	3.0	8.0	8.2	0.07	9 B	11/6
	,,	.. osc.			150	—	—	1.5	—	0.0215	—	—	5.75	4.5	2.5		
	ACTH 1 (TH)	.. hex.	4.0	1.3	250	100	– 3.0	3.0	6.0	1.6	0.75	9.0	9.5	11.25	0.002	7 B	11/6
	,,	.. osc.			100	—	—	4.0	—	0.003	—	—	10.25	4.0	2.5		
	TP 1340 (TP)	.. pent.	13.0	0.4	250	200	– 5.0	6.5	2.5	0.9	0.7	3.0	8.0	8.5	0.05	9 B	15/-
	,,	.. osc.			100	—	—	1.5	—	0.0215	—	—	5.75	4.5	2.5		
	TP 2620 (TP)	.. pent.	26.0	0.2	250	200	– 5.0	6.5	2.5	0.9	0.7	3.0	8.0	8.25	0.07	9 B	11/6
	,,	.. osc.			150	—	—	1.5	—	0.0215	—	—	5.75	4.5	2.5		
	TH 2320 (TH)	.. hex.	23.0	0.2	250	100	– 3.0	3.0	6.0	1.6	0.75	9.0	9.5	11.25	0.002	7 B	11/6
	,,	.. osc.			100	—	—	4.0	—	0.003	—	—	10.25	4.0	2.5		
	TH 2321 (TH)	.. hex.	23.0	0.2	150	100	– 3.0	3.0	6.0	1.0	0.65	9.0	9.5	11.5	0.0015	7 B	11/6
	,, ..	.. osc.			100	—	—	4.0	—	—	—	—	10.25	4.0	2.25		
MULLARD ..	FC 2 A (O)	.. pent.	2.0*	0.12	135	45	– 0.5	0.7	0.7	2.5	0.27	12.3	9.1	13.6	0.07	7 A	10/6
	,,	.. osc.			135	—	—	2.1	—	—	—	—	6.6	8.5	—		
	FC 2 (O)	.. pent.	2.0*	0.1	150	70	0	0.95	0.75	—	0.2	13.0	9.9	14.5	0.057	7 A	10/6
	,,	.. osc.			150	—	—	—	—	—	—	—	7.0	6.4	—		
	FC 4 (O)	.. pent.	4.0	0.65	250	90	– 1.5	1.6	3.8	1.6	0.6	12.0	9.0	12.5	0.06	7 B	11/6
	,,	.. osc.			90	—	—	2.0	—	—	—	—	9.4	6.1	—		
	TH 4 (TH)	.. hex.	4.0	1.0	250	70	– 1.5	4.0	6.0	1.5	1.0	29.0	7.4	14.3	—	7 B	11/6
	,,	.. osc.			150	—	—	6.0	—	—	1.2	—	—	2.8	1.8		
	TH 4 A (TH)	.. hex.	4.0	1.5	275	100	– 2.5	3.25	7.0	1.5	0.75	11.0	8.0	13.0	—	7 B	11/6
	,,	.. osc.			100	—	—	22.0	—	—	6.0	—	16.5	3.1	3.25		
	EK 2 (O) ..	.. pent.	6.3	0.2	250	50	–2.0	1.0	0.8	2.0	0.55	—	8.8	10.0	0.07	Ct. 8 A	11/6
	,,	.. osc.			200	—	—	2.5	—	—	—	—	6.0	4.5	—		

FREQUENCY-CHANGERS—(*Continued*)

	Type.		Heater		Volts.			Current (mA.).		AC Resistance (MΩ).	Conversion Conductance (mA/V.).	Opt. Osc. Volts (Peak).	Capacities (mmfds.).			Base.	Price.
			Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.				Input.	Output.	Grid-Anode.		
MULLARD—contd.	EK 3 (O) ..	.. pent.	6.3	0.72	250	100	– 2.5	2.5	5.5	2.0	0.65	17.0	14.5	15.0	0.1	Ct. 8 A	11/6
	"	.. osc.			100	—	—	6.0	—	—	—	—	14.0	7.5	—		
	ECH 2 (TH)	.. hex.	6.3	0.95	250	100	– 2.5	3.25	7.0	1.5	0.75	11.5	8.0	13.0	—	Ct. 8 A	11/6
	"	.. osc.			100	—	—	22.0	—	—	—	—	16.5	3.1	3.25		
	FC 13 C (O)	.. pent.	13.0	0.2	200	90	– 1.5	1.6	3.8	1.6	0.6	12.0	9.0	12.5	0.1	7 B	11/6
	"	.. osc.			90	—	—	2.0	—	—	—	—	9.4	6.1	—		
	TH 13 C (TH)	.. hex.	13.0	0.31	250	70	– 1.5	4.0	6.0	1.5	1.0	29.0	7.4	14.3	0.1	7 B	11/6
	"	.. osc.			100	—	—	6.0	—	—	1.2	—	—	2.8	1.8		
	TH 21 C (TH)	.. hex.	21.0	0.2	250	70	– 1.5	4.0	6.0	1.5	1.0	29.0	7.4	14.3	0.1	7 B	11/6
	"	.. osc.			100	—	—	6.0	—	—	1.2	—	—	2.8	1.8		
OSTAR-GANZ .	G 5 (H) ..	.. tet.	100/250	0.024	250	60	– 1.7	2.5	3.0	1.5	0.6	8.0	3.0	15.0	0.07	C 7 A	17/6
	" ..	.. osc.			140	—	—	3.0	—	—	—	—	—	—	—		
TRIOTRON ..	O 202 (O)	.. pent.	2.0*	0.14	135	45	0	0.6	2.5	2.5	0.25	11.3	9.1	14.3	0.07	7 A	10/6
	O 406 (O)	.. pent.	4.0	0.65	250	70	– 1.5	1.3	3.0	1.5	0.6	11.3	9.0	12.5	0.06	7 B	11/6
	TH 401 (TH)	.. hex.	4.0	1.45	250	150	– 2.0	3.5	—	—	0.75	—	—	—	—	7 B	11/6
	O 1307 (O)	.. pent.	13.0	0.2	200	70	– 1.5	0.8	3.0	1.5	0.6	11.3	9.0	12.5	0.06	7 B & Ct 8 A	11/6
TUNGSRAM ..	VO 2 (O)..	.. pent.	2.0*	0.13	135	45	0	0.7	0.6	2.5	0.27	11.0	9.1	14.3	0.07	7 A	10/6
	" ..	.. osc.			135	—	—	1.3	—	—	—	—	6.6	8.7	—		
	VO 2 S (O)	.. pent.	2.0*	0.13	135	45	0	0.7	0.6	2.5	0.27	11.0	6.6	8.7	0.07	Ct. 8 Z	10/6
	"	.. osc.			135	—	—	—	—	—	—	—	—	—	—		
	VX 2 (Hexode) &	—	2.0*	0.13	150	60	– 1.0	1.0	1.1	2.0	0.47	14.0	7.8	15.0	0.0015	7 AD &	9/-
	VX 2 S.															Ct. 8 AA	
	VO 4 (O)..	.. pent.	4.0	0.65	250	70	– 1.5	1.6	3.8	1.0	0.6	12.0	9.0	12.5	0.06	7 B	11/6
	" ..	.. osc.			90	—	—	2.0	—	—	—	—	9.4	6.1	—		
	TX 4 (TH)	.. hex.	4.0	1.0	300	80	– 1.5	5.5	6.0	1.5	1.0	17.0	6.2	13.0	0.05	7 B	11/6
	"	.. osc.			150	—	—	4.0	—	—	1.2	—	—	3.7	1.8		
	TH 4 A (TH)	.. hex.	4.0	1.45	250	100	– 2.0	3.5	7.5	1.5	0.75	12.0	8.0	12.8	—	7 B	11/6
	"	.. osc.			125	—	—	5.0	—	0.0035	6.0	—	16.5	3.0	3.2		
	EK 3 (O) ..	.. pent.	6.3	0.65	250	100	– 2.5	2.5	5.5	2.0	0.65	17.0	14.5	15.0	0.1	Ct. 8 A	11/6
	"	.. osc.			100	—	—	6.0	—	—	4.5	—	14.0	7.5	—		
	ECH 2 (TH)	.. hex.	6.3	0.95	250	100	– 2.0	3.25	7.0	1.5	0.75	12.0	8.0	13.0	0.8	Ct. 8 A	11/6
	"	.. osc.			100	—	—	5.0	—	0.0035	6.0	—	16.5	3.1	3.25		
	EK 2 (O)	.. pent.	6.3	0.2	250	60	– 2.0	1.1	1.0	2.0	0.55	12.0	8.4	11.3	—	Ct. 8 A	11/6
	" ..	.. osc.			200	—	—	2.5	—	—	—	—	6.0	4.5	—		
	EH 2 ..	.. hex.	6.3	0.2	250	100	– 3.0	4.2	2.8	2.0	0.4	19.0	—	—	—	Ct. 8 J	11/6
	6 TH 8 (TH)	.. hex.	6.3	0.6	300	80	– 1.5	5.5	6.0	2.0	1.0	17.0	6.2	13.0	0.05	A 8 A	11/6
	"	.. osc.			150	—	—	4.0	—	0.007	1.2	—	9.0	3.7	1.8		
	VO 13 & VO 13 S(O)	pent.	13.0	0.2	250	70	– 1.5	1.6	3.8	1.0	0.6	12.0	8.7	12.5	0.06	7 B &	11/6
	"	.. osc.			90	—	—	2.5	—	—	—	—	9.1	6.0	—	Ct. 8 A	
	TX 21 (TH)	.. hex.	21.0	0.2	250	80	– 1.5	5.5	6.0	1.5	1.0	17.0	6.2	13.0	0.05	7 B	11/6
	"	.. osc.			150	—	—	4.0	—	—	1.2	—	—	2.9	1.7		
	TH 29 (TH)	.. hex.	29.0	0.2	250	100	– 2.0	3.5	7.5	1.5	0.75	12.0	8.0	12.8	—	7 B	11/6
	"	.. osc.			125	—	—	—	—	0.0035	6.0	—	16.5	3.0	3.2		
AMERICAN ..	{ 1 A 6 (H)	.. tet.	2.0*	0.06	180	67.5	– 3.0	1.3	2.4	0.5	0.3	—	10.5	9.0	0.25	{ A 6 A	—
	{ 1 D 7 G	.. osc.			135	—	—	2.3	—	—	0.425	—	5.0	6.9	0.8	{ A 8 Q	
	{ 1 C 6 (H)	.. tet.	2.0*	0.12	180	67.5	– 3.0	1.5	2.0	0.75	0.325	—	10.0	10.0	0.3	{ A 6 A	—
	{ 1 C 7 G	.. osc.			135	—	—	3.3	—	—	1.0	—	6.0	6.0	1.5	{ A 8 Q	
	2 A 7 (H)	.. tet.	2.5	0.8	250	100	– 3.0	3.5	2.2	0.36	0.52	—	8.5	9.0	0.3	A 7 A	—
	"	.. osc.			200	—	—	4.0	—	—	—	—	7.0	5.5	1.0		
	6 A 7 (H)	.. tet.	6.3	0.3	250	100	– 3.0	3.5	2.2	0.36	0.52	—	8.5	9.0	0.3	A 7 A	—
	"	.. osc.			200	—	—	4.0	—	—	—	—	7.0	5.5	1.0		
	6 A 8 (H)	.. tet.	6.3	0.3	250	100	– 3.0	3.3	3.2	0.36	0.5	—	12.5	12.5	0.03	A 8 A	—
	"	.. osc.			250	—	—	4.0	—	—	—	—	6.5	5.0	0.8		
	6 F 7 (TP)	.. pent.	6.3	0.3	250	100	–10.0	2.8	0.6	2.0	0.3	7.0	3.2	12.5	0.003	A 7 A	—
	"	.. osc.			100	—	—	2.4	—	0.0178	0.45	—	2.5	3.0	2.0		
	6 L 7 ..	.. —	6.3	0.3	250	150	– 6.0	3.3	8.3	1.0	0.35	18.0	8.5	12.5	0.00005	A 8 B	—
	6 D 8 G (H)	.. tet.	6.3	0.15	250	100	– 3.0	—	—	0.32	0.5	—	8.0	11.0	0.3	A 8 A	—
	"	.. osc.			250	—	—	—	—	—	1.0	—	6.0	5.5	1.0		
	6 J 8 G (TH)	.. hex.	6.3	0.3	250	100	– 3.0	1.2	2.8	4.0	0.29	12.0	—	—	—	A 8 A	—
	"	.. osc.			150	—	—	5.0	—	—	—	—	—	—	—		
	6 P 7 G (TP)	.. pent.	6.3	0.3	250	100	–10.0	2.8	0.6	2.0	0.3	7.0	3.5	12.0	0.008	A 8 AG	—
	"	.. osc.			100	—	—	—	—	—	—	—	3.5	3.0	2.0		

SCREEN-GRID VALVES

Type.		Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen.	Volts. Grid.	Current (mA.). Anode.	Current (mA.). Screen.	AC Resistance (MΩ).	Mutual Conductance (mA/V.).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
BRIMAR ..	8 A 1 (P)	4.0	1.0	250	100	−1.5	3.5	1.2	0.6	4.0	—	—	—	5 B & 7 D	10/6
	8 D 2 (P)	13.0	0.2	250	100	−3.0	2.5	0.5	1.5	1.25	4.0	10.0	0.005	7 D	10/6
COSSOR ..	215 SG	2.0*	0.15	150	60	0	2.5	0.5	0.3	1.1	9.0	7.0	0.001	4 B	9/-
	220 SG	2.0*	0.2	150	60	0	3.1	0.6	0.2	1.6	9.0	7.0	0.001	4 B	9/-
	210 SPT (P) ..	2.0*	0.1	150	60	0	2.95	0.75	0.6	1.3	8.0	7.0	0.008	7 C	9/-
	MSGHA	4.0	1.0	200	80	−1.5	2.1	—	0.5	2.0	—	—	—	5 B	12/6
	MSGLA	4.0	1.0	200	80	−1.5	5.25	—	0.2	3.75	—	—	—	5 B	12/6
	MS/Pen & MS Pen B (P)	4.0	1.0	200	100	−1.5	4.8	1.3	0.8	2.8	9.5	8.5	0.003	7 D & 7 E	10/6
	MS/Pen A (P) ..	4.0	1.0	200	150	−2.5	9.0	5.0	0.09	4.0	—	—	—	5B	17/6
	41 MPT (P) ..	4.0	1.0	250	100	−1.5	12.0	2.0	0.2	4.8	—	—	—	7 D	15/-
	42 MPT (P) ..	4.0	2.0	200	200	−3.0	34.0	6.5	0.1	8.5	—	—	—	7 D	15/-
	41 MTS (SA) ..	4.0	1.0	250	100	—	—	—	—	—	—	—	—	7 V	20/-
	42 PTB (P) ..	4.0	2.0	200	200	−3.0	34.0	6.5	0.1	8.5	—	—	—	7 E	12/6
	4 TSA (SA) ..	4.0	1.0	250	100	—	—	—	—	—	—	—	—	7 AG	20/-
	13 SPA (P) ..	13.0	0.2	200	100	−3.0	2.3	0.6	1.0	1.25	5.0	9.0	0.003	7 E	10/6
	202 SPB (P) ..	20.0	0.2	250	100	−1.5	4.8	1.3	0.8	2.8	9.5	8.5	0.003	7 E	10/6
DARIO ..	PP 462 (P) ..	2.0*	0.18	150	150	—	3.0	1.0	0.55	1.85	5.2	5.6	0.003	7 C	9/-
	TB 622	2.0*	0.18	150	90	−0.5	2.0	0.5	0.35	1.4	—	—	0.008	4 B	9/-
	TE 424	4.0	1.0	200	100	−1.3	1.5	0.6	0.8	0.9	9.0	6.0	0.002	5 B	10/6
	TE 524	4.0	1.0	200	100	−2.0	3.0	1.0	0.45	2.0	12.0	7.0	0.002	5 B	10/6
	TE 464 (P) ..	4.0	1.1	200	100	−2.0	3.0	1.5	1.45	3.5	12.0	10.0	0.001	7 D & 5 B	10/6
	TE 444 (SD) ..	4.0	1.1	200	33	−2.3	0.35	0.25	3.0	3.0	11.0	7.0	0.003	C 7	20/-
	TF 44 (P)	4.0	0.65	250	250	−2.5	3.75	1.5	2.0	3.5	7.0	8.1	0.003	7 E	10/6
	TF 713 (P) ..	13.0	0.2	200	100	−2.	3.0	1.1	2.0	2.4	6.6	7.7	0.003	7 E	10/6
EVER-READY ..	K 40 B	2.0*	0.18	135	90	—	2.0	0.4	0.33	1.5	—	—	0.008	4 B	9/-
	A50 A (P)	4.0	1.0	200	100	−2.0	3.0	1.2	2.2	2.3	12.4	7.3	0.002	5 B	10/6
	A 50 B (P)	4.0	0.65	250	250	−2.4	4.0	1.5	2.0	3.4	6.9	8.1	0.003	7 E	10/6
	C 50 B (P)	13.0	0.2	200	200	−2.2	2.5	0.9	2.5	2.8	6.9	8.1	0.003	7 E	10/6
HIVAC ..	XSG	2.0*	0.065	120	60	0	2.2	0.5	0.5	0.75	1.7	2.7	0.02	Sm. 4 B***	15/6
	SG 215	2.0*	0.15	150	75	−1.5	2.7	0.8	0.25	1.0	7.9	9.2	0.002	4 B	9/-
	SG 220	2.0*	0.2	150	70	−1.5	2.4	0.9	0.33	1.5	9.0	9.4	0.002	4 B	9/-
	SG 220 SW.. ..	2.0*	0.2	150	70	−1.5	2.4	0.9	0.33	1.5	5.4	9.9	0.002	4 C	12/6
	HP 215 (P).. ..	2.0*	0.15	150	70	−1.5	1.5	0.3	0.5	1.2	8.4	8.0	0.004	4 B & 7 C	9/-
	AC/SL	4.0	1.0	200	80	−1.0	3.8	0.4	0.225	3.3	11.2	7.0	0.0015	5 B	10/6
	AC/SH	4.0	1.0	200	80	−1.5	7.4	0.5	0.5	3.5	11.6	7.0	0.0015	5 B	10/6
	AC/HP (P) ..	4.0	1.0	200	100	−2.0	4.2	1.4	0.35	3.2	12.9	9.3	0.003	5 B & 7 D	10/6
LISSEN ..	SG 215	2.0*	0.15	150	80	—	3.0	0.25	0.9	1.1	—	—	0.001	4 B	9/-
	ACSG	4.0	1.0	200	80	−1.5	7.0	0.5	0.34	4.0	—	—	0.001	5 B	10/6
MARCONI and OSRAM	S 12	2.0*	0.06	100	30	0	2.5	0.4	0.2	0.7	3.9	6.3	0.3	Sm. 4 B	17/6
	Z 21	2.0*	0.1	150	150	−0.5	2.5	0.8	—	1.7	10.0	6.5	0.005	4 B	9/-
	S 23	2.0*	0.1	150	70	0	1.4	0.8	0.3	1.1	8.35	9.0	0.003	4 B	9/-
	S 24	2.0*	0.15	150	70	0	1.4	1.0	0.3	1.4	9.3	8.9	0.004	4 B	11/-
	MS 4	4.0	1.0	250	70	−1.5	2.4	0.3	0.5	1.1	9.9	4.8	0.002	5 B	12/6
	MS 4 B	4.0	1.0	250	80	−1.0	3.4	1.2	0.35	3.2	12.7	5.6	0.002	5 B	10/6
	MSP 4 (P)	4.0	1.0	250	100	−1.75	3.0	1.0	1.0	4.0	14.0	10.0	0.01	7 D & 5 B	10/6
	MSP 41 (P) ..	4.0	1.0	250	240	−4.0	8.5	3.2	—	3.2	14.0	10.0	0.01	7 D & 5 B	15/-
	KTZ 41	4.0	1.5	250	250	−2.5	8.0	2.0	1.0	12.0	14.0	10.5	0.008	7 E	12/6
	ZA 1 (Acorn) (P) ..	4.0	0.25	250	100	−3.0	2.0	1.7	—	1.1	3.0	3.0	0.007	—	60/-
	KTZ 63	6.3	0.3	250	100	−3.0	2.0	0.5	—	1.225	5.1	10.4	0.0046	A 8 C	10/6
MAZDA ..	S 215 A	2.0*	0.15	150	60	0	2.0	0.3	1.3	1.1	8.5	12.5	0.002	4 B	11/-
	SP 215 (P)	2.0*	0.15	150	80	−1.5	2.1	0.7	0.8	1.6	10.0	8.5	0.007	7 C	9/-
	SP 210 (P)	2.0*	0.1	120	120	−1.0	1.1	0.33	2.0	1.2	10.0	11.25	0.005	7 C	9/-
	SP 22 (P)	2.0*	0.1	120	120	−1.0	1.1	0.38	1.35	1.2	7.0	12.5	0.0045	8 A	9/-
	ACSG	4.0	1.0	200	60	−1.5	4.5	0.8	0.9	1.9	10.0	10.0	0.001	5 B	12/6
	ACS 2	4.0	1.0	200	80	−1.5	7.0	0.8	0.4	4.3	12.0	10.0	0.001	5 B	12/6
	ACS 2 Pen (P) ..	4.0	1.0	250	100	−2.0	6.0	2.0	1.0	4.0	13.5	8.0	0.005	7 D	12/6
	ACSP 1 (P) ..	4.0	1.0	250	200	−3.0	4.8	4.1	—	2.6	13.0	8.75	0.0035	7 D	10/6
	ACSP 3 (P) ..	4.0	1.0	250	100	−1.7	7.9	2.5	0.55	7.0	14.5	11.0	0.005	7 E	15/-
	SP 41 (P)	4.0	0.95	250	250	−2.1	11.1	2.8	—	8.4	15.5	4.75	0.003	8 F	10/6
	SP 42 (P)	4.0	0.95	200	200	−1.25	16.0	3.75	—	8.0	10.0	7.0	0.004	8 F	10/6
	SP 2220 (P) ..	22.0	0.2	250	200	−3.0	4.8	4.1	—	2.6	13.0	8.75	0.0035	7 D	12/6

SCREEN-GRID VALVES—(*Continued*)

	Type.	Heater.		Volts.			Current (mA.).		AC Resistance (MΩ).	Mutual Conductance (mA/V.).	Capacities (mmfds.).			Base.	Price.
		Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.			Input.	Output.	Grid-Anode.		
MULLARD ..	PM 12 A	2.0*	0.18	135	90	0	2.0	0.4	0.33	1.5	—	—	0.008	4 B	9/-
	PM 12	2.0*	0.15	135	75	0	4.0	1.0	0.18	1.1	—	—	0.008	4 B	9/-
	SP 2 (P)	2.0*	0.18	135	135	0	3.0	1.25	0.7	1.8	11.0	6.0	< 0.01	7 C	9/-
	S 4 VA	4.0	1.0	200	110	−1.5	2.75	0.7	0.5	2.0	—	—	0.003	5 B	10/6
	S 4 VB	4.0	1.0	200	110	−1.5	4.6	1.05	0.3	2.5	—	—	0.003	5 B	10/6
	SP 4 (P)	4.0	1.0	200	100	−2.0	3.0	1.2	2.2	2.3	12.4	7.3	0.002	5 B & 7 D	10/6
	SP 4 B (P)	4.0	0.65	250	250	−2.4	4.0	1.5	2.0	3.4	6.9	8.1	< 0.003	7 E	10/6
	TSP 4 (P)	4.0	1.3	200	200	−2.5	8.0	1.5	—	4.73	9.6	7.5	0.01	7 E	17/6
	AP 4 (Acorn) (P) ..	4.0	0.2	250	100	−3.0	2.0	0.7	3.5	1.4	3.0	2.7	0.02	—	60/-
	SP 13 C (P) ..	13.0	0.2	200	200	−2.2	2.5	0.9	2.5	2.8	6.9	8.1	< 0.003	7 E	10/6
OSTAR-GANZ ..	S 25	100/250	0.024	250	100	−2.0	4.0	0.4	0.25	3.8	—	—	0.001	C 7 B	15/6
	S 100	100/250	0.024	250	100	−1.0	1.0	0.2	1.0	3.5	—	—	0.001	C 7 B	15/6
	H 3 (P)	100/250	0.024	250	100	−2.0	1.6	0.6	3.5	3.5	11.0	12.0	0.005	C 7 C	15/9
TRIOTRON ..	S 218 (P)	2.0*	0.18	150	150	−0.5	3.0	1.0	0.8	1.85	5.3	5.6	0.002	7 C	9/-
	S 215	2.0*	0.18	150	90	−0.5	2.0	0.25	0.35	1.4	—	—	0.05	4 B	9/-
	S 435 N (P) ..	4.0	1.1	200	100	−2.0	3.0	0.5	1.45	3.5	12.0	10.0	0.002	7 D & 5 B	10/6
	S 410 N	4.0	1.0	200	100	−2.0	3.0	0.5	0.45	2.0	9.0	6.0	0.02	5 B	10/6
	S 1324 (P)	13.0	0.2	200	100	−2.0	3.0	1.0	2.0	2.4	6.6	7.7	0.003	7 E	10/6
	S 1328 (P)	13.0	0.2	200	100	−2.0	3.0	1.0	2.0	2.4	8.0	6.8	0.002	Ct. 8 B	10/6
	S 2035 N (P) ..	20.0	0.18	200	100	−2.0	3.0	0.25	1.5	3.5	12.0	10.0	0.002	5 B	12/6
TUNGSRAM ..	SS 210	2.0*	0.12	150	75	−1.0	0.6	0.1	1.0	1.4	9.0	8.5	0.003	4 B	9/-
	HP 210 nc (P) ..	2.0*	0.12	150	150	−1.5	1.9	0.7	2.5	1.9	9.0	8.5	0.003	4 B & 7 C	9/-
	SP 2 B & SP 2 BS(P)	2.0*	0.05	135	135	−0.5	2.6	1.0	1.0	0.8	5.3	5.0	0.006	7 N & Ct. 8 T	9/-
	SP 2 D (P) ..	2.0*	0.12	150	150	−0.1	1.45	0.35	2.0	1.7	—	—	—	7 N	9/-
	HP 4101 (P) ..	4.0	1.0	200	100	−2.0	3.5	0.6	2.0	3.5	—	—	0.002	5 B & 7 D	10/6
	SP 4 B (P)	4.0	0.65	250	250	−2.0	2.9	0.8	2.0	4.0	6.4	7.6	0.003	7 E	10/6
	SP 4 & SP 4 S (P) ..	4.0	0.65	250	100	−2.0	3.0	1.5	1.5	3.5	6.4	7.6	0.003	7 E & Ct. 8 B	10/6
	AS 4120	4.0	1.0	250	100	−2.0	3.0	0.8	0.6	3.0	11.5	7.5	0.003	5 B	10/6
	EF 6 (P)	6.3	0.2	250	100	−2.0	3.0	1.0	1.75	2.0	5.4	6.9	0.003	Ct. 8 B	10/6
	SP 13 & SP 13 S (P)	13.0	0.2	250	100	−2.0	3.0	1.5	2.0	2.4	6.4	7.6	0.003	7 E & Ct. 8 B	10/6
	SP 13 B (P) ..	13.0	0.2	250	250	−1.5	3.5	1.5	1.5	3.5	6.4	7.6	0.003	7 E	10/6
AMERICAN ..	32	2.0*	0.06	135	67.5	−3.0	1.7	0.4	0.95	0.64	5.3	10.5	0.015	A 4 B	—
	1 B 4 & 1 E 5 G ..	2.0*	0.06	180	67.5	−3.0	1.7	0.4	1.2	0.65	4.6	11.0	0.007	A 4 B & A 8 R	—
	24 A	2.5	1.75	250	90	−3.0	4.0	1.7	0.6	1.05	5.3	10.5	0.007	A 5 B	—
	57 (P)	2.5	1.0	250	100	−3.0	2.0	0.5	1.5	1.225	5.0	6.5	0.007	A 6 B	—
	22	3.3*	0.132	135	67.5	−1.5	3.7	1.3	0.325	0.5	3.5	10.0	0.02	A 4 B	—
	77 (P)	6.3	0.3	250	100	−3.0	2.3	0.5	1.5	1.25	4.7	11.0	0.007	A 6 B	—
	36	6.3	0.3	250	90	−3.0	3.2	1.7	0.55	1.08	9.2	3.7	0.007	A 5 B	—
	6 C 6 (P)	6.3	0.3	250	100	−3.0	2.0	0.5	1.5	1.225	5.0	6.5	0.01	A 6 B	—
	6 J 7 (P)	6.3	0.3	250	100	−3.0	2.0	0.5	1.5	1.225	7.0	12.0	0.005	A 8 C	—

VARIABLE-MU VALVES

	Type.	Heater.		Volts.			Current (mA.).		AC Resistance (MΩ).	Mutual Conductance (mA/V.).	Capacities (mmfds.).			Base.	Price.
		Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.			Input.	Output.	Grid-Anode.		
BRIMAR ..	9 A 1 (P)	4.0	1.0	250	100	−1.5	5.0	2.0	0.6	4.25	—	—	—	5 B & 7 D	10/6
	9 D 2 (P)	13.0	0.2	250	125	−2.0	10.0	3.0	0.6	1.8	4.0	10.0	0.005	7 E	10/6
COSSOR ..	220 VS	2.0*	0.2	150	60	0	3.6	0.9	0.4	1.6	9.5	7.0	0.001	4 B	9/-
	220 VSG	2.0*	0.2	150	60	0	5.0	0.7	0.11	1.6	9.5	7.0	0.001	4 B	9/-
	210 VPT (P) ..	2.0*	0.1	150	60	0	2.9	0.75	0.6	1.1	8.0	7.0	0.008	7 C	9/-
	210 VPA (P) ..	2.0*	0.1	150	60	0	2.9	1.0	0.6	1.1	9.0	7.0	0.004	7 C	9/-

VARIABLE-MU VALVES—(*Continued*)

	Type.	Heater.		Volts.			Current (mA.).		AC Resistance (MΩ).	Mutual Conductance (mA/V.).	Capacities (mmfds.).			Base.	Price.
		Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.			Input.	Output.	Grid-Anode.		
COSSOR—cont.	MVSG	4.0	1.0	200	80	−1.5	7.5	0.75	0.2	2.5	—	—	—	5 B	10/6
	MVS/Pen & MVS/Pen B (P)	4.0	1.0	200	100	−1.5	4.3	1.3	0.6	2.2	9.5	8.5	0.003	7 D & 7 E	10/6
	13 VPA (P)	13.0	0.2	200	100	−3.0	7.0	1.7	0.8	1.8	5.0	9.0	0.003	7 D	10/6
	202 VP & 202 VPB (P)	20.0	0.2	250	100	−1.5	4.3	1.3	0.6	2.2	9.5	8.5	0.003	7 D & 7 E	10/6
DARIO	PF 472 (P)	2.0*	0.18	150	150	−0.5	2.5	0.5	0.5	1.7	5.7	5.1	0.002	7 C	9/-
	TB 552	2.0*	0.15	150	75	−0	4.0	0.4	0.35	1.5	—	—	0.002	4 B	9/-
	TE 474 (P)	4.0	1.1	200	100	−1.5	4.5	2.0	1.0	3.5	12.0	10.0	0.002	7 D & 5 B	10/6
	TE 554	4.0	1.0	200	100	−2.5	3.0	1.0	0.3	3.0	11.0	8.0	0.002	5 B	10/6
	TE 564 (P)	4.0	1.2	250	100	−1.75	4.0	2.0	1.5	2.25	12.0	10.0	0.006	7 D & 5 B	10/6
	TF 64 (P)	4.0	0.65	250	250	−2.75	11.0	4.5	—	2.0	5.2	8.2	0.002	7 E	12/6
	TF 313 (P)	13.0	0.2	200	100	−3.0	8.0	2.6	1.0	2.8	8.0	7.5	0.001	7 E	10/6
EVER-READY	K 50 N (Hexode)	2.0*	0.135	135	60	−1.5	2.0	0.95	1.3	1.4	7.9	16.3	0.002	7AD	9/-
	K 40 N	2.0*	0.18	135	90	0	1.8	0.4	—	1.4	—	—	0.003	4 B	9/-
	K 50 M (P)	2.0*	0.18	135	135	0	3.0	1.25	0.4	1.5	10.7	6.3	0.007	7 C	9/-
	A 50 N (P)	4.0	1.2	200	100	−2.0	4.25	1.8	1.4	2.5	12.5	10.2	0.006	7 D	10/6
	A 50 P (P)	4.0	0.65	250	250	−3.0	11.5	4.25	—	2.0	5.35	8.0	0.0023	7 E	10/6
	A 40 M	4.0	1.0	200	110	−1.5	6.0	0.8	—	2.5	—	—	0.003	5 B	10/6
	A 50 M (P)	4.0	1.0	200	100	−2.0	4.5	2.4	1.0	2.3	12.4	10.0	0.005	7 D	10/6
	C 50 N (P)	13.0	0.2	200	200	−2.0	9.0	3.6	—	2.2	6.1	8.0	0.0023	7 E	10/6
FERRANTI	VPT 4 (P)	4.0	1.0	250	100	−3.0	5.5	3.0	1.0	2.0	8.8	8.4	0.002	5 B	10/6
HIVAC	VS 215	2.0*	0.15	150	75	0	6.0	1.7	0.11	1.0	7.8	9.2	0.002	4 B	9/-
	VP 215 (P)	2.0*	0.15	150	70	0	3.75	0.75	—	1.25	8.4	8.0	0.004	4 B & 7 C	9/-
	VP 215 B & VP 215 C (P)	2.0*	0.15	120	120	0	3.25	0.95	1.0	1.2	5.3	8.4	0.003	7 N & 7 C	9/-
	ACVPB (P)	4.0	1.0	250	250	−1.5	12.0	5.0	1.0	4.0	5.3	9.9	0.0025	7 E	10/6
	AC/VS	4.0	1.0	200	80	−1.5	4.4	0.6	0.225	3.0	11.2	7.4	0.001	5 B	10/6
	AC/VH	4.0	1.0	200	80	−1.5	9.3	1.6	0.45	3.3	11.5	7.4	0.0015	5 B	10/6
	AC/VP (P)	4.0	1.0	200	100	−1.5	5.7	2.3	—	3.0	12.9	9.4	0.003	5 B & 7 D	10/6
	VP 13 (P)	13.0	0.3	200	100	−1.5	6.3	2.0	—	3.0	12.6	9.3	0.003	7 D	10/6
LISSEN	SG 2 V	2.0*	0.15	150	80	0	4.0	0.25	0.4	1.2	—	—	0.001	4 B	9/-
	ACSGV	4.0	1.0	200	80	−1.5	6.0	0.5	0.3	3.25	—	—	0.001	5 B	10/6
MARCONI and OSRAM	VS 24	2.0*	0.15	150	75	0	4.4	0.3	0.25	1.5	9.2	8.73	0.003	4 B	9/-
	VP 21 (P)	2.0*	0.1	150	60	0	2.8	0.7	1.0	1.1	11.5	9.0	0.03	7 C	9/-
	W 21	2.0*	0.1	150	150	0	3.5	1.2	—	1.4	10.5	6.8	0.006	4 B	9/-
	VMS 4	4.0	1.0	200	80	−0.5	12.0	2.0	0.25	2.2	9.9	4.8	0.002	5 B	10/6
	VMS 4 B	4.0	1.0	200	80	−0.5	6.7	1.3	0.25	2.9	9.9	4.8	0.002	5 B	10/6
	VMP 4 G (P)	4.0	1.0	250	100	−2.0	8.0	5.0	1.0	2.7	14.0	8.7	0.0026	7 D	10/6
	W 42 (P)	4.0	0.6	250	100	−3.0	7.6	1.85	—	1.5	—	—	—	7 E	10/6
	KTW 63	6.3	0.3	250	100	−3.0	7.6	1.9	0.7	1.5	5.1	10.4	0.005	A 8 C	10/6
	W 30 (P)	13.0	0.3	250	250	−1.0	12.0	6.0	1.0	4.0	5.7	10.0	0.002	7 D	15/-
	W 31 (P)	13.0	0.3	250	100	−2.0	8.0	5.0	1.0	2.7	14.0	8.7	0.0026	7 D	12/6
MAZDA	VP 22 (P)	2.0*	0.1	120	60	−1.5	1.2	0.32	1.3	0.8	7.0	12.5	0.0045	8 A	9/-
	VP 23 (P)	2.0*	0.05	120	60	−1.5	1.45	0.5	—	1.08	8.0	11.0	0.006	8 A	9/-
	VP 210 (P)	2.0*	0.1	120	70	−1.5	1.8	0.63	0.89	1.1	8.75	11.0	0.004	7 C	9/-
	ACVP 1 (P)	4.0	0.65	250	250	−4.0	8.8	2.2	0.85	2.0	10.0	8.0	0.005	7 D	10/6
	ACVP 2 (P)	4.0	0.65	250	250	−4.0	8.8	2.2	0.85	2.0	6.5	9.25	0.0025	7 E	10/6
	VP 41 (P)	4.0	0.65	250	250	−4.0	8.6	2.3	1.2	2.0	7.8	11.5	0.0025	8 F	10/6
	VP 1321 (P)	13.0	0.2	250	250	−4.0	8.8	2.2	0.85	2.0	10.0	7.75	0.005	7 D	10/6
	VP 1322 (P)	13.0	0.2	250	250	−4.0	8.8	2.2	0.85	2.0	6.5	9.25	0.0025	7 E	10/6
	VP 133 (P)	13.0	0.2	150	150	−3.0	8.2	2.0	0.7	2.0	5.5	11.5	0.0035	8F	10/6
MULLARD	PM 12 M	2.0*	0.18	135	90	0	1.8	0.4	—	1.4	—	—	0.008	4 B	9/-
	VP 2 (P)	2.0*	0.18	135	135	0	3.0	1.25	0.4	1.5	10.7	6.3	0.007	7 C	9/-
	VP 2 B (Hexode)	2.0*	0.135	135	60	−1.5	2.0	0.95	1.3	1.4	7.9	16.3	0.002	7 AD	9/-
	MM 4 V	4.0	1.0	200	110	−1.5	6.0	0.8	—	2.5	—	—	0.003	5 B	10/6
	VM 4 V	4.0	1.0	200	100	−1.5	8.5	1.0	—	1.2	—	—	0.003	5 B	17/6
	VP 4 (P)	4.0	1.0	200	100	−2.0	4.5	2.4	1.0	2.3	12.4	10.0	<0.005	7 D & 5 B	10/6
	VP 4 A (P)	4.0	1.2	200	100	−2.0	4.25	1.8	1.4	2.5	12.5	10.2	<0.006	7 D & 5 B	10/6
	VP 4 B (P)	4.0	0.65	250	250	−3.0	11.5	4.25	—	2.0	5.35	8.05	0.0023	7 E	10/6

VARIABLE-MU VALVES—(Continued)

Type.		Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen.	Volts. Grid.	Current (mA.). Anode.	Current (mA.). Screen.	AC Resistance (MΩ).	Mutual Conductance (mA/V.).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
MULLARD—contd.	EF 5 (P)	6.3	0.2	250	100	−3.0	8.0	2.6	1.2	1.7	5.4	6.9	0.003	Ct. 8 B	10/6
	EF 8 (P)	6.3	0.2	250	100	−2.2	8.0	0.25	0.4	1.8	4.9	7.8	0.007	Ct. 8 L	10/6
	EF 9 (P)	6.3	0.2	250	250	−2.5	6.0	1.7	1.25	2.2	5.0	7.0	0.003	Ct. 8 B	10/6
	VP 13 C (P)	13.0	0.2	200	200	−2.0	9.0	3.6	—	2.2	6.1	8.0	0.0023	7 E	10/6
	VP 13 A (P)	13.0	0.2	200	100	−2.0	4.0	1.14	1.0	2.2	—	—	0.003	Ct. 8 B	10/6
OSTAR-GANZ	MS 18	100/250	0.024	250	100	−2.0	5.0	4.0	0.5	3.0	—	—	—	C 7 B	15/6
	V 3 (P)	100/250	0.024	250	100	−2.0	3.5	1.5	3.2	2.5	11.0	12.0	0.025	C 7 C	15/9
TRIOTRON	S 217 (P)	2.0*	0.18	150	150	−0.5	2.5	0.5	0.55	1.7	5.7	5.1	0.002	7 C	9/-
	S 213	2.0*	0.15	150	75	−0.9	4.0	0.3	0.35	1.5	—	—	0.05	4 B	9/-
	S 434 N (P)	4.0	1.1	200	100	−1.5	4.5	0.01	1.0	3.5	12.0	10.0	0.002	7 D & 5 B	10/6
	S 415 N	4.0	1.0	200	100	−1.5	3.0	1.0	0.35	1.2	11.0	8.0	0.003	5 B	10/6
	S 420 (P)	4.0	0.65	250	250	−3.0	11.5	—	—	—	—	—	—	7 D	10/6
	S 1323 (P)	13.0	0.2	200	100	−3.0	8.0	2.6	1.0	2.8	8.0	7.5	0.001	7 E & Ct. 8 B	10/6
	S 2034 N (P)	20.0	0.18	200	100	−2.0	5.0	0.01	0.55	3.5	12.0	10.0	0.002	5 B	12/6
TUNGSRAM	HP 211 (P)	2.0*	0.12	150	150	−0.9	2.6	0.6	2.0	1.7	—	—	0.003	4 B & 7 C	9/-
	SE 211	2.0*	0.12	150	75	−0.9	1.0	0.1	1.5	1.5	—	—	0.003	4 B	9/-
	VP 2 B & VP 2 BS (P)	2.0*	0.05	135	135	−0.5	2.5	0.8	2.0	0.65	5.7	5.1	0.006	7 N & Ct. 8 T	9/-
	VP 2 D (P)	2.0*	0.12	150	75	−1.5	1.3	0.6	0.9	2.0	—	—	0.005	7 N	9/-
	HP 4106 (P)	4.0	1.0	200	100	−2.0	5.0	1.25	1.2	3.5	—	—	0.002	5 B & 7 D	10/6
	HP 4115 (P)	4.0	1.0	200	100	−2.0	4.3	1.5	1.4	3.2	—	—	0.002	5 B & 7 D	10/6
	VP 4 B (P)	4.0	0.65	250	250	−1.0	10.0	2.5	1.0	4.0	6.4	7.6	0.003	7 E	10/6
	EF 8 (Hexode)	6.3	0.2	250	250	−2.5	8.0	0.25	2.0	1.8	4.9	7.8	0.007	Ct. 8 L	10/6
	EF 5 (P)	6.3	0.2	250	100	−3.0	8.0	2.5	1.2	1.7	5.4	6.9	0.003	Ct. 8 B	10/6
	EF 9 (P)	6.3	0.2	250	250	−2.5	6.0	1.7	1.5	2.2	5.0	7.0	0.003	Ct. 8 B	10/6
	EBF 2 (P, DD)	6.3	0.2	250	250	−2.0	5.0	2.0	2.0	1.8	4.3	8.2	0.002	Ct. 8 R	11/6
	EFM 1 (P & CR Ind.)	6.3	0.2	250	250	−2.0	1.0	0.55	—	—	—	—	—	Ct. 8 S	12/-
	VP 13 & VP 13 S (P)	13.0	0.2	200	100	−3.0	8.0	2.6	1.0	2.8	6.4	7.6	0.003	7 E & Ct. 8 B	10/6
	HP 13 & HP 13 S (P)	13.0	0.2	250	100	−1.0	8.0	2.9	1.0	3.5	—	—	—	7 E & Ct. 8 B	10/6
	VP 13 B	13.0	0.2	250	200	−1.0	10.0	3.5	2.0	3.5	6.4	7.6	0.003	7 E	10/6
AMERICAN	34 (P)	2.0*	0.06	135	67.5	−3.0	2.8	1.0	0.6	0.6	6.0	11.5	0.015	A 4 B	—
	1 A 4 & 1D 5 G	2.0*	0.06	180	67.5	−3.0	2.3	0.7	0.96	0.75	4.6	11.0	0.007	A 4 B & A 8 R	—
	1 F 6 & 1 F 7 G (P) (DD)	2.0*	0.06	180	67.5	−1.5	2.0	0.6	1.0	0.65	—	—	—	A 6 K & A 8 T	—
	35	2.5	1.75	250	90	−3.0	6.5	2.5	0.4	1.05	5.3	10.5	0.007	A 5 B	—
	58 (P)	2.5	1.0	250	100	−3.0	8.2	2.0	0.8	1.6	4.7	6.5	0.007	A 6 B	—
	2 B 7 (P) (DD)	2.5	0.8	250	125	−3.0	9.0	2.3	0.65	1.125	3.5	9.5	0.007	A 7 B	—
	39, 44 (P)	6.3	0.3	250	90	−3.0	5.8	1.4	1.0	1.05	3.5	10.0	0.007	A 5 B	—
	78 (P)	6.3	0.3	250	125	−3.0	10.5	2.6	0.6	1.65	4.5	11.0	0.007	A 6 B	—
	6 B 7 (P) (DD)	6.3	0.3	250	125	−3.0	9.0	2.3	0.65	1.125	3.5	9.5	0.007	A 7 B	—
	6 K 7 (P)	6.3	0.3	250	125	−3.0	10.5	2.6	0.6	1.65	7.0	12.0	0.005	A 8 C	—
	6 D 6 (P)	6.3	0.3	250	100	−3.0	8.2	2.0	0.8	1.6	4.7	6.5	0.01	A 6 B	—
	6 S 7 (P)	6.3	0.15	250	100	−3.0	8.5	2.0	0.63	1.75	4.6	7.8	0.007	A 8 C	—
	6 B 8 (P) (DD)	6.3	0.3	250	125	−3.0	9.0	2.3	0.65	1.125	—	—	—	A 8 S	—
	6 U 7 (P)	6.3	0.3	250	100	−3.0	8.2	2.0	0.8	1.6	4.7	6.5	0.01	A 8 C	—

DIODES

Type.		Heater. Volts.	Heater. Amps.	Maximum Rating. Input Volts RMS.	Maximum Rating. Rect. Current (mA.).	No. of Diodes.	Capacities (mmfds.). Anode 1 to Cathode.	Capacities (mmfds.). Anode 2 to Cathode.	Capacities (mmfds.). Anode 1 to Anode 2.	Base.	Price.
BRIMAR	10 D 1	13.0	0.2	50	1.0	2	—	—	—	5 C	5/6
COSSOR	220 DD	2.0	0.2	—	—	2	3.5	3.5	0.7	5 C	5/6
	DD 4	4.0	0.75	—	—	2	3.7	3.7	0.7	5 C	5/6
	DDL 4	4.0	0.75	20	10.0	2	4.0	4.0	2.5	5 C	5/6

DIODES—(*Continued*)

Maker	Type	Heater Volts	Heater Amps	Max. Input Volts RMS	Max. Rect. Current (mA.)	No. of Diodes	Anode 1 to Cathode	Anode 2 to Cathode	Anode 1 to Anode 2	Base	Price
DARIO	TB 24	4.0	0.65	200	0.8	2	4.0	4.0	0.3	5 C	5/6
EVER-READY	A 20 B	4.0	0.65	140	0.8	2	4.5	4.5	0.5	5 C	5/6
	C 20 C	13.0	0.2	140	0.8	2	4.5	4.5	0.5	5 C	5/6
HIVAC	AC/DD	4.0	1.0	—	—	2	3.0	2.4	0.4	5 C	4/6
MARCONI and OSRAM	D 41	4.0	0.3	25	0.13	2	3.5	2.5	0.5	5 C	5/6
	D 42	4.0	0.6	75	15.0	1	4.0	—	—	4 H	10/-
	D 63	6.3	0.3	100	2.0	2	2.8	2.8	0.44	A 8 D	5/6
MAZDA	DD 207	2.0*	0.075	—	—	2	3.5	2.8	0.5	4 E	5/6
	V 914	4.0	0.3	—	1.0	2	3.5	3.0	0.25	5 C	5/6
	DD 41	4.0	0.5	—	—	2	5.0	4.6	0.06	8 H	5/6
	D 1	4.0	0.2	—	50.0	1	1.4	—	—	—	5/6
	DD 620	6.0	0.2	—	1.0	2	3.5	3.0	0.25	5 C	5/6
	DD 101	10.0	0.2	—	—	2	5.0	4.6	0.06	8 H	5/6
MULLARD	2 D 2	2.0	0.09	87.5	0.5	2	2.8	2.8	0.5	5 C	5/6
	2 D 4 A	4.0	0.65	140	0.8	2	4.5	4.5	0.5	5 C	5/6
	2 D 4 B	4.0	0.35	140	0.8	2	3.8	3.9	0.07	7 W	5/6
	EB 4	6.3	0.2	140	0.8	2	1.2	1.2	0.2	Ct. 8 K	5/6
	EAB 1	6.3	0.2	140	0.8	3	1.0	1.45	0.65	Ct. 8 Q	5/6
	2 D 13 C	13.0	0.2	140	0.8	2	4.5	4.5	0.5	5 C	5/6
OSTAR-GANZ	B 2	100/250	0.024	200	15.0	2	—	—	—	C 7 D	9/6
TRIOTRON	D 400	4.0	0.65	200	0.8	2	4.0	4.0	0.3	5 C	5/6
	D 1300	13.0	0.2	200	0.8	2	4.0	4.2	0.3	5 C	5/6
TUNGSRAM	D 418	4.0	0.18	100	5.0	1	7.0	—	—	4 K	5/6
	DD 4	4.0	0.65	200	0.8	2	4.0	4.0	0.5	5 C	5/6
	DD 4 D	4.0	0.4	100	4.0	2	4.5	4.5	0.4	7 W	5/6
	EB 4	6.3	0.2	100	0.8	2	1.2	1.2	0.2	Ct. 8 K	5/6
	EAB 1	6.3	0.2	200	0.8	3	2.25	1.0	0.4	Ct. 8 Q	5/6
	DD 6	6.3	0.2	200	0.8	2	3.5	3.5	0.5	5 C	5/6
	DD 13 & DD 13 S	13.0	0.2	200	0.8	2	4.0	4.0	0.5	5 C & Ct. 5 A	5/6
WESTINGHOUSE	W 4 (M)	—	—	24.0	0.25	1	—	—	—	—	5/-
	W 6 (M)	—	—	36.0	0.28	1	—	—	—	—	5/-
	WM 24 (M)	—	—	24.0	0.5	2	—	—	—	—	10/-
	WM 26 (M)	—	—	36.0	0.5	2	—	—	—	—	10/-
	WX 6 (M)	—	—	36.0	0.12	1	—	—	—	—	5/-
AMERICAN	6 H 6	6.3	0.3	100	4.0	2	4.6	4.6	0.02	A 8 D	—

TRIODE VALVES (AC Resistance greater than 7,000 ohms.)

Maker	Type	Heater Volts	Heater Amps	Anode Volts	Grid Volts	Anode Current (mA.)	AC Resistance (ohms)	Mutual Conductance (mA/V.)	Input (mmfds.)	Output (mmfds.)	Grid-Anode (mmfds.)	Base	Price
BRIMAR	HLA 2	4.0	1.0	200	− 2.5	6.0	9,000	5.5	—	—	—	5 A	9/6
	11 A 2 (DD)	4.0	1.0	200	− 2.0	3.0	18,000	2.8	—	—	—	7 G	9/6
	4 D 1	13.0	0.2	250	− 3.0	10.0	10,000	4.0	—	—	—	7 F	7/6
	11 D 3 (DD)	13.0	0.2	250	− 2.0	0.8	84,000	1.2	1.7	3.5	1.5	7 G	9/6

TRIODE VALVES—(*Continued*) (AC Resistance greater than 7,000 ohms.)

Maker	Type.	Heater Volts.	Heater Amps	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
COSSOR ..	210 RC	2.0*	0.1	150	– 1.5	0.85	50,000	0.8	5.0	2.0	6.0	4 A	4/9
	210 HL	2.0*	0.1	150	– 3.0	1.6	22,000	1.1	—	—	—	4 A	4/9
	210 HF	2.0*	0.1	150	– 3.0	1.6	15,800	1.5	—	—	—	4 A	4/9
	210 DET	2.0*	0.1	150	– 4.5	3.0	13,000	1.1	—	—	—	4 A	4/9
	210 LF	2.0*	0.1	150	– 4.5	4.8	10,000	1.4	—	—	—	4 A	4/9
	210 DDT (DD) ..	2.0*	0.1	100	0	2.3	25,000	1.1	3.0	10.5	1.6	5 E	7/6
	41 MH	4.0	1.0	200	– 1.5	3.2	18,000	4.0	9.5	14.0	2.5	5 A	7/6
	41 MHL	4.0	1.0	200	– 3.0	4.0	11,500	4.5	9.5	14.0	2.5	5 A	7/6
	DDT (DD)	4.0	1.0	200	– 3.0	3.0	17,000	2.4	4.0	6.5	1.0	7 G	9/6
	13 DHA (DD) ..	13.0	0.2	250	– 1.5	1.0	83,300	1.5	—	—	1.0	7 G	9/6
	202 DDT (DD) ..	20.0	0.2	200	– 3.0	3.0	17,000	2.4	4.0	6.5	1.0	7 G	9/6
DARIO ..	TB 282	2.0*	0.1	150	– 1.5	2.0	22,000	1.3	—	—	—	4 A	4/9
	TB 172	2.0*	0.1	150	– 4.5	4.0	12,000	1.4	—	—	—	4 A	4/9
	TB 102	2.0*	0.1	150	– 6.0	5.0	8,000	1.25	—	—	—	4 A	4/9
	BBC 12 (DD) ..	2.0*	0.14	135	– 4.5	2.5	10,500	1.5	—	—	—	5 E	7/6
	TE 244	4.0	1.0	200	– 3.5	6.0	10,000	2.4	6.0	7.0	2.0	5 A	7/6
	TBC 14	4.0	0.65	250	– 7.0	4.0	7,500	3.6	4.3	3.1	1.7	7 G	9/6
	TE 994	4.0	1.0	200	– 1.6	1.0	25,000	4.0	7.0	5.0	1.5	5 A	7/6
	TE 384	4.0	1.0	200	– 2.5	1.5	25,000	1.5	6.0	6.0	3.0	5 A	7/6
	TBC 113	13.0	0.2	200	– 5.0	4.0	7,500	3.6	4.3	3.1	1.7	7 G	9/6
	TB 9920	20.0	0.18	200	– 1.5	0.2	30,000	4.0	7.0	5.0	1.5	5 A	9/6
EVER-READY ..	K 30 A	2.0*	0.1	135	– 3.0	1.5	22,500	0.8	—	—	—	4 A	4/9
	K 30 B	2.0*	0.1	135	– 6.0	3.25	12,000	0.9	—	—	—	4 A	4/9
	K 30 K	2.0*	0.1	135	– 1.5	2.2	21,500	1.4	3.6	4.0	3.2	4 A	4/9
	K 30 C	2.0*	0.1	135	– 1.5	2.3	23,400	1.2	6.0	[illegible]	5.0	4 A	4/9
	K 30 D and K 30 E ..	2.0*	0.1	135	– 4.5	2.0	18,000	1.0	3.5	4.0	3.0	4 A	4/9
	K 23 B (DD) ..	2.0*	0.12	135	– 1.5	1.95	25,000	1.2	2.5	7.6	3.7	5 E	7/6
	K 23 A (DD) ..	2.0*	0.1	135	– 4.5	2.0	12,000	1.4	—	—	—	5 E	7/6
	A 30 B	4.0	0.65	200	– 2.0	2.0	36,000	2.0	8.8	7.8	3.4	5 A	7/6
	A 30 D	4.0	0.65	250	– 4.5	6.5	11,500	3.5	5.3	4.2	3.3	5 A	7/6
	A 23 A (DD) ..	4.0	0.65	250	– 7.0	4.0	13,500	2.0	3.5	2.9	1.7	7 G	9/6
	C 30 B	13.0	0.2	200	– 3.7	5.0	12,900	3.3	3.9	4.6	3.1	7 F	7/6
HIVAC ..	XD	2.0*	0.066	100	– 1.5	1.1	23,000	0.75	1.3	1.5	2.7	Sm. 4 A * * *	10/6
	XL	2.0*	0.066	100	– 3.0	2.5	14,000	0.85	1.4	1.6	2.7	Sm. 4 A * * *	10/6
	H 210	2.0*	0.1	150	– 3.0	1.1	22,000	1.15	4.3	4.5	4.8	4 A	3/9
	DDT*215 (DD) ..	2.0*	0.15	150	– 3.0	3.0	12,500	1.6	3.8	3.9	4.0	5 E	7/–
	D 210	2.0*	0.1	150	– 4.5	2.4	12,000	1.35	4.0	4.5	4.4	4 A	3/9
	D 210 SW ..	2.0*	0.1	150	– 4.5	2.4	12,000	1.35	2.4	4.5	2.6	4 I	5/6
	L 210	2.0*	0.1	150	– 6.0	4.2	7,500	1.6	—	—	—	4 A	3/9
	AC/DDT (DD) ..	4.0	1.0	200	– 4.0	5.0	15,000	2.3	2.4	5.1	[illegible]	7 G	9/6
	AC/HL	4.0	1.0	200	– 2.75	6.0	10,000	3.5	6.8	7.0	5.5	5 A	7/6
	DDT 13 (DD) ..	13.0	0.3	200	– 4.0	5.0	15,000	2.3	2.4	5.1	3.3	7 G	10/6
	HL 13	13.0	0.3	200	– 2.75	6.0	10,000	3.5	6.5	6.9	5.5	7 F	8/6
LISSEN ..	H 2	2.0*	0.1	150	– 1.5	1.0	45,000	1.1	—	—	—	4 A	4/9
	HL 2	2.0*	0.1	150	– 3.0	1.5	22,000	1.6	—	—	—	4 A	4/9
	L 2	2.0*	0.1	150	– 4.5	2.0	10,000	2.0	—	—	—	4 A	4/9
	L 2 D (SD) ..	2.0*	0.1	150	– 4.5	2.0	12,000	1.5	—	—	—	[illegible]	4/9
MARCONI and OSRAM	H 12	2.0*	0.06	100	– 1.5	0.6	21,600	1.2	2.5	1.6	4.3	Sm. 4 A	15/–
	HL 2	2.0*	0.1	150	– 3.0	1.8	18,000	1.5	5.2	3.5	8.4	4 A	4/9
	L 21	2.0*	0.1	150	– 6.0	2.2	8,900	1.8	—	—	—	4 A	4/9
	HD 22 (DD) ..	2.0*	0.2	150	– 3.0	2.0	18,000	1.5	1.8	15.0	3.6	5 E	7/6
	HD 23 (DD) ..	2.0*	0.15	150	– 2.0	1.0	28,600	1.4	2.75	10.0	2.5	5 E	7/6
	MH 4	4.0	1.0	200	– 3.0	4.5	11,000	3.6	7.1	4.4	6.5	5 A	7/6
	MH 41	4.0	1.0	200	– 1.5	5.0	3,300	6.0	8.1	4.3	4.3	5 A	9/6
	MHL 4	4.0	1.0	200	– 6.0	7.0	8,000	2.5	4.27	1.8	3.7	5 A	7/6
	MHD 4 (DD) ..	4.0	1.0	200	– 3.0	3.0	18,200	2.2	2.5	5.2	4.1	7 G	9/6

TRIODE VALVES—(*Continued*) (AC Resistance greater than 7,000 ohms.)

Maker	Type.	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
MARCONI and OSRAM, contd.	H 42	4.0	0.6	250	− 2.0	1.0	66,000	1.7	—	—	—	7 F	7/6
	DH 42 (DD)	4.0	0.6	250	− 3.0	1.1	58,000	1.2	—	—	—	7 G	9/6
	A 537	4.0	0.4	150	− 6.0	3.3	10,000	1.55	1.4	1.5	1.7	Special Side Ct.	50/-
	MH 40..	4.0	1.0	200	− 3.0	2.7	18,750	2.4	—	—	—	5 A	50/-
	HA 1 (Acorn).. ..	4.0	0.25	180	− 4.5	4.0	11,800	1.7	—	—	—	—	50/-
	H 63	6.3	0.3	250	− 2.0	1.0	66,000	1.5	2.6	5.3	3.0	A 8 F	7/6
	DH 63 (DD)	6.3	0.3	250	—	—	58,000	1.2	2.5	4.8	2.0	A 8 E	9/6
	L 63	6.3	0.3	250	− 8.0	9.0	7,700	2.6	5.2	4.0	4.3	A 8 G	7/6
	H 30	13.0	0.3	250	− 1.7	5.5	13,300	6.0	5.2	8.4	2.9	7 F	12/6
	DH 30 (DD)	13.0	0.3	200	− 1.7	3.8	18,000	4.5	4.9	11.8	2.5	7 G	12/6
MAZDA ..	HL 2	2.0*	0.1	150	− 1.5	2.7	21,000	1.5	5.25	3.75	5.0	4 A	4/9
	L 2	2.0*	0.1	150	− 3.0	5.3	10,000	1.9	5.3	3.6	5.0	4 A	4/9
	HL 21 DD (DD) ..	2.0*	0.15	150	− 2.0	2.0	21,000	1.5	2.5	4.75	3.25	5 E	7/6
	L 21 DD (DD) ..	2.0*	0.15	150	− 5.0	2.3	10,000	1.9	2.5	4.75	3.25	5 E	7/6
	HL 22	2.0*	0.1	150	− 2.0	2.0	21,000	1.5	2.75	5.0	4.5	8 B	4/9
	HL 23	2.0*	0.05	150	− 2.0	2.0	21,000	1.5	2.75	5.25	5.0	8 B	4/9
	HL 22 DD (DD) ..	2.0*	0.1	150	− 2.0	2.0	21,000	1.5	2.25	6.75	3.25	8 K	7/6
	HL 23 DD (DD) ..	2.0*	0.05	150	− 2.4	2.0	21,000	1.2	2.0	6.0	3.5	8 K	7/6
	ACHL	4.0	1.0	200	− 3.5	5.0	11,700	3.0	8.0	11.5	3.25	5 A	7/6
	AC 2 HL	4.0	1.0	200	− 1.75	4.9	11,500	6.5	8.5	9.0	3.5	5 A	7/6
	ACHLDD (DD) ..	4.0	1.0	200	− 3.0	4.3	13,800	2.6	5.0	9.0	2.0	7 G	9/6
	ACHLDDD (TD) ..	4.0	1.0	200	− 3.0	4.9	13,000	2.7	3.75	9.5	2.0	9 E	16/6
	HL 41 DD (DD) ..	4.0	0.65	250	− 6.0	4.5	13,000	2.3	3.5	4.5	3.5	8 E	9/6
	HL 41	4.0	0.65	250	− 5.1	5.0	10,300	3.4	5.5	4.5	5.5	8 G	7/6
	HL 1320	13.0	0.2	250	− 4.5	7.5	10,000	3.0	4.25	5.75	2.5	7 F	7/6
	HLDD 1320 (DD) ..	13.0	0.2	200	− 3.0	4.3	15,000	2.0	4.25	10.5	2.0	7 G	9/6
	HL 133 DD (DD) ..	13.0	0.2	250	− 6.0	4.5	13,000	2.3	3.5	4.5	3.5	8 E	9/6
	HL 133	13.0	0.2	250	− 5.7	5.0	11,700	3.0	4.0	5.0	4.75	8 P	7/6
MULLARD ..	DA 1	2.0*	0.05	40	−0.25	0.25	80,000	0.4	3.8	5.4	1.6	Sm. 4 A	15/-
	DA 2	2.0*	0.05	40	−2.15	1.25	13,600	0.5	3.4	5.4	1.4	Sm. 4 A	15/-
	PM 1 HF	2.0*	0.1	135	− 3.0	1.5	22,500	0.8	—	—	—	4 A	4/9
	PM 1 LF	2.0*	0.1	135	− 6.0	3.25	12,000	0.9	—	—	—	4 A	4/9
	PM 1 HL	2.0*	0.1	135	− 1.5	2.3	23,400	1.2	6.0	4.0	5.0	4 A	4/9
	PM 2 DX	2.0*	0.1	135	− 4.5	2.0	18,000	1.0	3.5	4.0	3.0	4 A	4/9
	PM 2 DL	2.0*	0.1	135	− 4.5	2.0	12,000	1.0	3.5	4.0	3.0	4 A	4/9
	PM 2 HL	2.0*	0.1	135	− 1.5	2.2	21,500	1.4	3.6	4.0	3.2	4 A	4/9
	TDD 2 A (DD) ..	2.0*	0.12	135	− 1.5	1.95	25,000	1.2	2.5	7.6	3.7	5 E	7/6
	TDD 2 (DD)	2.0*	0.1	135	− 4.5	2.0	12,000	1.4	—	—	—	5 E	7/6
	904 V	4.0	0.65	200	− 2.0	2.0	36,000	2.0	8.8	7.8	3.4	5 A	7/6
	354 V	4.0	0.65	250	− 4.5	6.5	11,500	3.5	5.3	4.2	3.3	5 A	7/6
	244 V	4.0	0.65	200	− 5.5	5.5	9,000	2.8	—	—	—	5 A	7/6
	TDD 4 (DD)	4.0	0.65	250	− 7.0	4.0	13,500	2.0	3.5	2.9	1.7	7 G	9/6
	AT 4 (Acorn).. ..	4.0	0.25	200	− 6.0	4.5	12,500	2.0	1.0	0.6	1.4	—	50/-
	EBC 3 (DD)	6.3	0.2	200	− 4.3	4.0	15,000	2.0	—	—	—	Ct. 8 G	9/6
	HL 13 C	13.0	0.2	200	− 3.7	5.0	12,000	3.3	3.9	4.6	3.1	7 F	7/6
	TDD 13 C	13.0	0.2	200	− 5.0	4.0	13,500	2.0	3.5	2.9	1.7	7 G	9/6
OSTAR-GANZ ..	A 520	100/250	0.024	250	− 6.0	4.0	8,800	2.5	—	—	—	5 A	13/6
	D 130	100/250	0.024	250	− 1.0	2.0	40,000	3.5	—	—	—	C 7 E	13/9
TRIOTRON ..	W 213	2.0*	0.1	150	− 2.5	1.0	22,000	1.3	—	—	5.5	4 A	4/9
	HD 2	2.0*	0.08	200	− 5.0	5.0	15,000	1.0	—	—	—	4 A	4/9
	SD 2	2.0*	0.1	150	− 4.5	4.0	12,000	1.4	—	—	—	4 A	4/9
	A 214	2.0*	0.1	150	− 4.5	4.0	12,000	1.4	—	—	5.5	4 A	4/9
	TD 2	2.0*	0.1	150	− 6.0	5.0	8,000	1.25	—	—	—	4 A	4/9
	DT 215 (DD)	2.0*	0.1	135	− 4.5	2.5	10,500	1.5	—	—	—	5 E	7/6
	A 440 N	4.0	1.0	200	− 1.6	1.0	25,000	4.0	7.0	5.0	1.5	5 A	7/6
	DT 436	4.0	0.65	250	− 7.0	4.0	7,500	3.6	4.3	3.1	1.7	7 G	9/6
	DT 1336	13.0	0.2	200	− 5.0	4.0	7,500	3.6	4.3	3.1	1.7	7 G	9/6

TRIODE VALVES—(*Continued*) (AC Resistance greater than 7,000 ohms.)

	Type.	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
TUNGSRAM	HL 2	2.0*	0.13	135	– 1.5	2.2	21,000	1.5	3.9	4.0	3.2	4 A	4/9
	HR 210	2.0*	0.1	200	– 1.5	1.0	23,000	1.3	—	—	4.0	4 A	4/9
	LD 210	2.0*	0.1	150	– 4.5	3.0	14,000	1.3	—	—	4.0	4 A	4/9
	DDT 2 (DD)	2.0*	0.1	135	– 3.0	1.0	21,000	1.4	2.6	7.7	2.8	5 E	7/6
	DDT 2 B & DDT 2 BS (DD)	2.0*	0.1	135	– 4.5	2.5	16,000	1.0	—	—	—	5 E & Ct. 8 V	7/6
	HR 2 & HR 2 S	2.0*	0.065	135	– 1.5	1.2	40,000	0.6	6.5	5.5	3.5	4 A & Ct. 8 W	4/9
	LL 2 & LL 2 S (D)	2.0*	0.2	135	– 2.5	3.0	11,500	2.6	—	—	—	4 A & Ct. 8 W	4/9
	HL 4 +	4.0	0.65	250	– 4.5	5.0	11,000	3.5	4.9	4.5	3.5	5 A	7/6
	HL 4 g	4.0	0.65	250	– 4.5	5.0	11,000	3.5	4.9	4.5	1.7	7 F	7/6
	DDT 4 (DD)	4.0	0.65	250	– 5.0	4.0	11,000	3.6	4.3	3.1	1.7	7 G	9/6
	EBC 3 (DD)	6.3	0.2	250	– 5.5	5.0	15,000	2.5	4.0	3.1	1.6	Ct. 8 G	9/6
	HL 13 & HL 13 S	13.0	0.2	200	– 3.0	6.0	11,000	3.5	4.9	5.5	1.7	7 F & Ct. 8 C	7/6
	DDT 13 & DDT 13 S (DD)	13.0	0.2	200	– 5.0	4.0	11,000	3.6	4.3	3.1	1.7	7 G & Ct. 8 G	9/6
AMERICAN	30 & 1 H 4 G	2.0*	0.06	135	– 9.0	3.0	10,300	0.9	3.0	2.1	6.0	A 4 A & A 8 V	—
	1B5/25S & 1H6G (DD)	2.0*	0.06	135	– 3.0	0.8	35,000	0.575	1.6	1.9	3.6	A 6 C & A 8 U	—
	27	2.5	1.75	250	–21.0	5.2	9,250	0.975	3.1	2.3	3.3	A 5 A	—
	55 (DD)	2.5	1.0	250	–20.0	8.0	7,500	1.1	1.5	4.3	1.5	A 6 D	—
	56	2.5	1.0	250	–13.5	5.0	9,500	1.45	3.2	2.2	3.2	A 5 A	—
	2 A 6 (DD)	2.5	0.8	250	– 2.0	0.4	91,000	1.1	1.7	3.8	1.7	A 6 D	—
	37	6.3	0.3	250	–18.0	7.5	8,400	1.1	3.5	2.9	2.0	A 5 A	—
	75 & 6 B 6 G (DD)	6.3	0.3	250	– 2.0	0.4	91,000	1.1	1.7	3.8	1.7	A 6 D & A 8 E	—
	76	6.3	0.3	250	–13.5	5.0	9,500	1.45	3.5	2.5	2.8	A 5 A	—
	85 (DD)	6.3	0.3	250	–20.0	8.0	7,500	1.1	1.5	4.3	1.5	A 6 D	—
	6 C 5	6.3	0.3	250	– 8.0	8.0	10,000	2.0	4.0	13.0	1.8	A 8 G	—
	6 F 5	6.3	0.3	250	– 2.0	0.9	66,000	1.5	6.0	12.0	2.0	A 8 F	—
	6 Q 7 (DD)	6.3	0.3	250	– 3.0	1.1	58,000	1.2	5.0	4.4	1.4	A 8 E	—
	6 R 7 (DD)	6.3	0.3	250	– 9.0	9.5	8,500	1.9	4.8	4.0	2.5	A 8 E	—
	6 Q 6 (SD)	6.3	0.15	250	– 3.0	1.2	62,000	1.05	—	—	—	A 8 O	—
	6 L 5	6.3	0.15	250	– 9.0	8.0	9,000	1.9	3.0	5.0	2.7	A 8 G	—
	6 J 5	6.3	0.3	250	– 8.0	9.0	7,700	2.6	3.8	3.3	3.4	A 8 G	—
	6 K 5	6.3	0.3	250	– 3.0	1.1	50,000	1.4	2.4	3.6	2.0	A 8 M	—
	6 C 8 G‡‡‡	6.3	0.3	250	– 4.5	3.1	26,000	1.45	3.4	3.5	2.5	A 8 AA	—
	6 T 7 G (DD)	6.3	0.15	250	– 3.0	1.2	62,000	1.05	—	—	—	A 8 E	—
	6 A C 5 G	6.3	0.4	250	+13.0	32.0	36,700	3.4	—	—	—	A 8 G	—
	6 F 8 G ‡‡‡	6.3	0.6	250	– 8.0	9.0	7,700	2.6	3.3	1.5	4.5	A 8 AA	—
	6 V 7 G (DD)	6.3	0.3	250	–20.0	8.0	7,500	1.1	2.0	3.5	1.7	A 8 E	—

TRIODE VALVES (AC Resistance less than 7,000 ohms.)

	Type.	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
BRIMAR	PA 1	4.0	1.0	200	– 10.5	40.0	1,050	12.0	4,000	1,250	260	—	—	—	5 A	12/6
COSSOR	215 P	2.0*	0.15	150	– 7.5	10.0	4,000	2.25	9,000	150	—	3.0	3.0	6.0	4 A	6/-
	220 P	2.0*	0.2	150	– 7.5	11.0	4,000	2.25	9,000	190	—	3.5	3.0	5.5	4 A	6/-
	220 PA	2.0*	0.2	150	– 4.5	10.0	4,000	4.0	9,000	180	—	4.5	3.0	9.0	4 A	6/-
	230 XP	2.0*	0.3	150	– 18.0	22.0	1,500	3.0	3,500	450	—	9.5	3.0	6.0	4 A	10/-
	2 XP	2.0*	2.0	300	– 36.0	50.0	900	7.0	4,000	3,150	700	8.0	4.5	12.0	4 A	9/6
	41 MP	4.0	1.0	200	– 7.5	24.0	2,500	7.5	3,000	1,000	320	6.0	5.0	6.5	5 A	10/-
	41 MXP	4.0	1.0	200	– 12.5	40.0	1,500	7.5	2,000	1,600	300	6.0	5.0	6.5	5 A	9/6
	4 XP	4.0*	1.0	250	– 28.5	48.0	900	7.0	3,000	3,000	600	8.0	4.5	12.0	4 A	9/6
	402 P	40.0	0.2	200	– 12.5	40.0	1,330	7.5	2,500	1,600	320	6.0	5.5	6.0	7 F	9/6

TRIODE VALVES—(*Continued*) (AC Resistance less than 7,000 ohms.

Type.		Heater Volts.	Heater Amps.	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.). Input.	Output.	Grid-Anode.	Base.	Price.
DARIO ..	TB 062	2.0*	0.33	150	− 10.5	13.0	3,000	2.0	8,000	550	—	—	—	—	4 A	6/-
	TB 122	2.0*	0.2	150	− 4.5	6.0	3,600	3.5	7,000	150	—	—	—	—	4 A	6/-
	TB 052	2.0*	0.15	150	− 15.0	7.0	4,200	1.2	10,000	200	—	—	—	—	4 A	6/-
	TB 032	2.0*	0.20	150	− 30.0	12.0	2,000	1.5	6,000	500	—	—	—	—	4 A	6/-
	TE 094	4.0	1.0	200	− 16.0	12.0	7,000	1.3	3,000	600	850	7.0	5.0	1.5	5 A	10/-
	TD 044	4.0*	0.65	250	− 40.0	40.0	1,000	3.0	1,500	2,500	1,000	5.0	6.0	7.0	4 A	9/6
	TF 104	4.0*	2.0	400	− 36.0	61.0	2,500	4.0	2,700	5,700	600	—	—	—	4 A	20/-
EVER-READY	K 30 G	2.0*	0.2	135	− 6.0	5.0	6,000	2.0	7,000	150	—	6.3	3.3	5.5	4 A	6/-
	S 30 C	4.0*	1.0 }	300	− 38.0	50.0	1,200	5.0	2,300	3,500	760	8.8	5.0	14.0	4 A	9/6
	S 30 D	2.0*	2.0 }													
HIVAC ..	XP	2.0*	0.066	100	− 9.0	5.0	5,000	1.0	10,000	50	—	1.4	1.5	2.7	Sm. 4 A ***	12/6
	P 215	2.0*	0.15	150	− 12.0	8.0	3,600	2.2	10,000	150	—	—	—	—	4 A	4/9
	P 220	2.0*	0.2	150	− 7.5	6.0	4,700	3.0	9,000	175	—	—	—	—	4 A	5/6
	PP 220	2.0*	0.2	150	− 12.0	12.5	2,300	3.0	5,000	250	—	—	—	—	4 A	6/6
	PX 230 ..	2.0*	0.3	150	− 15.0	17.5	1,850	3.5	4,000	450	—	—	—	—	4 A	7/6
	PX 230 SW ..	2.0*	0.3	150	− 15.0	17.5	1,850	3.5	4,000	450	—	4.5	11.5	5.8	4 I	12/-
	AC/L	4.0	1.0	200	− 13.5	17.0	2,350	4.25	6,300	675	760	7.0	7.2	6.1	5 A	7/6
	PX 41	4.0*	1.0	250	− 40.0	48.0	830	6.0	3,500	2,500	830	—	—	—	4 A	9/6
	PX 5	4.0*	2.0	400	− 34.0	62.5	1,480	6.5	3,000	5,750	530	—	—	—	4 A	20/-
LISSEN ..	P 220	2.0*	0.2	150	− 13.5	7.6	4,000	1.75	10,000	160	—	—	—	—	4 A	6/-
	PX 240 ..	2.0*	0.4	200	− 32.0	25.0	1,500	3.0	5,000	800	—	—	—	—	4 A	10/-
MARCONI and OSRAM	L 12	2.0*	0.06	45	− 4.5	1.9	6,000	0.8	10,000	12	—	2.0	1.6	4.0	Sm. 4 A	15/-
	LP 2	2.0*	0.2	150	− 4.5	11.5	3,900	3.85	7,000	150	—	—	—	—	4 A	6/-
	P 2	2.0*	0.2	150	− 10.5	19.0	2,150	3.5	4,500	300	—	—	—	—	4 A	10/-
	ML 4	4.0	1.0	200	− 9.0	20.0	2,860	4.2	7,000	500	400	—	—	—	5 A	10/-
	PX 4	4.0*	1.0	300	− 42.0	50.0	830	6.0	4,000	3,500	950	—	—	—	4 A	9/6
	PX 25	4.0*	2.0	400	− 31.0	62.5	1,265	7.5	3,200	5,500	530	—	—	—	4 A	20/-
	PX 25 A ..	4.0*	2.0	400	− 100.0	62.5	580	6.9	{ 4,800 2,800†	8,400 } 32,000† }	1,600	—	—	—	4 A	25/-
	DA 30	4.0*	2.0	500	− 134.0	60.0	580	6.9	3,400†	44,000†	—	—	—	—	4 A	25/-
	DA 60	6.0*	4.0	500	− 135.0	120.0	835	3.0	3,000	10,000	1,150	—	—	—	Lg. 4 A	110/-
	DA 100 ..	6.0*	2.7	1,000	− 149.0	100.0	1,410	3.9	6,700	30,000	1,490	—	—	—	Lg. 4 A	168/-
	DA 250 ..	10.0*	2.0	2,500	− 130	100.0	2,290	7.0	12,000	800,000†	—	—	—	—	Special	336/-
MAZDA ..	P 220	2.0*	0.2	150	− 7.0	5.5	3,700	3.4	10,000	160	—	—	—	—	4 A	6/-
	P 220 A ..	2.0*	0.2	150	− 14.0	15.0	1,850	3.5	4,100	350	—	—	—	—	4 A	10/-
	PA 20	2.0*	2.0	300	− 36.0	48.0	1,000	6.5	3,000	4,200	750	—	—	—	4 A	9/6
	ACP	4.0	1.0	200	− 13.5	17.0	2,650	3.75	6,000	650	800	—	—	—	5 A	7/6
	ACP 1	4.0	1.0	200	− 28.0	24.0	1,450	3.7	5,000	1,000	1,200	—	—	—	5 A	9/6
	ACP 4	4.0	1.0	600	− 29.0	6.0	2,850	7.0	—	—	—	—	—	—	5 L	17/6
	PP 3/250 ..	4.0*	1.0	300	− 37.0	48.0	1,000	6.5	3,000	4,200	775	—	—	—	4 A	9/6
	PP 5/400 ..	4.0*	2.0	400	− 32.0	62.5	1,500	6.0	2,700	5,900	510	—	—	—	4 A	30/-
	P 41	4.0	0.95	250	− 11.8	16.0	2,100	8.0	—	—	—	—	—	—	8 G	9/6
	PP 3521 ..	35.0	0.2	200	− 25.0	70.0	600	10.0	2,000	2,300	360	—	—	—	7 R	9/6
MULLARD ..	PM 2	2.0*	0.2	135	− 10.5	6.0	4,400	1.7	9,000	150	—	—	—	—	4 A	6/-
	PM 2 A ..	2.0*	0.2	135	− 6.0	5.0	6,000	2.0	7,000	150	—	6.3	3.3	5.5	4 A	6/-
	PM 202 ..	2.0*	0.2	135	− 10.5	14.0	2,000	3.5	3,700	350	—	—	—	—	4 A	10/-
	AC 042	2.0*	2.0	300	− 38.0	50.0	1,200	5.0	2,300	3,500	760	8.8	5.0	14.0	4 A	9/6
	TT 4	4.0	1.0	250	− 16.0	20.0	3,300	3.2	10,000	500	800	7.0	3.7	3.4	5 A	10/-
	164 V	4.0	0.65	200	− 9.0	12.0	4,700	3.4	—	—	750	8.6	8.4	3.2	5 A	14/-
	AC 044	4.0*	1.0	300	− 38.0	50.0	1,200	5.0	2,300	3,500	760	8.8	5.0	14.0	4 A	9/6
	DO 24	4.0*	2.0	400	− 34.0	63.0	2,500	4.0	2,500	5,900	540	—	—	—	4 A	20/-
	DO 26	4.0*	2.0	400	− 92.0	63.0	950	3.8	3,000	7,500	1,500	—	—	—	4 A	20/-

TRIODE VALVES—(*Continued*) (AC Resistance less than 7,000 ohms.)

Type.		Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Grid.	Anode Current (mA.).	AC Resistance (ohms).	Mutual Conductance (mA/V.).	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
MULLARD, contd.	DO 25	6.0*	1.1	400	−112.0	63.0	800	3.75	4,000	7,000	1,780	—	—	—	4 A	30/-
	MZ 05–60 ..	6.0*	1.7	500	−120.0	120.0	940	3.2	2,000	11,000	1,000	7.0	10.0	9.0	Lg. 4 A	110/-
	MZ 1-100 ..	6.0*	2.7	1,000	−145.0	100.0	1,400	4.0	7,000	30,000	1,450	11.8	9.3	10.4	Lg. 4 A	126/-
	MZ 1–75 ..	10.0*	1.1	1,000	− 80.0	75.0	2,500	4.0	7,500	20,000	1,050	13.6	9.7	13.5	—	160/-
	MZ 2-250 ..	11.0*	2.5	2,000	−105.0	125.0	2,500	6.0	9,000	75,000	840	18.0	6.0	16.0	—	300/-
OSTAR-GANZ ..	U 920	100/250	0.024	200	− 7.0	7.0	3,700	3.0	10,000	750	1,000	—	—	—	5 A	13/6
	L 1525	100/250	0.024	200	− 20.0	20.0	1,850	3.0	5,000	900	1,000	—	—	—	5 A	13/9
	K 3560	100/250	0.024	200	− 50.0	60.0	500	6.0	1,200	2,500	800	—	—	—	5 A	19/6
	K 2050	100/250	0.024	200	− 70.0	40.0	1,000	5.0	2,700	2,500	800	—	—	—	5 A	19/6
TRIOTRON ..	YD 2	2.0*	0.2	150	− 4.5	6.0	3,600	3.5	10,000	350	—	—	—	—	4 A	6/-
	ZD 2	2.0*	0.15	150	− 18.0	7.0	4,200	1.2	13,000	150	—	—	—	—	4 A	6/-
	UD 2	2.0*	0.33	150	− 15.0	12.0	2,000	2.0	5,000	500	—	—	—	—	4 A	6/-
	E 235	2.0*	0.2	150	− 7.5	13.0	3,000	3.0	8,000	550	—	—	—	—	4 A	6/-
	E 430 N ..	4.0	1.0	200	− 16.0	12.0	7,000	1.3	10,000	350	1,000	7.0	5.0	1.5	5 A	7/6
	K 435/10 ..	4.0*	0.65	250	− 40.0	40.0	1,300	2.7	1,500	2,500	1,000	5.0	6.0	7.0	4 A	9/6
	K 480	4.0*	2.0	550	− 36.0	45.0	2,500	4.0	3,500	5,000	800	7.1	4.4	6.0	4 A	20/-
TUNGSRAM ..	P 215	2.0*	0.15	150	− 12.0	12.0	3,300	1.5	7,000	260	—	—	—	—	4 A	6/-
	SP 220	2.0*	0.2	150	− 12.0	14.0	2,200	3.0	6,700	360	—	—	—	—	4 A	6/-
	LP 220	2.0*	0.2	150	− 4.5	5.0	3,900	3.5	7,500	200	—	—	—	—	4 A	6/-
	P 12/250 ..	4.0*	1.0	250	− 33.0	48.0	830	6.0	2,400	2,750	700	—	—	—	4 A	9/6
	P 15/250 ..	4.0*	1.0	250	− 44.0	60.0	660	6.0	2,500	3,500	750	—	—	—	4 A	10/6
	O 15/400 ..	4.0*	1.0	500	− 37.0	40.0	1,800	4.5	6,000	3,500	900	—	—	—	4 A	10/6
	P 26/500 ..	4.0*	2.0	500	−102.0	62.5	530	7.0	5,000	6,300	1,600	—	—	—	4 A	17/6
	P 27/500 ..	4.0*	2.0	500	− 31.0	62.5	1,050	8.5	5,000	5,000	500	—	—	—	4 A	17/6
	P 30/500 ..	4.0*	2.0	500	−150.0	60.0	750	4.0	2,500	6,000	2,500	—	—	—	4 A	20/-
	P 25/500 ..	6.0*	1.1	500	−104.0	65.0	1,000	3.0	4,500	5,000	1,600	—	—	—	4 A	20/-
	P 60/500 ..	6.0*	4.0	600	−110.0	130.0	1,000	3.5	2,600	15,000	1,000	—	—	—	Lg. 4 A	67/6
	P −100/1,000 ..	6.0*	2.7	1,000	−146.0	100.0	1,400	4.0	6,700	30,000	1,500	—	—	—	Lg. 4 A	120/-
	P 25/450 ..	7.5*	1.25	450	− 84.0	55.0	1,900	2.1	4,300	4,600	1,500	—	—	—	4 A	20/-
	P 28/500 ..	7.5*	1.25	500	− 50.0	48.0	3,700	2.2	8,000†	50,000†	—	—	—	—	4 A & A 4 A	17/6
AMERICAN ..	31	2.0*	0.13	135	− 22.5	8.0	4,100	0.925	7,000	185	—	3.5	2.7	5.7	A 4 A	—
	45	2.5*	1.5	275	− 56.0	36.0	1,700	2.05	4,600	2,000	1,550	4.0	3.0	7.0	A 4 A	—
	2 A 3	2.5*	2.5	250	− 45.0	60.0	800	5.25	2,500	3,500	750	9.0	4.0	13.0	A 4 A	—
	2 B 6 (DT) ..	2.5	2.25	250	− 24.0	40.0	5,150	3.5	5,000	4,000	600	—	—	—	A 7 D	—
	6 D 5	6.3	0.7	275	− 40.0	31.0	2,250	2.1	7,200	1,400	1,300	—	—	—	A 8 F	—
	6 B 5 & 6 N 6 G††	6.3	0.8	300	6	45.0	—	—	7,000	4,000	—	—	—	—	A 6 E & A 8 W	—
	6 A 3 & 6 B 4 G	6.3*	1.0	250	− 45.0	60.0	800	5.25	2,500	3,200	—	—	—	—	A 4 A & A 8 V	—
	6 E 6††	6.3	0.6	250	− 27.5	18.0	3,500	1.7	14,000	1,600	—	—	—	—	A 7 E	—
	6 A 5 G ..	6.3	1.25	250	− 45.0	60.0	800	5.25	2,500	3,750	750	7.0	5.0	16.0	A 8 G	—

OUTPUT TETRODE AND PENTODE VALVES

Type.		Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen.	Volts. Grid.	Current (mA.). Anode.	Current (mA.). Screen.	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
BRIMAR ..	Pen B 1	2.0*	0.2	150	150	− 4.5	8.1	1.8	18,000	500	—	—	—	—	5 F	9/-
	Pen A 1	4.0*	1.0	250	250	−16.0	32.0	7.0	8,000	2,850	450	—	—	—	5 G	10/6
	7 A 2	4.0	1.2	250	250	−17.0	32.0	8.0	8,000	3,200	330	—	—	—	7 J	10/6
	7 A 3	4.0	2.0	250	250	− 6.0	32.0	8.0	8,500	4,000	140	—	—	—	7 J	10/6
	7 D 8	13.0	0.2	250	250	− 6.0	32.0	8.0	8,500	4,000	140	—	—	—	7 J	10/6
	7 D 5	13.0	0.35	250	250	−16.5	34.0	6.5	7,000	3,000	410	—	—	—	7 J	10/6
	7 D 6	40.0	0.2	250	250	− 6.0	32.0	8.0	8,500	4,000	140	—	—	—	7 J	10/6
	7 D 3	40.0	0.2	180	135	−20.1	38.0	7.5	5,000	2,750	440	—	—	—	7 J	10/6

OUTPUT TETRODE AND PENTODE VALVES—(*Continued*)

	Type	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen.	Volts. Grid.	Current (mA.) Anode.	Current (mA.) Screen.	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.) Input.	Capacities (mmfds.) Output.	Capacities (mmfds.) Grid-Anode.	Base.	Price.
COSSOR	220 OT (T)	2.0*	0.2	150	150	− 4.5	9.5	2.0	20,000	500	—	8.0	4.0	1.0	5 F	9/-
	230 PT	2.0*	0.3	150	150	−15.0	14.0	3.0	10,000	1,000	—	—	—	—	5 F	16/6
	220 PT	2.0*	0.2	150	150	− 9.0	19.0	4.0	7,500	1,000	—	10.5	11.5	—	5 F	13/6
	220 HPT	2.0*	0.2	150	150	− 4.5	8.0	1.5	10,000	500	—	10.5	11.0	—	5 F	9/-
	MP Pen	4.0	1.0	250	250	−16.0	30.0	6.0	10,000	3,500	450	14.0	12.0	—	7 J	13/6
	42 MP Pen	4.0	2.0	250	250	− 5.5	32.0	6.0	8,000	3,100	140	15.5	12.0	1.3	7 J	10/6
	PT 41	4.0*	1.0	250	200	−12.5	30.0	6.0	8,000	2,600	350	—	—	—	5 F	10/6
	PT 41 B	4.0*	1.0	400	300	−40.0	30.0	6.0	8,000	3,600	1,200	—	—	—	5 F	22/6
	42 OTDD (T) (DD) ..	4.0	2.0	250	250	− 5.5	34.0	7.0	6,500	3,100	130	—	—	—	7 I	12/6
	42 OT (T)	4.0	2.0	250	250	− 5.5	34.0	7.0	6,500	3,100	130	15.5	5.0	1.3	7 J	10/6
	402 OT (T) & 402 Pen	40.0	0.2	250	250	−12.0	32.0	6.0	8,000	2,500	310	11.5	6.0	0.7	7 Q	10/6
	40 PPA	40.0	0.2	150	150	−25.0	36.0	6.0	4,000	2,300	600	—	—	—	7 J	10/6
	402 Pen A	40.0	0.2	150	150	− 9.0	56.0	11.0	2,500	3,000	130	16.5	15.0	—	7 Q	10/6
DARIO	TC 432	2.0*	0.2	150	150	− 4.5	9.5	2.0	15,000	420	—	—	—	—	4 G & 5 F	9/-
	TE 434	4.0*	1.1	250	250	−14.0	36.0	7.0	8,000	3,400	325	9.0	14.0	1.1	5 F	10/6
	TE 534	4.0	1.1	250	250	−15.0	24.0	7.0	10,000	2,500	500	7.0	7.0	1.2	5 G	10/6
	TE 634	4.0	1.35	250	250	−22.0	36.0	9.0	8,000	3,400	500	8.0	9.0	1.0	7 J	10/6
	TL 44	4.0	1.5	200	200	− 6.0	32.0	3.0	8,000	3,500	175	—	—	—	7 J	10/6
	TBL 44 (DD) ..	4.0	2.2	250	250	− 6.0	32.0	4.5	7,000	4,000	150	13.0	9.0	0.05	7 X	12/6
	TL 54	4.0	2.0	250	250	−12.5	70.0	7.0	3,500	8,500	175	14.0	10.0	1.0	7 J	12/-
	TB 4320	20.2	0.2	200	100	−19.0	40.0	5.0	7,000	3,500	400	—	—	1.1	Ct. 8 D	10/6
	TL 413	33.0	0.2	250	250	−13.0	36.0	4.5	4,500	4,000	320	—	—	1.2	7 J	10/6
EVER-READY ..	K 70 B	2.0*	0.15	135	135	− 4.5	5.6	1.35	19,000	340	—	8.5	13.0	1.0	5 F	9/-
	K 70 D	2.0*	0.3	135	135	− 2.4	5.0	0.8	24,000	300	—	11.0	11.0	1.15	5 F	9/-
	A 70 C	4.0	1.95	250	250	− 5.8	36.0	5.0	8,000	3,800	145	14.0	7.0	2.0	7 J	10/6
	A 70 B	4.0	1.35	250	250	−22.0	36.0	3.0	6,000	3,800	500	—	—	—	7 J	10/6
	A 70 D	4.0	1.95	250	250	− 5.8	36.0	5.0	8,000	3,800	145	14.0	7.0	2.0	7 J	10/6
	A 27 D	4.0	2.25	250	250	− 6.0	36.0	5.0	7,000	4,300	145	13.0	9.5	0.5	7 X	12/6
	A 70 E	4.0	2.1	250	275	−14.0	72.0	7.0	3,500	8,800	175	14.0	11.0	1.0	7 J	12/-
	C 70 D	35.0	0.2	200	200	− 9.0	40.0	6.0	4,000	3,100	165	14.9	10.7	1.2	7 J	10/6
FERRANTI ..	PT 4 D (DD) ..	4.0	2.0	250	250	− 6.0	32.5	7.0	6,500	3,500	150	12.0	18.0	0.7	7 I	12/6
HIVAC	XY	2.0*	0.14	100	100	− 6.0	5.5	1.1	15,000	200	—	—	—	—	Sm. 5 A	15/6
	Y 220 (T)	2.0*	0.2	150	150	− 4.5	10.5	1.3	11,500	500	—	6.3	3.8	0.9	4 G or 5 J	9/-
	Z 220 (T)	2.0*	0.2	150	150	− 6.0	18.0	2.1	7,500	1,000	—	6.1	3.8	0.8	4 G or 5 J	9/6
	Y 230 (T)	2.0*	0.3	150	150	− 3.0	7.0	1.0	20,000	400	—	8.4	5.1	1.1	5 J	9/-
	AC/Y (T)	4.0	1.0	250	250	−10.0	32.0	4.3	6,500	3,000	300	7.9	4.8	1.6	5 G or 7 J	10/6
	AC/Z (T)	4.0	2.0	250	250	− 5.5	32.0	4.3	6,500	3,000	160	10.2	5.0	1.5	5 G or 7 J	10/6
	AC/ZDD (T) (DD) ..	4.0	2.0	250	250	− 5.5	32.0	4.3	6,500	3,000	160	9.9	4.3	0.8	7 I	12/6
	FY (T)	4.0*	1.0	250	250	−10.0	32.0	6.0	6,000	3,000	250	7.6	4.8	1.6	5 J	10/6
	AC Q (T)	4.0	1.35	375	250	−22.0	57.0	2.5	4,000	11,500	370	—	—	—	7 J	12/-
	Y 13 (T)	13.0	0.3	250	250	−22.0	35.0	4.5	4,000	3,000	550	7.6	4.8	1.5	7 J	11/6
	Z 26 (T)	26.0	0.3	250	250	− 5.5	32.0	4.3	6,500	3,000	160	9.8	4.9	1.5	7 J	11/6
LISSEN	PT 240	2.0*	0.4	200	150	−10.5	16.0	3.0	12,500	1,000	—	—	—	—	5 F	9/-
	PT 225	2.0*	0.2	150	150	− 6.0	8.0	2.0	18,700	400	—	—	—	—	4 G or 5 F	9/-
	PT 2 A	2.0*	0.2	150	150	−10.5	18.0	3.0	8,500	1,100	—	—	—	—	4 G or 5 F	9/-
	ACPT	4.0	1.25	250	200	− 8.0	31.0	4.0	7,500	3,000	240	—	—	—	5 G	10/6
MARCONI and OSRAM	KT 2 (T)	2.0*	0.2	150	150	− 4.5	9.5	1.9	20,000	500	—	11.3	13.1	1.6	5 F	9/-
	KT 21 (T)	2.0*	0.3	150	120	− 2.5	5.3	1.1	19,000	460	—	12.0	9.9	1.14	5 F	9/-
	MKT 4 (T)	4.0	1.0	250	200	−11.0	32.0	5.0	8,000	2,800	300	11.0	9.1	0.8	7 J	10/6
	KT 41 (T)	4.0	2.0	250	250	− 4.4	40.0	8.0	7,800	4,500	90	19.5	12.5	2.0	7 J	10/6
	KT 42 (T)	4.0	1.0	250	250	−16.5	34.0	5.5	7,000	3,250	420	9.8	9.0	0.8	7 J	10/6
	N 43	4.0	2.0	250	250	− 4.4	40.0	10.0	7,800	4,500	90	15.5	16.5	0.3	7 Q	25/-
	DN 41 (DD) ..	4.0	2.3	250	250	− 4.4	40.0	8.0	7,800	4,500	90	18.5	15.7	0.75	7 I	12/6
	PT 25 H	4.0*	2.0	400	400	−16.0	62.5	12.5	5,000	10,000	250	—	—	—	5 F	45/-
	KT 63 (T)	6.3	0.7	250	250	−16.5	34.0	5.5	7,000	3,000	420	9.8	9.0	0.8	A 8 P	10/6
	KT 66 (T)	6.3	1.27	250	250	−15.0	85.0	6.3	2,200	7,250	170	14.8	11.5	0.9	A 8 P	15/-
	KT 30 (T)	13.0	0.3	250	250	−12.0	40.0	7.0	7,500	2,700	260	—	—	—	7 J	13/6
	KT 31 (T)	{13.0 / 26.0}	{0.6 / 0.3}	200	180	− 4.4	40.0	10.6	5,500	2,500	87	19.0	11.0	0.7	7 T	13/6
	KT 32 (T)	26.0	0.3	135	135	− 7.6	75.0	5.0	1,300	3,500	95	21.0	11.5	1.0	A 8 P	12/-
	KT 33 (T)	26.0	0.3	200	200	−13.2	60.0	10.0	3,000	5,000	188	—	—	—	A 8 P	12/-

OUTPUT TETRODE AND PENTODE VALVES—(*Continued*)

Type.		Heater.		Volts.			Current (mA.).		Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.).			Base.	Price.
		Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.				Input.	Output.	Grid-Anode.		
MAZDA	Pen 220	2.0*	0.2	150	150	− 4.5	10.0	2.0	14,000	600	—	—	—	—	5 F	9/-
	Pen 220 A	2.0*	0.2	150	150	− 9.0	18.0	3.6	6,000	1,100	—	—	—	—	5 F	13/6
	Pen 231	2.0*	0.3	120	120	− 2.5	5.0	1.0	19,000	370	—	—	—	—	5 F	9/-
	Pen 24	2.0*	0.3	120	120	− 3.3	5.0	1.0	15,000	440	—	—	—	—	8 C	9/-
	Pen 25	2.0*	0.15	120	120	− 3.6	5.0	1.0	14,000	400	—	—	—	—	8 C	9/-
	AC/Pen	4.0	1.0	250	250	−15.5	32.0	6.0	7,500	3,400	400	—	—	—	7 J	10/6
	AC 2/Pen	4.0	1.75	250	250	− 5.3	32.0	6.0	6,700	3,500	140	—	—	—	7 J	10/6
	AC 2/Pen DD (DD)	4.0	2.0	250	250	− 5.3	32.0	6.0	6,700	3,500	140	—	—	—	7 I	12/6
	AC 4/Pen (T)	4.0	1.75	250	250	− 8.75	64.0	13.0	3,400	7,000	114	—	—	—	7 J	12/-
	AC 5/Pen & Pen 45 (T)	4.0	1.75	250	250	− 8.5	40.0	7.5	5,200	4,850	175	22.75	12.25	0.85	7 J & 8 J	10/6
	AC 5/Pen DD & Pen 45 DD (T, DD)	4.0	2.0	250	250	− 8.5	40.0	7.5	5,200	4,850	175	19.5	12.75	0.7	7 I & 8 L	12/6
	AC 6/Pen (T)	4.0	1.75	300	200	− 7.6	60.0	12.0	—	—	90	22.0	7.0	1.0	7 AC	12/-
	Pen 1340	13.0	0.4	250	250	− 9.0	41.0	8.0	5,500	4,000	185	—	—	—	7 J	13/6
	Pen DD 1360 (DD)	13.0	0.6	250	250	− 5.3	32.0	6.0	6,700	3,500	140	—	—	—	7 I	16/-
	Pen 3520	35.0	0.2	250	250	−11.8	40.0	8.0	5,500	3,700	250	—	—	—	7 J	20/6
	Pen 3820 & Pen 383 (T)	38.0	0.2	160	175	−10.0	64.0	13.0	2,600	3,750	130	—	—	—	7 J & 8 J	10/6
	Pen DD 4020 (DD)	40.0	0.2	250	250	− 8.0	40.0	8.0	5,300	3,800	165	—	—	—	7 I	12/6
	Pen DD 4021 & Pen DD 453 (DD)	40.0	0.2	160	175	−10.0	64.0	13.0	2,600	3,750	130	—	—	—	7 I & 8 L	12/6
MULLARD	PM 22 A	2.0*	0.15	135	135	− 4.5	5.6	1.35	19,000	340	—	8.5	13.0	<1.0	5 F & 4 G	9/-
	PM 22	2.0*	0.3	135	135	− 9.0	13.0	3.5	8,000	600	—	—	—	—	5 F & 4 G	16/6
	PM 22 C	2.0*	0.3	135	135	−16.0	23.0	—	5,000	1,450	—	—	—	—	5 F	13/6
	PM 22 D	2.0*	0.3	135	135	− 2.4	5.0	0.8	24,000	300	—	11.0	11.0	1.15	5 F	9/-
	Pen 4 VA	4.0	1.35	250	250	−22.0	36.0	3.0	6,000	3,800	500	—	—	—	7 J & 5 G	10/6
	Pen A 4 & Pen 4 VB	4.0	1.95	250	250	− 5.8	36.0	5.0	8,000	3,800	145	14.0	7.0	2.0	7 J	10/6
	PM 24 M	4.0*	1.1	250	250	−17.0	30.0	5.6	7,000	2,800	480	—	—	—	5 F	10/6
	PM 24 E	4.0*	2.0	500	200	−35.0	50.0	9.0	7,000	10,000	750	—	—	—	5 F	45/-
	Pen B 4	4.0	2.1	250	275	−14.0	72.0	7.0	3,500	8,800	175	14.0	11.0	<1.0	7 J	12/-
	Pen 4 DD (DD)	4.0	2.25	250	250	− 6.0	36.0	5.0	7,000	4,300	145	13.0	9.5	<0.5	7 X	12/6
	Pen 428	4.0	2.1	375	275	—	48.0	5.0	6,500†	28,000†	165†	—	—	—	7 J	25/-
	EL 2	6.3	0.2	250	250	−18.0	32.0	5.0	8,000	3,600	500	—	—	—	Ct. 8 D	10/6
	EL 3	6.3	1.2	250	265	− 6.6	36.0	4.5	7,000	4,500	163	—	—	—	Ct. 8 M	10/6
	EL 6	6.3	1.3	250	250	− 7.0	72.0	8.5	3,500	8,500	85	—	—	0.35	Ct. 8 M	12/-
	EBL 1 (DD)	6.3	1.5	250	250	− 6.0	36.0	5.0	7,000	4,300	150	—	—	—	Ct. 8 N	12/6
	Pen 26	24.0	0.2	200	100	−19.0	40.0	5.0	5,000	3,000	420	—	—	—	Ct. 8 D	10/6
	Pen 36 C	35.0	0.2	200	200	− 9.0	40.0	6.0	4,000	3,100	165	14.9	10.7	<1.2	7 J	10/6
OSTAR-GANZ	PT 3	100/250	0.024	250	250	−16.0	25.0	5.0	7,000	2,000	500	—	—	—	C 7 F	16/-
	M 43	100/250	0.037	250	200	−26.0	40.0	4.0	5,000	3,500	500	—	—	—	C 7 F	16/9
	M 44	100/250	0.037	250	200	− 7.5	40.0	5.0	5,000	3,000	160	—	—	—	C 7 F	17/6
TRIOTRON	P 225	2.0*	0.2	150	150	− 4.5	9.5	2.0	15,000	500	—	—	—	—	4 G & 5 F	9/-
	P 435	4.0*	1.1	250	250	−14.0	36.0	5.0	7,000	2,800	400	9.0	14.0	1.1	5 F	10/6
	P 440 N	4.0	1.1	250	250	−15.0	24.0	5.0	7,500	2,000	500	7.0	7.0	1.2	5 G & 7 O	10/6
	P 441 N	4.0	1.35	250	250	−22.0	36.0	3.2	9,000	2,800	540	8.0	9.0	1.0	7 O	10/6
	P 496	4.0	1.5	200	200	− 6.0	32.0	3.0	8,000	3,500	175	—	—	—	7 O	10/6
	DP 495 (DD)	4.0	2.25	250	250	− 6.0	36.0	—	—	—	—	—	—	—	7	12/6
	P 2060	20.0	0.2	200	100	−19.0	40.0	5.0	7,000	3,500	400	—	—	1.1	Ct. 8 D	10/6
	P 3580	33.0	0.2	250	250	−23.0	36.0	4.5	4,500	4,000	—	—	—	1.2	7 O	10/6
	DP 4480 (DD)	44.0	0.2	200	200	− 8.5	45.0	—	—	—	—	—	—	—	7	12 6
TUNGSRAM	PP 215 & PP 215 S	2.0*	0.15	90	90	− 4.5	8.0	1.2	14,000	200	—	—	—	—	5 F & Ct. 8 X	9/-
	PP 222	2.0*	0.22	150	150	− 6.0	9.0	2.0	14,000	600	—	—	—	—	4 G & 5 F	9/-
	PP 225 & PP 225 S	2.0*	0.265	135	135	−12.0	18.0	2.0	6,000	800	—	—	—	—	5 F & Ct. 8 X	9/-
	PP 2 & PP 2 S	2.0*	0.14	135	135	− 5.0	7.0	1.0	19,000	440	—	—	—	—	4 G & 5 F & Ct. 8 X	9/-
	PP 4	4.0*	1.1	250	250	−15.0	36.0	6.0	7,500	3,100	400	—	—	—	5 F	10/6
	APP 4 A	4.0	1.2	250	250	−16.5	36.0	6.0	7,000	3,500	400	—	—	—	5 G & 7 J	10/6
	APP 4 B	4.0	2.0	250	250	− 5.0	36.0	4.0	7,000	3,600	140	—	—	—	7 J	10/6
	APP 4 C	4.0	2.0	250	250	− 5.0	36.0	4.0	7,000	3,600	140	—	—	—	7 O	10/6
	APP 4 E	4.0	2.0	375	275	−13.5	72.0	8.0	3,500	8,800	175	—	—	—	7 O	12/-
	APP 4 g (SW)	4.0	2.0	250	250	− 6.0	36.0	4.0	7,000	3,600	150	—	—	—	7 E	15/-

OUTPUT TETRODE AND PENTODE VALVES—(*Continued*)

	Type.	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen.	Volts. Grid.	Current (mA.). Anode.	Current (mA.). Screen.	Optimum Load (ohms).	Power Output (mW.).	Bias Resistance (ohms).	Capacities (mmfds.). Input.	Capacities (mmfds.). Output.	Capacities (mmfds.). Grid-Anode.	Base.	Price.
TUNGSRAM —cont.	DDPP 4 B & DDPP 4 M (DD)	4.0	2.0	250	250	−5.0	36.0	4.0	7,000	3,600	150	—	—	—	7 I & 7 X	12/6
	APP 4 g*	4.0	2.0	250	250	−6.0	36.0	4.0	7,000	3,600	150	—	—	—	7 Q	15/-
	EBL 1 (DD)	6.3	1.4	250	250	−6.0	36.0	4.0	7,000	3,600	150	—	—	—	Ct. 8 N	12/6
	EL 2	6.3	0.2	250	250	−18.0	32.0	5.0	8,000	3,600	480	—	—	—	Ct. 8 D	10/6
	EL 3	6.3	1.2	250	250	−7.0	36.0	4.5	7,000	4,500	175	—	—	—	Ct. 8 M	10/6
	EL 5	6.3	1.2	250	275	−14.0	72.0	7.0	3,500	8,800	175	—	—	—	Ct. 8 M	13/6
	EL 6	6.3	1.4	250	250	−7.0	72.0	8.5	3,500	8,200	85	—	—	—	Ct. 8 M	12/-
	ELL 1‡‡	6.3	0.45	250	275	−21.5	16.5	5.8	16,000	5,400	600	—	—	—	Ct. 8 U	12/-
	PP 24 & PP 24 S	24.0	0.2	200	100	−19.0	40.0	5.0	5,000	3,200	400	—	—	—	7 Q & Ct. 8 D	10/6
	DDPP 39 & DDPP 39 M (DD)	35.0	0.2	200	200	−8.0	45.0	6.0	4,400	3,200	170	—	—	—	7 I & 7 X	12/6
	PP 35, PP 34, & PP 34 S	35.0	0.2	200	200	−6.5	45.0	5.0	4,400	3,200	170	—	—	—	7 J, 7 Q, Ct. 8 D	10/6
	PP 36	35.0	0.2	200	200	−6.5	45.0	5.0	5,000	3,200	170	—	—	—	7 O	10/6
	PP 37 & CL 6	35.0	0.2	200	100	−9.5	45.0	5.0	4,500	3,500	190	—	—	—	7 Q & Ct. 8 D	10/6
AMERICAN	33	2.0*	0.26	135	135	−13.5	14.5	3.0	7,000	700	—	8.0	12.0	1.0	A 5 C	—
	1 F 4 & 1 F 5 G	2.0*	0.12	135	135	−4.5	8.0	2.6	16,000	340	—	—	—	—	A 5 C & A 8 Y	—
	950	2.0*	0.12	135	135	−16.5	7.0	2.0	13,500	450	—	—	—	—	A 5 C	—
	1 E 7 G†††	2.0*	0.24	135	135	−7.5	6.5	2.0	24,000	650	—	—	—	—	A 8 Z	—
	1 G 5 G	2.0*	0.12	90	90	−6.0	8.5	2.7	8,500	300	—	—	—	—	A 8 Y	—
	1 J 5 G	2.0*	0.12	135	135	−16.5	7.0	2.0	13,500	450	—	—	—	—	A 8 Y	—
	47	2.5	1.75	250	250	−16.5	31.0	6.0	7,000	2,700	450	8.6	13.0	1.2	A 5 C	—
	59	2.5	2.0	250	250	−18.0	35.0	9.0	6,000	3,000	400	—	—	—	A 7 F	—
	2 A 5	2.5	1.75	250	250	−16.5	34.0	6.5	7,000	3,000	400	—	—	—	A 6 H	—
	38	6.3	0.3	250	250	−25.0	22.0	3.8	10,000	2,500	1,000	3.5	7.5	0.3	A 5 E	—
	41 & 6 K 6 G	6.3	0.4	250	250	−18.0	32.0	5.5	7,600	3,400	475	—	—	—	A 6 H & A 8 H	—
	42	6.3	0.7	250	250	−16.5	34.0	6.5	7,000	3,000	400	—	—	—	A 6 H	—
	89	6.3	0.4	250	250	−25.0	32.0	5.5	6,750	3,400	650	—	—	—	A 6 I	—
	6 A 4 and LA	6.3*	0.3	180	180	−12.0	22.0	3.9	8,000	1,400	465	—	—	—	A 5 C	—
	6 F 6	6.3	0.7	315	315	−22.0	42.0	8.0	7,000	5,000	440	—	—	—	A 8 H	—
	6 L 6 (T)	6.3	0.9	300	200	−12.0	51.0	3.0	4,500	6,500	220	—	—	—	A 8 H	—
	6 Y 6 G	6.3	1.25	135	135	−13.5	58.0	3.0	2,000	3,600	220	—	—	—	A 8 H	—
	6 V 6 G	6.3	0.45	250	250	−12.5	45.0	4.5	5,000	4,250	—	—	—	—	A 8 H	—
	6 G 6 G	6.3	0.15	180	180	−9.0	15.0	2.5	10,000	1,100	400	—	—	—	A 8 H	—
	6 K 6 G	6.3	0.4	250	250	−18.0	32.0	5.5	7,600	3,400	480	—	—	—	A 8 H	—
	12 A 5	12.6	0.3	180	180	−27.0	40.0	9.0	4,500	2,800	550	—	—	—	A 7 G	—
	12 A 7	12.6	0.3	135	135	−13.5	9.0	2.5	13,500	550	—	—	—	—	A 7 C	—
	43	25.0	0.3	135	135	−20.0	34.0	7.0	4,000	2,000	500	—	—	—	A 6 H	—
	25 A 6	25.0	0.3	180	135	−20.0	40.0	8.0	5,000	2,750	400	—	—	—	A 8 H	—
	25 B 6	25.0	0.3	95	95	−15.0	45.0	4.0	2,000	1,750	300	—	—	—	A 8 H	—
	48	30.0	0.4	125	100	−20.0	56.0	9.5	1,500	2,500	300	—	—	—	A 6 H	—
	25 L 6 G	26.0	0.3	110	110	−7.0	50.0	3.5	2,000	—	130	—	—	—	A 8 H	—
	25 A 7 G	25.0	0.3	100	100	−15.0	20.5	4.0	4,500	770	—	—	—	—	A 8 AH	—

QUIESCENT OUTPUT VALVES

	Type.	Heater. Volts.	Heater. Amps.	Volts. Anode.	Volts. Screen	Volts. Grid.	Current (mA.). No-signal Anode.	Current (mA.). No-signal Screen.	Current (mA.). Average.	Input Impedance (ohms).	Optimum Load (ohms).	Power Output (mW.).	Base.	Price.
COSSOR	220 B (B)	2.0*	0.2	120	—	0	2.5	—	6.0	3,000	12,000	1,100	7 K	9/6
	240 B (B)	2.0*	0.4	120	—	0	4.0	—	8.5	2,500	8,000	2,000	7 K	9/6
	240 QP (QPP)	2.0*	0.4	150	150	−12.0	3.0	0.7	6.0	∞	24,000	1,250	7 L	12/6
DARIO	TB 402 (B)	2.0*	0.2	150	—	0	3.0	—	6.0	4,000	14,500	1,500	7 K	9/6
	BLL 32 (Q)	2.0*	0.44	135	135	−10.5	2.5	—	4.0	∞	15,500	1,350	9 D	12/6

QUIESCENT OUTPUT VALVES—(*Continued*)

	Type	Heater.		Volts.			Current (mA.).			Input Impedance (ohms).	Optimum Load (ohms).	Power Output (mW.).	Base.	Price.
							No-Signal							
		Volts.	Amps.	Anode.	Screen.	Grid.	Anode.	Screen.	Average.					
EVER-READY ..	K 77 A (Q)	2.0*	0.45	135	135	−10.5	2.5	—	4.0	∞	16,000	1,400	9 D	12/6
	K 33 A (B)	2.0*	0.2	135	—	0	3.0	—	4.2	4,000	14,000	1,250	7 K	9/6
	K 33 B (B)	2.0*	0.2	135	—	− 4.5	3.0	—	3.8	4,000	14,000	1,450	7 K	9/6
HIVAC	B 230 (B)	2.0*	0.3	150	—	0	2.5	—	5.5	4,000	14,500	1,250	7 K	9/6
	QP 240 (Q)	2.0*	0.4	150	150	−18.0	8.0	1.2	14.0	∞	14,500	1,400	7 L	12/6
LISSEN	BB 240 A (B)	2.0*	0.4	150	—	− 3.0	5.0	—	7.0	8,000	8,000	3,500	7 K	9/6
	B 2	2.0*	0.1	120	—	—	2.0†	—	—	—	14,000†	1,200†	4 A	6/–
MARCONI and OSRAM	B 21 (B)	2.0*	0.2	150	—	− 6.0	2.2	—	7.5	36,000	12,000	2,000	7 K	12/6
	QP 21 (Q)	2.0*	0.4	150	150	− 9.0	3.0	—	6.0	∞	24,000	1,200	7 L	12/6
MAZDA	PD 220 (B)	2.0*	0.2	150	—	− 1.15	0.8	—	7.0	3,300	11,500	2,850	7 K	11/–
	PD 220 A (B)	2.0*	0.2	150	—	− 6.0	2.5	—	7.5	7,000	10,000	2,900	7 K	11/–
	QP 240 (Q)	2.0*	0.4	150	130	−11.5	4.0	0.8	6.0	∞	15,000	2,250	9 D	17/6
	QP 230 (Q)	2.0*	0.3	120	120	− 9.6	4.65	0.95	—	∞	17,000	850	7 L	12/6
	PA 40 (Q)	4.0*	2.0	450	—	−96.5	110.0†	—	—	∞	4,000†	43,000†	4 A	20/–
MULLARD ..	PM 2 B (B)	2.0*	0.2	135	—	0	3.0	—	4.2	4,000	14,000	1,250	7 K	9/6
	PM 2 BA (B)	2.0*	0.2	135	—	− 4.5	3.0	—	3.8	4,000	14,000	1,450	7 K	9/6
	QP 22 A (Q)	2.0*	0.45	135	135	−10.5	2.5	—	4.0	∞	16,000	1,400	9 D	12/6
	QP 22 B (Q)	2.0*	0.3	120	120	− 9.6	4.65	1.15	—	∞	16,000	850	7 L	12/6
TRIOTRON ..	E 220 B (B)	2.0*	0.2	150	—	0	3.0	—	7.0	6,500	18,000	1,350	7 K	9/6
TUNGSRAM ..	CB 220 (B)	2.0*	0.25	150	—	−3.0	2.5	—	15.0	4,000	10,000	2,000	7 K	9/6
	CB 215 & CB 215 S (B)	2.0*	0.22	135	—	0	2.0	—	12.0	—	10,000	1,700	7 K & Ct. 8 Y	9/6
AMERICAN ..	19 & 1 J 6 G (B) ..	2.0*	0.26	135	—	0	5.0	—	—	—	10,000	2,100	A 6 G & A 8 X	—
	49 (B) (T)	2.0*	0.12	180	—	0	4.0†	—	—	—	12,000†	3,500†	A 5 D	—
	53 (B)	2.5	2.0	300	—	0	35.0	—	—	—	10,000	10,000	A 7 E	—
	46 (B) (T)	2.5*	1.75	400	—	0	12.0†	—	—	—	5,800†	20,000†	A 5 D	—
	79 & 6 Y 7 G (B) ..	6.3	0.6	250	—	0	10.6	—	—	—	14,000	8,000	A 6 F & A 8 N	—
	6 A 6 & 6 N 7 (B) ..	6.3	0.8	300	—	0	35.0	—	—	—	10,000	10,000	A 7 E & A 8 N	—
	6 Z 7 G (B)	6.3	0.63	180	—	0	8.4	—	—	—	12,000	4,200	A 8 N	—

RECTIFYING VALVES

	Type.	Filament		Type of Rectification.	Max. Anode Volts (RMS).	Max. Rect. Current (mA.).	Unsmoothed Rect. Volts at		Base.	Price.
		Volts.	Amps.				Full-current.	Half-current.		
BRIMAR	R 1	4.0	1.0	FW	250—0—250	60	260	290	4 E	9/–
	R 2	4.0	2.5	FW	350—0—350	120	360	410	4 E	9/–
	R 3	4.0	2.5	FW	500—0—500	120	610	640	4 E	9/–
	1 D 5	40.0	0.2	HW	250	75	265	300	5 I	9/–
COSSOR	506 BU	4.0*	1.0	FW	250—0—250	60	230	270	4 E	9/–
	442 BU	4.0*	2.5	FW	350—0—350	120	350	400	4 E	9/–
	460 BU	4.0*	2.5	FW	500—0—500	120	520	600	4 E	9/–
	40 SUA	40.0	0.2	HW	250	75	205	280	5 I	9/–
	43 IU	4.0	2.5	FW	350—0—350	120	360	400	4 E	9/–
	44 IU	4.0	2.5	FW	500—0—500	120	560	610	4 E	9/–
	4/100 BU	4.0*	2.5	FW	500—0—500	200	540	590	4 E	15/–
	405 BU	4.0*	5.0	FW	1,500—0—1,500	25	1,720	1,800	4 E	20/–
	225 DU	2.0*	0.5§	VD	750	20	2,000	—	7 Y	20/–
	SU 2150	2.0	1.15	HW	8,000	2	9,500	10,000	4 F	20/–
DARIO	SW 1	4.0*	1.0	HW	400	60	400	450	4 D	9/–
	FW 1	4.0*	1.0	FW	250—0—250	60	245	280	4 E	9/–
	FW 2	4.0*	1.0	FW	350—0—350	120	320	370	4 E	9/–
	TZ 34	4.0	2.0	FW	350—0—350	120	375	425	4 E	9/–
	FW 3	4.0*	2.0	FW	500—0—500	120	500	570	4 E	9/–

RECTIFYING VALVES—(Continued)

Type.		Filament. Volts.	Filament. Amps.	Type of Rectification.	Max. Anode Volts (RMS).	Max. Rect. Current (mA.).	Unsmoothed Rect. Volts at Full-current	Unsmoothed Rect. Volts at Half-current.	Base.	Price.
DARIO—cont.	1 FW 1	4.0	2.0	FW	500—0—500	120	500	570	4 E	9/-
	TW 1	20.0	0.2	HW	250	80	250	270	5 I	9/-
	TW 2	30.0	0.2	FW	125—0—125	120	125	150	5 H	9/-
EVER-READY	A 11 B	4.0	2.4	FW	350—0—350	120	395	418	4 E	9/-
	S 11 A	4.0	1.0	FW	250—0—250	60	250	275	4 E	9/-
	A 11 C	4.0	2.4	FW	500—0—500	120	550	600	4 E	9/-
	A 11 D	4.0	2.0	FW	350—0—350	120	380	430	4 E	9/-
	S 11 D	4.0	2.0	FW	350—0—350	120	385	425	4 E	9/-
	C 10 B	20.0	0.2	HW	250	75	210	265	5 I	9/-
FERRANTI	R 4	4.0*	2.5	FW	350—0—350	120	275	350	4 E	9/-
	GR 4	4.0*	3.0	FW, MV	350—0—350	350	330	380	4 E	25/-
HIVAC	UU 60/250	4.0	1.25	FW	300—0—300	75	310	360	4 E	8/6
	UU 120/350 A	4.0	2.5	FW	350—0—350	120	345	395	4 E	8/6
	UU 120/500	4.0	2.5	FW	500—0—500	120	530	595	4 E	9/-
	MR 1	4.0*	3.0	HW	1,000	250	1,100	1,220	4 D	20/-
	U 26	13.0 or 26.0	0.6 or 0.3	HW	250	75	175	240	7 M	9/-
				FW	250—0—250	120	230	270		
				VD	110	75	140	205		
	HVU 1	4.0	1.0	HW	6,000	3	6,250	7,500	4 F	15/-
LISSEN	U 650	6.0*	0.5	HW	300	40	300	350	4 D	10/6
MARCONI and OSRAM	U 10	4.0*	1.0	FW	250—0—250	60	260	300	4 E	9/-
	U 12	4.0*	2.5	FW	350—0—350	120	325	380	4 E	9/-
	MU 12	4.0	2.5	FW	350—0—350	120	340	410	4 E	9/-
	U 14	4.0*	2.5	FW	500—0—500	120	540	620	4 E	9/-
	MU 14	4.0	2.5	FW	500—0—500	120	540	600	4 E	9/-
	U 18	4.0*	3.75	FW	500—0—500	250	520	600	4 E	15/-
	U 16	2.0*	0.25	HW	5,000	2	6,800	7,000	4 F	15/-
	U 17	4.0*	1.0	HW	2,500	30	2,950	3,050	4 F	15/-
	GU 1	4.0*	[illegible]	HW, MV	1,000	250	1,100	1,150	4 D	25/-
	GU 5	4.0*	3.0	HW MV	1,500	250	1,270	1,300	4 F	25/-
	U 50	5.0*	2.0	FW	350—0—350	120	325	380	A 8 AE	9/-
	U 52	5.0*	3.0	FW	500—0—500	250	495	600	A 8 AE	15/-
	U 30	26.0	0.3	HW	180	120	136	175	7 M	9/-
				VD	220	75	425	480		
	U 31	26.0	0.3	HW	250	120	270	310	A 8 AC	9/-
MAZDA	UU 4	4.0	2.2	FW	350—0—350	120	370	415	4 E	9/-
	UU 5	4.0	2.3	FW	500—0—500	120	555	600	4 E	9/-
	U 4020	40.0	0.2	HW	250	120	265	300	5 I	9/-
	MU 2	2.0*	2.5	HW, MV	4,500	5	—	—	4 F	20/-
	U 21	2.0	1.65	HW	4,500	5	—	—	4 F	20/-
	UD 41	4.0	2.3	FW, VD	550	35	1,255	1,390	7 AA	20/-
	UU 6	4.0	1.35	FW	350—0—350	90	387	426	8 O	9/-
	UU 7	4.0	2.2	FW	350—0—350	120	370	415	8 O	9/-
	U 403	40.0	0.2	HW	250	120	265	300	8 M	9/-
MULLARD	1 W 2	4.0	1.2	FW	250—0—250	60	220	260	4 E	9/-
	DW 2	4.0*	1.0	FW	250—0—250	60	250	275	4 E	9/-
	1 W 3	4.0	2.4	FW	350—0—350	120	395	418	4 E	9/-
	DW 3	4.0*	2.0	FW	350—0—350	120	350	375	4 E	9/-
	1 W 4	4.0	2.4	FW	500—0—500	120	550	600	4 E	9/-
	1 W 4/350	4.0	2.0	FW	350—0—350	120	380	430	4 E	9/-
	DW 4/350	4.0*	2.0	FW	350—0—350	120	385	425	4 E	9/-
	AZ 1	4.0*	1.1	FW	300—0—300	100	285	325	Ct. 8 O	9/-
	AZ 2	4.0*	2.0	FW	500—0—500	120	—	—	Ct. 8 O	9/-
	AZ 3	4.0*	2.0	FW	350—0—350	120	380	430	Ct. 8 O	9/-
	RZ 1-150	4.0*	4.0	FW	1,000—0—1,000	150	1,100	1,200	4 E	60/-
	RG 1-125	2.0*	5.0	HW, (Gas)	1,400	125	1,250	—	Edison Screw	15/-
	RG 1-240	4.0*	2.7	HW, (Gas)	1,500	250	1,350	—	—	15/-
	HVR 1	2.0*	0.3	HW	6,000	5	5,400	6,900	4 F	20/-
	HVR 2	4.0	0.65	HW	6,000	3	6,200	7,500	4 F	20/-
	UR 1 C	20.0	0.2	HW	250	75	210	265	5 I	9/-
	UR 3	30.0	0.2	FW	250—0—250	120	270	310	Ct. 8 F	9/-

RECTIFYING VALVES—*(Continued)*

	Type.	Filament.		Type of Rectification.	Max. Anode Volts (RMS).	Max. Rect. Current (mA.).	Unsmoothed Rect. Volts at		Base.	Price.
		Volts.	Amps.				Full-current.	Half-current.		
OSTAR-GANZ ..	EG 50	100/250	0.024	HW	300	50	250	300	5 I	9/6
	EG 100	100/250	0.024	HW	300	120	200	300	5 I	12/9
	NG 100	100/250	0.044	2×HW	300	2×100	200	300	C 7 G	17/6
PHILIPS	1821	4.0*	1.0	FW	250—0—250	60	250	280	4 E	9/-
	1881	4.0	1.2	FW	250—0—250	60	250	285	4 E	9/-
	1881 A	4.0	2.4	FW	250—0—250	60	250	285	4 E	12/6
	1807	4.0*	2.0	FW	350—0—350	120	350	390	4 E	9/-
	1867	4.0	2.4	FW	350—0—350	120	350	395	4 E	9/-
	1561	4.0*	2.0	FW	500—0—500	120	500	585	4 E	9/-
	1861	4.0	2.4	FW	500—0—500	120	500	590	4 E	9/-
	CY 1 & CY 1 C	20.0	0.2	HW	250	75	210	265	Ct. 8 E & 5 I	9/-
	CY 2	20.0	0.2	FW	250—0—250	120	270	310	5 I	9/-
TRIOTRON ..	G 429	4.0*	0.3	HW	250	30	250	280	4 D	9/-
	G 470	4.0*	1.0	FW	300—0—300	75	300	350	4 E	9/-
	G 4120	4.0*	2.0	FW	350—0—350	120	—	—	4 E	9/-
	G 4120 N	4.0*	2.5	FW	350—0—350	120	—	—	4 E	9/-
	G 2080	20.0	0.2	HW	250	80	250	270	5 I & Ct. 8 E	9/-
	G 3060	30.0	0.2	2×HW	125	120	125	150	Ct. 8 F	9/-
	G 3412	33.0	0.18	2×HW	125	120	125	150	7 M	12/6
TUNGSRAM ..	PV 75/1000	2.2	4.0	FW	1,000	75	1,200	1,300	4 M	64/-
	RG 250/3000	2.5*	5.0	HW	3,000	250	—	—	A 4 F	20/-
	APV 4	4.0	2.0	FW	400—0—400	120	425	467	4 E	9/-
	RV 200/600	4.0*	2.0	FW	600—0—600	200	630	715	4 E	15/-
	RV 120/350 & RV 120/350S	4.0*	2.0	FW	350—0—350	120	350	390	4 E & Ct. 8 O	9/-
	RV 120/500 & RV 120/500S	4.0*	2.0	FW	500—0—500	120	500	600	4 E & Ct. 8 O	9/-
	RG 250/1000	4.0*	3.0	HW	1,000	250	1,100	1,150	4 D	20/-
	PV 100/2000	4.0	2.2	FW	2,000	100	2,900	2,950	—	100/-
	V-20/7000	4.0*	2.3	HW	7,000	20	—	—	4 F	16/-
	RG 1000/3000	5.0*	6.75	HW	3,000	1,000	—	—	—	40/-
	EZ 2	6.3	0.4	FW	350—0—350	60	350	400	Ct. 8 P	9/-
	EZ 3	6.3	0.65	FW	400—0—400	100	423	465	Ct. 8 P	9/-
	EZ 4	6.3	0.9	FW	400—0—400	175	380	450	Ct. 8 P	20/-
	PV B 6	6.3	0.6	FW	400—0—400	100	425	465	5 H	9/-
	PV 25	25.0	0.3	FW, VD	250	120	265	285	7 AE	9/-
	V 30	30.0	0.2	HW	275	120	265	285	5 I	9/-
	PV 30 & PV 30 S ..	30.0	0.2	FW, VD	275	60	265	285	7 AE & Ct. 8 F	9/-
	PV 29 & PV 29 S ..	30.0	0.2	FW, VD	125	120	133	150	7 AE & Ct. 8 F	9/-
AMERICAN ..	80	5.0*	2.0	FW	400—0—400	110	400	450	A 4 C	—
	81	7.5*	1.25	HW	700	85	—	—	A 4 D	—
	82	2.5*	3.0	FW, MV	500—0—500	125	—	—	A 4 C	—
	83	5.0*	3.0	FW, MV	500—0—500	250	—	—	A 4 C	—
	83-V & 5 V 4 G	5.0	2.0	FW	400—0—400	200	440	495	A 4 C & A 8 I	—
	84	6.3	0.5	FW	350—0—350	50	430	450	A 5 F	—
	5 Z 3 & 5 U 4 G & 5 X 4 G	5.0*	3.0	FW	500—0—500	250	480	550	A 4 C & A 8 A E & A 8 A F	—
	5 Z 4	5.0*	2.0	FW	400—0—400	125	450	510	A 8 I	—
	12 Z 3	12.6	0.3	HW	250	60	250	280	A 4 E	—
	25 Z 5	25.0	0.3	VD	125	100	—	—	A 6 J	—
	5 Y 3 & 5 Y 4 G	5.0*	2.0	FW	400—0—400	110	—	—	A 8 I & A 8 A F	—
	6 X 5	6.3	0.6	FW	350—0—350	75	—	—	A 8 K	—
	25 Z 6	25.0	0.3	VD	125	85	—	—	A 8 D	—
	5 W 4	5.0*	1.5	FW	350—0—350	110	—	—	A 8 I	—
	1-V	6.3	0.3	HW	350	50	380	440	A 4 E	—
	6 W 5 G	6.3	0.9	FW	350—0—350	100	—	—	A 8 K	—
	5 T 4	5.0	2.0	FW	450—0—450	250	—	—	A 8 AE	—
	OZ 4	—	—	FW (Gaseous)	300—0—300	75	300	—	A 8 L	—
	6 ZY 5 G	6.3	0.3	FW	350—0—350	35	420	440	A 8 K	—

METAL RECTIFIERS

Type. WESTINGHOUSE	Capacity (mfd.) of Voltage Doubling or Reservoir Condenser, 50 c/s Mains.	Peak Voltage Rating of Condensers (Working).	Type of Rectifier.	Max. Input Volts (RMS).	Max. Input Current (mA.).	Normal Rect. Current (mA.).	Unsmoothed Rect. Volts at Full-current.	Unsmoothed Rect. Volts at Half-current.	Price.
HT 14	4 + 4	200	VD HW	80 135	60 30	20	140	170	10/-
HT 16	4 + 4	400	HW VD	400 240	90 200	60	330	515	13/-
HT 17	8 + 8	250	VD HW	150 250	300 150	100	225	350	15/-
2 x HT 17 ..	6 + 6	500	VD	300	550	120	530	620	—
HT 15	4 + 4	200	VD HW	140 250	120 80	30	230	315	12/6
H 1	100	12	HW	3.5	15	10	3.6	4	4/2
H 10	10	50	HW	35	15	10	36	40	4/6
H 50	2	250	HW	175	15	10	180	205	7/10
H 75	2	400	HW	260	15	10	270	305	10/-
H 100	1	500	HW	350	15	10	360	410	12/4
H 176	0.5	1,100	HW	620	15	10	650	750	20/-
J 10	10	250	HW	80 **	3	2	80	—	4/6
J 20	5	500	HW	160 **	3	2	160	—	4/8
J 50	2	650	HW	400 **	3	2	400	—	7/10
J 100	1	1,250	HW	800 **	3	2	800	—	12/4
J 176	0.5	2,000	HW	1,400 **	3	2	1,400	—	20/-
Two H 120 ..	0.5 + 0.5	700	VD	480	30	10	870	1,000	—
Two H 176 ..	0.25 + 0.25	1,000	VD	720	30	10	1,300	1,500	—
Ten H 176 ..	0.05 + 0.05	5,000	VD	3,600	30	10	6,500	7,500	—
Two J 10 ..	10 + 10	250	VD	80 **	6	2	170	—	—
Two J 50 ..	2 + 2	650	VD	400 **	6	2	850	—	—
Two J 100 ..	1 + 1	1,250	VD	800 **	6	2	1,700	—	—
Two J 176 ..	0.5 + 0.5	2,000	VD	1,400 **	6	2	3,000	—	—
Ten J 176 ..	0.1 + 0.1	12,000	VD	7,000 **	6	2	15,000	—	—

VIBRATORS

Type.	Input. Volts.	Input. Amps. (approx)	AC Volts to Transformer Primary.	Output. Volts.	Output. mA.	Price.
BULGIN.						
HTV 7§§ ..	4.0	5.0	2.6—0—2.6	250	60	20/-
HTV 5§§ ..	6.0	3.5	4—0—4	250	60	20/-
HTV 6 ..	6.0	3.5	4—0—4	—	—	17/6
HTV 454 ..	6.0	3.5	4—0—4	—	—	20/-
HTV 708§§ ..	6.0	3.5	4—0—4	250	60	22/6
HTV 400 ..	6.0	3.5	4—0—4	—	—	20/-
HTV 714§§ ..	6.0	3.5	4—0—4	250	60	22/6
HTV 442 ..	6.0	3.5	4—0—4	—	—	20/-
HTV 8§§ ..	12.0	1.75—2.2	8—0—8	250	60	20/-
HTV 350 ..	12.0	1.75—2.2	8—0—8	—	—	20/-
HTV 14 ..	24.0	0.85—1.2	16—0—16	—	—	20/-
HTV 10§§ ..	24.0	0.85—1.2	16—0—16	250	60	22/6
HTV 11§§ ..	32.0	0.5—0.65	22—0—22	250	60	22/6
HTV 550 ..	32.0	0.5—0.65	22—0—22	—	—	22/6
HEAVER-MALLORY.						
600	6.3	5.0	—	350	100	—
G 600	12.0	5.0	—	350	100	—
MASTERADIO-MALLORY.						
W 49	3—5.5	5.0	—	—	—	18/6
94	5—9	5.0	—	—	—	15/6
49§§	5—9	5.0	—	350	100	18/6
G 94	10—18	5.0	—	—	—	15/6
G 49§§ ..	10—18	5.0	—	350	100	18/6
F 94	30—35	5.0	—	—	—	25/-
ROTHERMEL.						
49§§	6.0	2.5	—	250	—	20/-
94§§	6.0	2.5	—	250	—	18/6
G 49	12.0	3.7	—	250	—	25/-
G 94	12.0	3.5	—	250	—	20/-
SIMMONDS.						
SR 2	2.0	2.7	—	135	20	18/6
NR 2	2.0	3.0	—	—	—	12/6
NR 4	4.0	2.0	—	—	—	12/6
SR 4	4.0	1.2	—	135	20	18/6
SR 6	6.0	0.65	—	135	20	18/6
SR 6 H ..	6.0	3.0	—	250	50	21/-
SR 12 H ..	12.0	1.5	—	250	50	21/-
NR 220 ..	220.0	0.2	—	—	—	14/6

BARRETTERS

Type.	Normal Current (Amps.).	Range of Volts dropped across Barretter.	Base.	Price.
MARCONI and OSRAM.				
301	0.3	138—221	Edison Screw	8/6
302	0.3	112—195	Edison Screw	8/6
303	0.3	86—129	Edison Screw	8/6
304	0.3	95—165	Edison Screw	8/6
OSRAM.				
202	0.2	120—200	4 J	8/6
PHILIPS.				
1904	0.1	40—70	4 J	12/6
1933	0.1	50—160	4 J	15/-
1927	0.18	60—120	4 J	12/6
1928	0.18	100—210	4 J	15/-
C 2	0.2	60—120	4 J or Ct. 8 H	12/6
C 1	0.2	90—230	4 J or Ct. 8 H	10/-
C 3	0.2	100—200	Ct. 8 H	15/-
1920	0.25	40—70	4 J	12/6
1934	0.25	85—195	4 J	15/-
1941	0.3	100—240	4 J	15/-
TUNGSRAM.				
BR 201 or BR 201 S	0.2	90—230	4 J or Ct. 8 H	9/-
BR 202 or BR 202 S	0.2	40—100	4 J or Ct. 8 H	12/6
BR 3000 c	3.0	7—18	Edison Screw	—

SUPPLIERS OF AMERICAN TYPE VALVES

British Manufacturers:

Brimar: Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

Ferranti: Ferranti, Ltd., Radio Works, Moston, Manchester, 10.

Mullard: Mullard Wireless Service Co., Ltd., 225, Tottenham Court Road, London, W.1.

Tungsram: Tungsram Electric Lamp Works (Great Britain), Ltd., 82, Theobalds Road, London, W.C.1.

British Agents for American Valves:

Arcturus: Hassid, Austin and Co., Ltd., 66, Wilson Street, Finsbury Square, London, E.C.2.

Rogers (Canadian): R. M. Electric, Ltd., Majestic Works, Oaklands Rd., Cricklewood, London, N.W.2.

Philco: Philco Radio and Television Corporation of G.B. Ltd., Aintree Road, Perivale, Middlesex.

National Union: Universal Radio Distributors, 24, Fitzroy Square, London, W.1.

Sylvania: Claude Lyons, Ltd., 76, Oldhall Street, Liverpool, 3, and 40, Buckingham Gate, London, S.W.1.

Raytheon: Frank Heaver, Ltd., Bush House, Aldwych, London, W.C.2.

Triad: Premier Supply Stores, Jubilee Works, 167, Lower Clapton Road, London, E.5.

VALVE BASES

Guide to British and American Types

The connections for both British and American valve bases are given in these pages, and it is particularly important to note that the view is of the valve base itself or the underside of the valve holder.

ABBREVIATIONS USED IN THE TABLES

A	= Anode.	OA	= Oscillator Anode.
B	= Class B	OG	= Oscillator Grid.
C	= Cathode.	R	= Resistance.
DA	= Diode Anode.	S	= Screen.
DC	= Diode Cathode.	SG	= Screen-grid.
Dr	= Driver.	Sh.	= Shield
G	= Grid.	Sup.	= Suppressor-Grid.
H	= Heater.	TA	= Triode Anode.
HCT	= Heater Centre-Tap.	Tar.	= Target.
IG	= Injector Grid.	TC	= Top-cap.
M	= Metallising and metal-shield.	TG	= Triode Grid.

NOTES.—Numerical subscripts indicate in multi-electrode valves the order of assembly of the grids, G1 being the grid nearest the cathode, and in multiple valves they distinguish the different electrode assemblies. In one or two cases the now rarely found side-terminal on a valve is included under the column headed TC. The same valve-base drawing is used for both British and American Octal bases. Actually, the pin spacing and spigot size are slightly different.

The British Types

4-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4
DH Triode	4A	—	A	G	– F	+ F
DH Screen grid	4B	A	SG	G	– F	+ F
DH Screen-grid	4C	G	A	SG	– F	+ F
DH Rectifier HW	4D	—	A	—	F	F
DH or IH Rectifier FW ..	4E	—	A	A	F	F
DH or IH Rectifier HW (High Voltage)	4F	A	—	—	F	F
DH Output Pentode	4G	SG	A	G	–F	+ F
IH Diode	4H	—	A	C	H	H
DH Triode	4I	G	A	—	–F	+ F
Barretter	4J	—	—	—	R	R
IH Diode	4K	DA	C	—	H	H

5-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5
IH Triode	5A	—	A	G	H	H	C
IH Screen-grid	5B	A	SG	G	H	H	C
IH Duo-diode	5C	—	DA	DA	H	H	C
IH Duo-diode	5D	DA	DA	M	H	H	C
DH Duo-diode-triode ..	5E	G	A	AVC DA	– F	+ F	Det. DA
DH Pentode	5F	—	A	G	– F	+ F	SG
IH Pentode	5G	SG	A	G	H	H	C
IH Rectifier FW ..	5H	—	A	A	H	H	C
IH Rectifier HW ..	5I	—	A	—	H	H	C
DH Tetrode	5J	—	A	G1	F	F	G2
IH Pentode	5K	A	SG	H	G	H, C	Sup.

7-PIN BASE CONNECTIONS

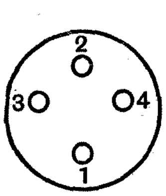
Type of Valve	Base	TC	1	2	3	4	5	6	7
DH Frequency-changer	7A	G	OA	OG	SG	F	F	M	A
IH Frequency-changer	7B	G	OA	OG	SG	H	H	C	A
DH Screened Pentode.	7C	A	M	G	Sup.	F	F	—	SG
IH Screened Pentode..	7D	A	M	G	Sup.	H	H	C	SG
IH Screened Pentode..	7E	G	M	A	Sup.	H	H	C	SG
IH Triode	7F	G	M	—	—	H	H	C	A
IH Duo-diode-triode..	7G	G	DA	M	DA	H	H	C	A
IH Single-diode-tetrode	7H	A	—	G	SG	H	H	C	DA
IH Duo-diode-output pentode	7I	G	DA	A	DA	H	H	C	SG
IH Pentode	7J	—	—	G	SG	H	H	C	A
DH Class "B" ..	7K	—	G2	G1	A1	F	F	—	A2
DH QPP	7L	—	G2	G1	A1	F	F	SG	A2
IH Rectifier, FW or VD	7M	—	HCT	A1	C1	H	H	C2	A2
DH Screened Pentode.	7N	G	M	A	Sup.	F	F	—	SG
IH Pentode	7O	—	Sup.	G	SG	H	H	C	A
DH Driver and Class B	7P	Dr. A	BG2	BG1	BA1	F	F	Dr. G	BA2
IH Pentode	7Q	G	—	—	SG	H	H	C	A
IH Triode	7R	—	—	G	—	H	H	C	A
IH Double-triode ..	7S	—	—	G1	A1	H	H	C	A2
IH Pentode	7T	G	HCT	—	SG	H	H	C	A
CR Tuning Indicator...	7U	—	—	TG	Tar.	H	H	C	TA
IH Split-anode Pentode	7V	—	A	G	SG	H	H	C	A
IH Duo-diode... ...	7W	—	M	DA2	C2	H	H	C1	DA1
IH Duo-diode-output pentode	7X	G	DA	C	DA	H	H	A	SG
VD Rectifier	7Y	—	—	A1	F1	F1	F2	F2	A2
IH Split-anode-tetrode	7Z	G	M	A	A	H	H	C	SG
VD Rectifier	7AA	—	—	—	H1, C1	H1	H2	H2, C2, A1	A2
IH Battery Pentode ..	7AB	A	M	G	—	H, C	H	—	SG
IH Tetrode	7AC	A	—	G	SG	H	H	C	—
DH Hexode	7AD	G1	M	A	G3	F	F	G4	G2
VD Rectifier	7AE	—	—	A2	C2	H	H	C1	A1
IH Screened Pentode..	7AF	G	—	A	Sup.	H	H	C, M	SG
IH Split-anode tetrode	7AG	A	M	G	SG	H	H	C	A

8-PIN (BRITISH OCTAL) BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5	6	7	8
DH Screened Pentode	8A	G	F	—	A	SG	Sup.	M	—	F
DH Triode	8B	—	F	—	A	—	G	M	—	F
DH Output Pentode..	8C	—	– F	—	A	SG	G	—	—	+ F
CR Tuning Indicator..	8D	—	H	C	TA	—	TG	—	Tar.	H
IH Duo-diode-triode..	8E	G	H	C	A	—	DA	M	DA	H
IH Screened Pentode	8F	G	H	C	A	SG	Sup.	M	—	H
IH Triode ..	8G	—	H	C	A	—	G	M	—	H
IH Duo-diode ..	8H	—	H	C1	DA1	S	DA2	M	C2	H
DH Triode Pentode ..	8I	G	F	—	A	OA	OG	M	SG	F
IH Output Pentode ..	8J	—	H	C	A	SG	G	M	—	H
DH Duo-diode-triode .	8K	G	F	—	A	—	DA	M	DA	F
IH Duo-diode-pentode	8L	G	H	C	A	SG	DA	M	DA	H
IH Rectifier HW ..	8M	—	H	—	C	—	A	—	—	H
DH Rectifier FW ..	8N	—	H	—	A	—	A	—	—	H
IH Rectifier FW ..	8O	—	H, C	—	A	—	A	—	—	H
IH Triode	8P	G	H	C	A	—	—	M	—	H
IH Frequency-changer	8Q	G	H	C	A	OA	OG	M	SG	H
IH Hexode	8R	G1	H	C	A	G2	G3	M	G4	H
IH Double-triode ..	8S	—	H	C	A1	—	G1	G2	A2	H
IH Double Pentode ..	8T	—	H	C	A1	SG	G1	G2	A2	H
IH Duo-diode ..	8U	—	H	—	DA	C	DA	M	—	H
IH Rectifier	8V	—	H	—	A	C	A	—	—	H
DH Double-Pentode..	8W	—	F	—	A1	SG	G1	G2	A2	F

9-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5	6	7	8	9
DH Frequency-changer	9A	G	SG	A	Sup.	F	F	—	OA	OG	M
IH Frequency-changer	9B	G	SG	A	Sup.	H	H	C	OA	OG	M
IH Duo-diode-RF Pentode	9C	G	SG	A	—	H	H	C	AVC DA	Det. DA	M
DH QPP	9D	—	G1	A1	SG1	F	F	—	SG2	A2	G2
IH Triple-diode-triode.	9E	G	DA2	DA3	—	H	H	C	A	DA1	M



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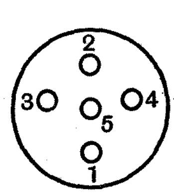
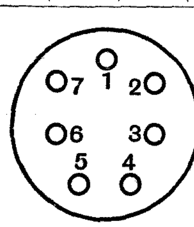
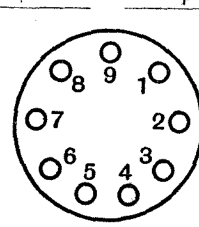


5 PIN



7 PIN



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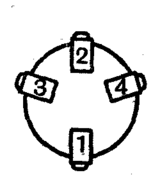

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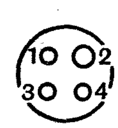

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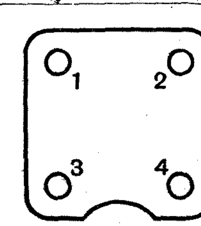

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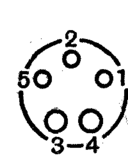


Sm.5

VARIOUS 4-PIN AND 4-CONTACT TYPES

Type of Valve	Base	TC	1	2	3	4
DH Midget Triode	Sm. 4A	—	A	G	F	F
DH Midget Screen-grid ..	Sm 4B	A	SG	G	F	F
DH Large Output Triode ..	Lg. 4A	—	A	F	F	G
DH Midget Triode	Ct. 4A	—	A	G	− F	+ F

VARIOUS 5-PIN AND 5-CONTACT TYPES

Type of Valve	Base	TC	1	2	3	4	5
DH Midget Pentode ..	Sm. 5A	—	A	G	F	F	SG
IH Duo-diode.. ..	Ct. 5A	—	DA	H	H	C	DA
IH Duo-diode.. ..	Ct. 5B	DA	M	H	H	C	DA

8-CONTACT TYPES

Type of Valve	Base	TC	1	2	3	4	5	6	7	8
Frequency-changer	Ct. 8A	G	M	H	H	C	OA	OG	SG	A
RF Pentode ..	Ct. 8B	G	M	H	H	C	Sup.	—	SG	A
Triode	Ct. 8C	G	M	H	H	C	—	—	—	A
Output Pentode ..	Ct. 8D	G	—	H	H	C	—	—	SG	A
HW Rectifier ..	Ct. 8E	—	—	H	H	C	—	—	—	A
FW Rectifier ..	Ct. 8F	—	C1	H	H	C2	A1	—	—	A2
Duo-diode-triode..	Ct. 8G	G	M	H	H	C	DA	DA	—	A
Barretter	Ct. 8H	—	—	—	—	—	R	—	—	R
CR Tuning Indicator	Ct. 8I	—	—	H	H	C	—	TG	Tar.	TA
Hexode	Ct. 8J	G1	M	H	H	C	G3	G4	G2	A
Duo-diode.. ..	Ct. 8K	—	M	H	H	C1	DA1	S	DA2	C2
IH Hexode ..	Ct. 8L	G1	M	H	H	C	G4	G2	G3	A
IH Tetrode ..	Ct. 8M	—	—	H	H	C	—	G	SG	A
IH Duo-diode-Output Pentode	Ct. 8N	G	—	H	H	C	DA	DA	SG	A
DH FW Rectifier..	Ct. 8O	—	—	F	F	—	A	—	—	A
IH FW Rectifier..	Ct. 8P	—	—	H	H	C	A	—	—	A
IH Triple-diode ..	Ct. 8Q	—	M	H	H	C	DA3	—	DA2	DA1
IH Duo-diode-RF Pentode	Ct. 8R	G	M	H	H	C	DA	DA	SG	A
VM Pen. with CR Tun. Ind.	Ct. 8S	—	—	H	H	C, G3	Tar.	G1	G2, Sh.	A
DH Screened Pentode	Ct. 8T	G	M	F	F	—	Sup.	—	SG	A
Double-Pentode ..	Ct. 8U	—	G1	H	H	C	A2	G2	SG	A1
DH Duo-diode-triode	Ct. 8V	G	M	F	F	—	DA	DA	—	A
DH Triode ..	Ct. 8W	—	—	F	F	—	—	G	—	A
DH Output Pentode	Ct. 8X	—	—	F	F	—	—	G	SG	A
DH Class B ..	Ct. 8Y	—	—	F	F	—	A2	G1	G2	A1
DH Frequency-changer	Ct. 8Z	G	M	F	F	—	OA	OG	SG	A
DH Hexode ..	Ct.8AA	G	M	F	F	—	IG	Sup.	SG	A

OSTAR-GANZ BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5	6	7
IH Frequency-changer	C7A	G	C	H	H	SG	OG	OA	A
IH Screen-grid ..	C7B	A	C	H	H	SG	G	—	—
IH RF Pentode ..	C7C	G	C	H	H	SG	Sup.	M	A
IH Duo-diode ..	C7D	DA	C	H	H	M	—	—	DA
IH Triode	C7E	—	C	H	H	—	G	—	A
IH Pentode	C7F	—	C	H	H	SG	G	Sup.	A
IH Rectifier	C7G	—	C1	H	H	C2	A2	—	A1

The American Types

4-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4
DH Triode	A4A	—	F	A	G	F
DH Screen-grid ..	A4B	G	F	A	SG	F
DH Rectifier FW ..	A4C	—	F	A	A	F
DH Rectifier HW ..	A4D	—	F	A	—	F
IH Rectifier HW ..	A4E	—	H	A	C	H

5-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5
IH Triode	A5A	—	H	A	G	C	H
IH Screen-grid ..	A5B	G	H	A	SG	C	H
DH Pentode	A5C	—	F	A	G	SG	F
DH Tetrode	A5D	—	F	A	G1	G2	F
IH Pentode	A5E	G	H	A	SG	C	H
IH Rectifier FW ..	A5F	—	H	A	A	C	H

6-PIN BASE CONNECTIONS

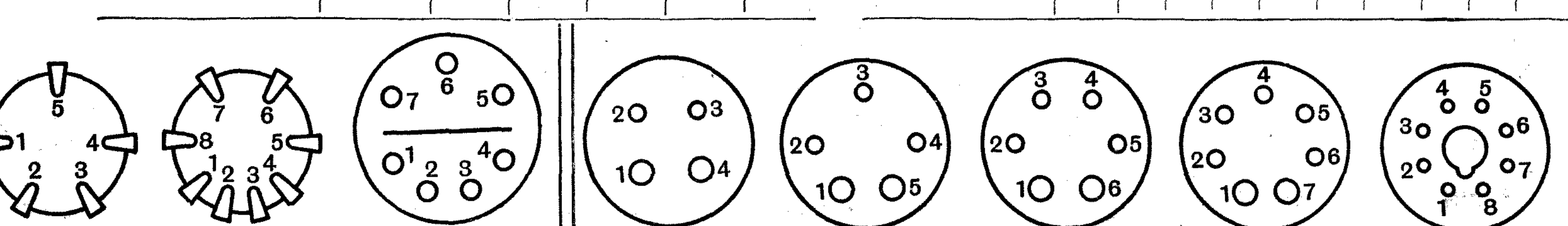
Type of Valve	Base	TC	1	2	3	4	5	6
DH Frequency-changer ..	A6A	G	F	A	OA	OG	SG	F
IH RF Pentode	A6B	G	H	A	SG	Sup.	C	H
DH Duo-diode-triode ..	A6C	—	F	A	DA	DA	G	F
IH Duo-diode-triode ..	A6D	G	H	A	DA	DA	C	H
IH Duo-triode	A6E	—	H	A2	A1	G1	C2	H
IH Duo-triode	A6F	G1	H	A2	G2	C	A1	H
DH Duo-triode	A6G	—	F	A2	G2	G1	A1	F
IH Pentode	A6H	—	H	A	SG	G	C	H
IH Pentode	A6I	G1	H	A	G2	G3	C	H
IH Rectifier, FW	A6J	—	H	A1	C1	C2	A2	H
DH Duo-diode-pentode ..	A6K	G	F	A	SG	DA	DA	F

7-PIN BASE CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5	6	7
IH Frequency-changer	A7A	G	H	A	SG	OA	OG	C	H
IH Duo-diode-pentode	A7B	G	H	A	SG	DA	DA	C	H
IH Single-diode-pentode	A7C	G	H	A	SG	DC	DA	C	H
IH Duo-triode.. ..	A7D	—	H	A2	A1	G1	G2, C1	C2	H
IH Duo-triode.. ..	A7E	—	H	A2	G2	C	G1	A1	H
IH Pentode	A7F	—	H	A	G2	G1	G3	C	H
IH Pentode	A7G	—	H	A	SG	G	C	HCT	H

8-PIN BASE (OCTAL) CONNECTIONS

Type of Valve	Base	TC	1	2	3	4	5	6	7	8
IH Frequency-changer	A8A	G	M	H	A	SG	OG	OA	H	C
IH Mixer	A8B	G	M	H	A	SG	IG	—	H	C
IH RF Pentode ..	A8C	G	M	H	A	SG	Sup.	—	H	C
IH Duo-diode ..	A8D	—	M	H	DA2	C2	DA1	—	H	C1
IH Duo-diode-triode	A8E	G	M	H	A	DA	DA	—	H	C
IH Triode	A8F	G	M	H	—	A	—	—	H	C
IH Triode	A8G	—	M	H	A	—	G	—	H	C
IH Pentode ..	A8H	—	M	H	A	SG	G	—	H	C
IH Rectifier FW ..	A8I	—	M	H	—	A	—	A	—	H & C
IH Rectifier FW ..	A8J	—	—	M	H	A2	C2	A1	—	H & C1
IH Rectifier FW ..	A8K	—	M	H	A	—	A	—	H	C
Gaseous Rectifier FW	A8L	—	M	—	A	—	A	—	—	C
IH Triode	A8M	G	M	H	A	—	—	—	H	C
IH Duo-triode ..	A8N	—	M	H	A1	G1	G2	A2	H	C
IH Single diode-triode	A8O	G	—	H	A	—	DA	—	H	C
IH Tetrode... ...	A8P	—	—	H	A	SG	G	—	H	C
DH Frequency-changer	A8Q	G	—	+ F	A	SG	OG	OA	− F	—
DH RF Tetrode ...	A8R	G	—	+ F	A	SG	—	—	− F	—
IH Duo-diode-pen.	A8S	G	M	H	A	DA	DA	SG	H	C
DH Duo-diode-pen.	A8T	G	—	+ F	A	DA	DA	SG	− F	—
DH Duo-diode-triode	A8U	—	—	+ F	A	DA	DA	G	− F	—
DH Triode	A8V	—	—	+ F	A	—	G	—	− F	—
IH Double-triode ...	A8W	—	M	H	A2	A1	G1	—	H	C
DH Double-triode...	A8X	—	—	+ F	A1	G1	G2	A2	− F	—
DH Pentode ...	A8Y	—	—	+ F	A	SG	G	—	− F	—
DH Double Pentode	A8Z	—	—	+ F	A1	G1	G2	A2	− F	SG
IH Double-triode ...	A8AA	G1	M	H	A1	C1	G2	A2	H	C2
IH Tuning Indicator	A8AB	—	—	H	TA	Tar.	TG	—	H	C
DH Rectifier HW ..	A8AC	—	—	F	—	—	A	—	F	C
IH All-stage ..	A8AD	G1	H	C	A	G5	G4	G3	G2	H
DH Rectifier FW ..	A8AE	—	—	F	—	A	—	A	—	F
DH Rectifier FW ..	A8AF	—	—	—	A	—	A	—	F	F
IH Triode Pentode .	A8AG	G	—	H	H	A	SG	OA	OG	C
IH Pentode-diode ..	A8AH	—	DC	H	A	SG	G	DA	H	C



Ct. 5 Ct. 8 C7 PIN 4 PIN 5 PIN 6 PIN 7 PIN 8 PIN (OCTAL)

(*Concluded from p. 409.*)
"Triodes," while a duo-diode-RF pentode is listed among "Screen-grid" or "Variable-Mu" valves according to the characteristics of the pentode section.

Triodes

Triodes are divided into two categories: those with a resistance greater than 7,000 ohms and those with a resistance less than 7,000 ohms. The former are now used chiefly as AF amplifiers, grid detectors, and oscillators, while the latter are output or driver valves.

For a grid detector a valve with a resistance of 7,000-10,000 ohms is usually the best from the point of view of quality, but where high amplification is important a higher resistance can be selected. The deterioration in quality will usually be small and in some cases non-existent, depending very largely upon the circuit conditions. For amplification purposes the valve should have a resistance of less than 15,000 ohms in most cases when transformer coupling is used. With resistance coupling a valve with a resistance of 10,000-100,000 ohms is suitable.

In calculating the amplification from the formula already given, it is important to remember that the mutual conductance and AC resistance both depend on the operating voltages. The figures given in the tables are for zero grid bias and 100 volts HT, following the standard practice. The actual values at maximum HT and the optimum negative grid bias are not widely different, but when using resistance coupling it is a wise plan to take the resistance as being about 25 per cent. greater than the figure given and the mutual conductance as about 25 per cent. less. In general, the coupling resistance should be about three to five times the valve resistance and the grid leak of the following valve not less than twice the coupling resistance and preferably higher. It is, however, unwise to exceed 2 megohms for a grid leak and in the case of an output valve 0.5 megohm. Output valves operating with fixed bias instead of the usual automatic bias may have to be worked with a grid circuit resistance of 50,000 ohms or less, and the use of resistance coupling is then hardly practicable.

Values for cathode bias resistances are not given for small triodes since they depend on the operating conditions adopted. When resistance coupling is used the required value of bias resistance can be estimated by dividing the coupling resistance by the amplification factor of the valve. This will not always give the optimum value, but it will give a value which is usually surprisingly close to it.

Output Valves

Valves with resistances below 7,000 ohms are chiefly of the output type. In most cases the figures given are for a single valve in Class A operation. When two valves are used in Class A push-pull, the anode and grid voltages remain the same and each valve takes the same current. The value of the bias resistance must be halved and the anode-to-anode load doubled. In practice the load can often be about 1.5 times that for one valve with some advantage in output. The output obtainable from two valves in Class A push-pull is about 2-2.5 times that given by one valve alone.

In some cases greatly increased output can be obtained by operating valves in Class AB1, AB2, or B. All valves are not suitable for these modes of operation. Some are designed especially for one particular system and a pair will then give a surprisingly large output.

Cases of this nature are met with among tetrodes and pentodes in particular, and valve makers' ratings for a valve vary greatly according to the method of operation. It is impracticable to include all operating conditions in the tables, and except where otherwise indicated operation in Class A is to be understood with a single valve and automatic grid bias.

The classification of output stages is made on the following basis. A Class A stage is one in which the anode current flows throughout the whole cycle of input grid voltage and grid current is not permitted. The mean anode current is substantially constant irrespective of the input voltage, up to the overload point. It can be either a single valve or a push-pull stage.

In Class AB1 grid current is not permitted, and the anode current flows over the major portion of the cycle of input voltage, but not necessarily over the whole cycle. Two valves in push-pull are used and the mean anode current fluctuates with the signal. The condition of operation is about half-way between Class A and what is often termed quiescent push-pull. A Class AB2 stage is the same as a Class AB1, but a larger input is applied and the valves run into grid current.

A Class B1 stage is one in which no grid current is permitted and a pair of valves in push-pull is used. The valves are so biased that anode current flows in each for only about one-half of the cycle of input voltage. That is, each valve is biased to about the point of anode current cut-off. The anode current fluctuates considerably with a signal. A Class B2 stage is the same, but a larger signal is applied and grid current flows.

On this basis what is familiarly termed a QPP stage is Class B1, and the so-called Class B is Class B2. In the tables, operating conditions for these systems are quoted chiefly in the case of the special valves, of which the majority are battery types. The "QPP" valves are double-pentodes and the "Class B" types double-triodes; for clarity, the distinguishing symbols Q and B are employed instead of the more strictly correct B1 and B2.

Whatever type of output stage is used, it must be operated into the correct load impedance. Figures for this are given in the tables. In practice the speech coil of the loud speaker rarely has the correct impedance, so that an output transformer is necessary, and the ratio is readily calculated by dividing the optimum load impedance by the speech-coil impedance and taking the square root of the result. When the speech-coil impedance is less than the optimum load impedance, the transformer ratio is step-down.

With triodes in Class A the matching is not very critical. It is much more so with tetrodes, pentodes, and Class AB and Class B stages generally. Tetrodes and pentodes also have a high output resistance which leaves the loud speaker substantially undamped, and it is consequently often advantageous with these valves to use negative feed-back to reduce the effective output resistance.

Class AB1 and Class B1 stages demand a more carefully designed output transformer than Class A types. A low DC resistance for the primary is needed, and it is usually important that the two half-primaries be sectionalised and interleaved with one another to keep the leakage inductance between them at a low figure. Class AB2 and Class B2 stages have the same output transformer requirements, but as they have a low input impedance a driver valve and well-designed driver transformer are needed.

Rectifiers

Few remarks are necessary on rectifiers, but it is as well to point out that the reservoir condenser must be rated for working at not less than 1.4 times the RMS AC input to the rectifier. Thus, for a full-wave rectifier with an input of 500-0-500 volts the condenser must be at least 700 v. working.

A number of rectifiers rated for very high voltages is to be found. These are of the half-wave type and are intended for providing the very small current taken by a cathode-ray tube. They are primarily television valves. The reservoir condenser with these is usually 0.1 mfd.

The data for metal rectifiers is essentially the same as for valves. The capacities of voltage-doubler condensers, however, depend on the mains frequency, the values given being for 50 c/s. With 100 c/s mains the capacities must be one-half the listed figures and with 25 c/s supplies double.

Each valve has its base connections definitely identified. In every case the figure opposite a valve in the "Base" column denotes the number of pins in the base, while the following letter denotes the connections for that number of pins. A preceding letter is used to distinguish between different arrangements of the same number of pins. Thus, a conventional 4-pin triode is listed as Base 4A, while a 4-pin screen-grid valve has Base 4B. The Midget valves have different pin arrangements and a triode is listed as Sm.4A, being an abbreviation for "small 4-pin base, A connections." Similarly, an American valve base has the prefix A, and Continental types the prefix C. Side-contact types are distinguished by Ct.

It should be noted that the same drawing is used for the British and American octal-base. Actually the pin spacing is slightly different in the two and the centre spigots are not the same size. The British octal base is denoted by "8" and the American by "A8."

The code is an arbitrary one, but is easy to remember, for the numeral and any preceding letters show at a glance the number of pins in the base and the type of base, while the following letter refers to the connections for the particular valve.

In connection with the small 4-pin base for Midget valves, this is used by several valve makers, and it should be pointed out that the different makes are not all interchangeable. The bases appear the same at a glance and the connections are the same. Actually, however, the pin spacing is slightly different in the Hivac valves from that adopted by Marconi, Mullard and Osram.

In a few cases it will be noticed that two or more valve type numbers are quoted for the same characteristics and that two base codes also appear. This indicates that the same valve is available under different type numbers with different bases. As an example, we find AC/5 Pen. and Pen. 45 under the type column for one Mazda pentode, and in the base column 7J and 8J. This indicates that the AC/5 Pen. has type 7J base and the Pen. 45 the 8J base. Otherwise the valves are identical in all characteristics except, possibly, interelectrode capacities. Slight differences in capacities are sometimes found with different bases.

Random Radiations

By "DIALLIST"

Moscow Televises

SOME time ago it was announced in *The Wireless World* that the Russian broadcasting authorities had ordered a television transmitter which was to be erected at Moscow. The other night, whilst wandering over the 25-metre band, I picked up Moscow in the midst of a broadcast of news snips, given in French by a man and a woman announcer, turn by turn. As I tuned in, the male announcer was talking about television. The Moscow plant, said he, was now installed; the most complete tests have been made and a regular programme service was to start on November 1st. If the wavelength to be used was given, that must have been done during the part of the item that I missed. It was, however, stated that a 341-line scanning would be used, which, I take it, was a slip of the tongue for 441. So far as I can remember—I hadn't a pencil by me at the moment wherewith to make jottings—the number of frames a second was to be twenty-five.

Some Studios!

The description of the Moscow television studios must have made the personnel at the Alexandra Palace green with envy, if they heard it. Huge theatres and rooms, specially built for the purpose, were described, and it was stated that they were equipped with every gadget and contrivance that the most exacting of producers could require. The staff or the artists need never fear that they will be too hot or too cold, for air-conditioning plant would keep the temperature throughout the building constant, winter and summer alike, at 20 degrees centigrade, which works out at 68 degrees Fahrenheit. Moscow, one gathered, is particularly proud of the lighting arrangements of its studios: lights rated at no less than 150 kilowatts are available at any time. It seems hardly likely that we shall be able to look-in on Moscow yet awhile; but it is quite on the cards that the sound portion of the television transmissions will be heard here. I'd be grateful if any reader who picks it up would let me know.

Dry Cells in Parallel

ONE has always understood that it wasn't sound practice to try to run small or smallish dry cells in parallel. If you measure the EMF of a dozen brand-new cells with a precision instrument you'll find distinct differences between them. Make another set of measurements when the cells have been for a few hours under the same load, and there'll be differences again. But it won't by any means always be the cell with the highest initial EMF that gives the best reading after doing a job of work; and if two cells start with exactly the same EMF, the odds are much against its continuing to remain the same when they have been under equal loads for a bit. You'd think, therefore, that if you yoked up two or more cells in parallel, they'd tend to help to run each other down. But in practice it doesn't work out like that. One big American dry battery company does a huge business in dry cells designed for filament heating purposes. After making a long series of experiments, they were satisfied that a battery of, say, four 4-oz. cells in parallel had a longer life and gave better service all round than a single one-pound cell put to precisely the same uses. The cells must, of course, be very carefully graded and matched before being made up into batteries; but if this is done there's no doubt about the results.

More in Them

When you come to work it out you find (leaving out of account the bottoms of the cans) that the area of zinc presented to the electrolyte by four one-inch by six-inch cells is just twice that of a single two-inch by six-inch cell. You might think, offhand, that the volume of the very important sacs within the cells would be much less in a combination of four small cells than in a single big one. But it isn't. Assuming that the diameter of the sacs in the small cells is three-quarters of an inch, and that in the large cell one and five-eighths inches, the volume of that in the single big cell is very little greater than that of the four smaller ones put together. But volume isn't everything in the case of a depolariser. By carefully selecting and proportioning the materials within the sacs, the four smaller ones can be made to do their work most effectively. But, after all, the available zinc surface offered for the electrolyte to work upon is the thing that matters most in a dry cell, which provides current by, so to speak, eating up zinc. With twice the zinc surface the four small cells in parallel obviously score heavily over the single cell of twice the diameter.

Off With His Head!

BETWEEN ourselves, I am not perfectly certain that one very strong reason for my choice of my present house wasn't the fact that its garden contained a particularly fine and sturdy poplar tree. Standing some forty yards away from the window of my den, it towered to a height of one hundred feet or so. Can you imagine a more perfect ready-made aerial mast? Certainly I couldn't when I saw it. But note those past tenses in my description of that noble tree. Before I could get my aerial up there came mighty gales, and when I saw that poplar bending before them—bending, what is more, in the direction of a large and expensive greenhouse belonging to a neighbour—I decided sadly that there was nothing for it but decapitation. And so the aerial mast of my dreams has lost fifty splendid feet. As soon as the executioners finish clearing up their débris I'll have a first-rate aerial up, with the comfortable feeling that the robust support at its far end will stand up to anything short of a typhoon.

Have We Progressed?

"ALL-WAVE A.C. Mains Superhet; 15-50, 30-60, 220-560, 95/-2,000 Metres; Single tuning knob; Moving-Coil Speaker; Five Valves; 9-k/cs Selectivity; 2½ Watts output. Price 27 Guineas." That specification isn't quoted from a current list, and I am wondering whether you could say just what its date was. Actually, it comes from *The Wireless World* Guide to Receivers of 1933. At first sight you might think that we hadn't progressed very much in those five years, except in the matter of price. The most complicated of those five valves was actually a vari-mu screen grid; four modern valves would give far greater sensitivity and overall amplification, and a set of the same class would cost eight or nine guineas—roughly, one-third of what it did only five years ago.

We Certainly Have

But the eight or nine-guinea set of to-day would have other things which didn't appear in the twenty-seven-guinea model of 1933. You wouldn't find AVC mentioned in current specification because we take it for granted; it wasn't mentioned in that of 1933 because it wasn't there. Some kind of tone control is part and parcel of the make-up of most respectable sets to-day, though it was rare five years ago. Hum was apt to be a great nuisance in the models of those days; we shouldn't think much of their reproduction, which was lacking both in bass and "top," and we should probably notice a considerable amount of distortion owing to the methods of detection used. the most surprising thing, perhaps, about that 1933 guide is that sets look in the illustrations very much as they look to-day. One notices only two obvious differences: few of them have station names on the dials and none have buttons to press.

TELEVISION AT THE DORCHESTER. Nearly 40 sets were arranged in strategic positions for viewing by 550 guests at a recent banquet of the Royal Photographic Society. A few of the receivers, those arranged around the central tables, are seen in the picture, whilst others were distributed along the walls of the room to provide all those present with a good view. Manufacturers of television receivers co-operated in the demonstration.

Recent Inventions

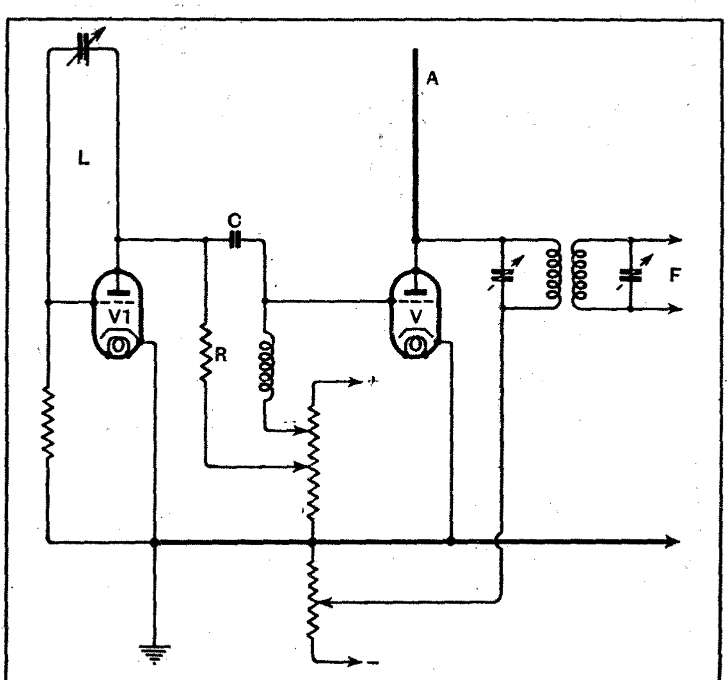
The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

Brief descriptions of the more interesting radio devices and improvements issued as patents will be included in this section.

U.S.W RECEIVERS

THE Figure shows a frequency-changing unit which is suitable for receiving wavelengths of the order of one metre. The aerial A is directly connected to the negatively biased anode of a triode valve V, which is of the Barkhausen-Kurz type and acts as a detector when the incoming signals have been mixed with local oscillations generated by a second valve V1.

The latter operates as an ordinary triode, the grid and anode being back-coupled through two parallel leads L which are bridged by a condenser to form the frequency determining circuit. The local oscillations so generated are fed to the positively charged grid of the valve V through a condenser C and resistance R. Here they are mixed with the incoming signals through the action of a "virtual" cathode," which is created between the grid and anode of the valve V. The virtual cathode and anode function, in fact, as a rectifying diode.



Ultra-short-wave frequency-changing circuit.

The resulting beat frequency is fed to the intermediate-frequency stage F through a transformer coupling, which is connected in the anode circuit of the valve V, either directly as shown, or through a coil which acts as a choke to the original signals.

Marconi's Wireless Telegraph Co., Ltd. (Communicated by G. L. Grundmann). Application date, December 31st, 1936. No. 488269.

o o o o

TELEVISION SCANNING

IN "interlaced" scanning each frame is usually made up of a whole number of lines, plus a fraction, this being necessary in order to ensure that the lines of one frame coincide with the spaces between the lines of the next frame.

In the alternative arrangement now proposed, certain of the frames contain more lines than others, though in each case there is no fraction of a line left over. But the number of lines per complete picture, divided by the number of frames per complete picture, must be a whole number, plus a fraction. This fraction is again necessary in order to secure accurate interleaving.

The advantage of the new system is that it avoids the "crowding" of the "line" and "frame" synchronising-impulses which is bound to occur, after every second framing impulse, in the known system. The clean separation of the two series of impulses in the time-base circuit of the receiver is thus made easier, and a possible source of distortion more readily avoided.

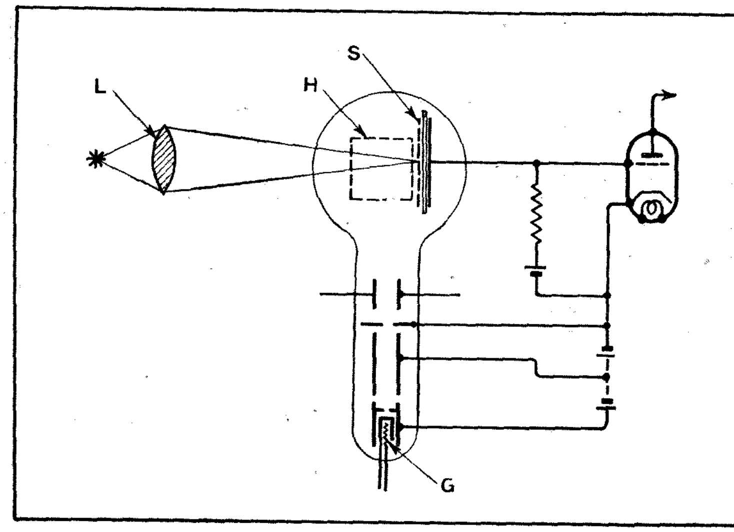
Telefunken Ges für drahtlose Telegraphie m.b.h. Convention date (Germany), January 24th, 1936. No. 489307.

o o o o

TELEVISION TRANSMITTERS

IN the Iconoscope type of television transmitter, the photo-sensitive mosaic screen is usually set at an angle to the main axes of the cathode-ray tube so that it can be exposed both to the external light coming from the scene to be televised, and also to the scanning stream inside the tube. The scanning stream must, therefore, strike against the mosaic screen obliquely instead of at right-angles, and this naturally increases the difficulty of obtaining uniform results.

In the arrangement shown, the mosaic screen S is located at right-angles to the rays of light projected on to it by the lens L, in which position it is parallel to the main electron stream from the "gun" G of the tube. The electron stream is, however, deflected through a right angle by the field from an external magnet (indicated by the dotted-line square H), so that it reaches the screen in a direction normal to its surface, and scans it rectilinearly.



Television system in which the mosaic screen is set parallel to the main electron stream.

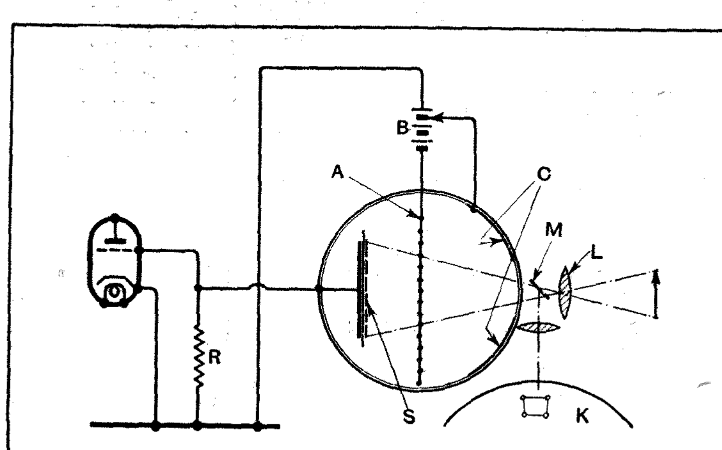
Radio-Akt. D. S. Loewe. Convention dates (Germany), October 25th and November 29th, 1935. No. 489362.

SCANNING SYSTEMS

THE scene to be televised is projected on to a mosaic screen, which is then scanned by a moving ray of light instead of a moving electron stream.

As shown in the Figure, the picture is projected by a lens L on to the mosaic screen S. The tube is also provided with a meshwork anode A which is positively biased from a source B, and a photo-electric cathode C, which is deposited on the opposite wall of the glass vessel.

The light falling on the screen S sets up a "charge image" in the usual way. It also excites the cathode A to produce a diffused emission of electrons of low intensity. These fall upon the mosaic screen and are sufficient to reduce the "dark" portions of the original picture to zero potential, leaving the "high-light" portions with positive charges. The screen is then scanned by a ray of light, which may be produced by a rotating disc K after reflection from a mirror M. The action of the light restores the mosaic elements to the normal potential due to the positive field from the anode A, so that the "black" points produce the strongest and the "high lights" the weakest signals across the output resistance R.



Scanning a screen by a ray of light which restores the mosaic elements to their normal potential.

Radio-Akt D. S. Loewe. Convention date (Germany), November 22nd, 1935. No. 489422.

The Wireless World
THE PRACTICAL RADIO JOURNAL
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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

EDITORIAL COMMENT

Television Expansion

Alternative Methods of Distribution

THE twenty-fifth Thomas Hawksley lecture, at the Institute of Mechanical Engineers, was given on November 4th by Sir Noel Ashbridge, and it dealt with television. The main body of the lecture was devoted to the principles and the development of television, but the possibilities lying in the future were touched upon.

Sir Noel mentioned the possibility of erecting a station with three or four times the maximum power of the present one, but pointed out that this only means a doubling of the present signal strength at any given point. Increase in range would be obtainable, but difficulties through the hilly country in the North of England and in Scotland must not be overlooked.

The question of wavelengths is very important, and it was disclosed that at present there is only one extra wavelength in the neighbourhood of 6-7 metres available. By international agreement one further wavelength might be secured. Unless several stations can be operated on one wavelength, however, it would be necessary to use shorter wavelengths for additional stations.

Additional Wavelengths

Under a new agreement which comes into force in September, 1939, one channel at about 5 metres will be available, and two more around 3 metres, with a further five channels at about 1½ metres. Owing to the screening effect of buildings and hills, Sir Noel thought it doubtful whether these very short wavelengths would be suitable for broadcasting.

Assuming the wavelength problem can be solved, the next difficulty is to link the stations together. Independent operation of the stations with local studios is possible but is open to financial drawbacks. The linking of transmitters for a common programme can be done by means of special cables or by a wireless link.

With the concentric cable it is necessary to use a high-frequency carrier, but quite low power will suffice and any suitable carrier frequency can be used, for it is not radiated and so will not cause interference with other stations. The main difficulty with a cable link is the high cost of the cable itself and of the necessary repeaters, but there are also certain technical difficulties in maintaining suitable frequency and phase characteristics. The system has the great advantages, however, of occupying no space in the ether and of not being subject to ignition interference.

Wireless Links

The use of a wireless link is relatively simple from the point of view of distortionless transmission, but there is the difficulty of finding a suitable waveband in which the transmitters can operate. There is also the danger of fading or similar effects.

Such linking transmitters would, of course, be highly directional and the system can be visualised as consisting of a number of transmitters and receivers, each working from one hilltop to another about 50 miles apart.

Both systems are under consideration, but considerable experimental work will be necessary before either can form a part of a regular broadcast service.

Sir Noel's lecture serves as a reply to our leader of September 29th, "Television Distribution—Is There a

Plan?" and the answer, we regret to say, seems to be "No, not yet." Further television stations must not be looked for in the immediate future. It is also clear that the difficulties are mainly financial. From the technical point of view there is little doubt that the use of entirely independent transmitters, each with its own studios, is the best course. Probably wavelengths for four such stations could be found above 5 metres and with high power a very useful area of the country could be covered.

The great drawback to this scheme is the cost, not so much of providing the transmitters and studios, but of giving four independent programmes. It is undoubtedly because of the programme cost that attention is being directed towards the linking of transmitters so that a common programme can be radiated. This is likely to result in more costly apparatus, for, however the linking is carried out, it will undoubtedly prove expensive, but in the long run the total cost will almost certainly be less.

There are also considerable technical difficulties connected with the linking of stations. There is little doubt that these difficulties can be overcome, but whether they can be overcome at a low enough cost to justify the erection of a chain of television stations is a matter which the future will decide.

Meanwhile, it is evident that concentration must take place to make television in the area at present served a real success. The present service area includes a large proportion of our total population, and there is great scope for progress here yet, although it seems rather hard on those television enthusiasts who must wait patiently before their areas will be served as well.

B.B.C. Licence Fee

A RUMOUR has been in circulation recently that to meet the increasing expenditure of the B.B.C., the annual licence fee of listeners should be increased from the present 10s. to £1. At first sight £1 a year does not seem an excessive fee to pay for 12 months of B.B.C. fare, but on the other hand, the greatest caution should surely be exercised before bringing about any change which might result in a reduction in the number of listeners.

From the point of view of national organisation it is imperative that every effort should be made to encourage at least one wireless set in every home; if only on account of the value of this means of communication with the public in any time of emergency. To increase the licence fee might quite likely put a check on the number of listeners and would most affect members of the community whose circumstances prevent them from having access to other means of communication, such as the telephone, available to those who would not be much concerned if an increase in the licence fee were introduced.

Ionospheric Clouds

SCATTERED reflections from localised concentrations of ions in the atmosphere were recently discovered and described by T. L. Eckersley and E. V. Appleton. The height of these clouds was 100 km., i.e., below the E-layer, and it now appears that similar clouds exist during the afternoon and evening above the F-layer (250 km.).

Working with 50 kW in a horizontal half-wave dipole, L. Harang and W. Stoffregen, of the Auroral Observatory, Tromso, Norway, have succeeded in penetrating the F-layer and obtaining photographic records of scattered reflections at heights between 850 and 1,600 km. (*Nature*, November 5th, 1938.) A second transmitter and receiver was used to ascertain the critical penetrating frequency of the F-layer and to ensure that the main pulse should be always above this frequency.

Panic Broadcasts

AS recorded in another column, the Columbia Broadcasting System of America has announced that in future no "fake" news bulletins of a kind that could possibly cause alarm among listeners shall be transmitted in any programme. This decision was made as a result of the widespread panic caused in the U.S.A. by the broadcasting of H. G. Wells' "War of the Worlds."

It is, of course, right and proper that every care should be taken to avoid alarming timorous listeners, but it would be a pity if every broadcasting authority (including our own B.B.C.) were to be stampeded into making too-hasty decisions. There is always a tendency to scale down programme matter to the lowest level of intelligence, and if it is now decided that all broadcasting must be of such a nature as to avoid all possible risk of misunderstanding among the simplest, least sophisticated and most credulous of its audience, it will inevitably become colourless and, in particular, dramatic presentations would suffer.

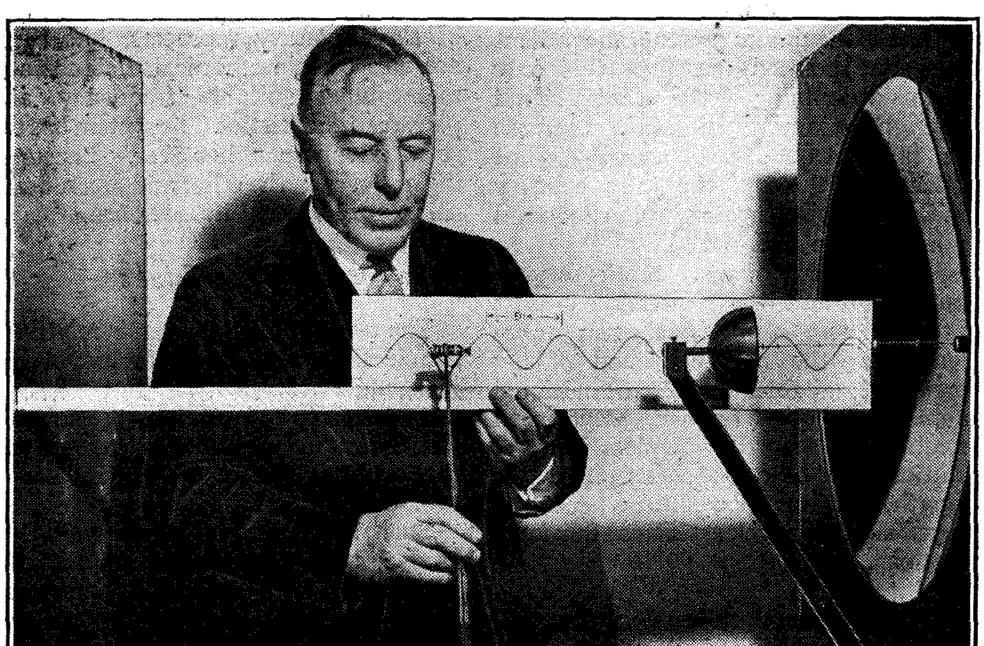
This does not mean that the faked news bulletin should be considered as a legitimate part of the dramatic producer's stage properties. One hesitates to suggest that it should be entirely withheld from him, but anything of this nature broadcast should at least be drawn in such a vein of heavy burlesque that none could be deceived.

New Wavelength Plan

RADIO manufacturers need have no fear that drastic wave changes will come into force this winter as a result of the present conference of the International Broadcasting Union at Brussels. Although the Union is concerned with a revision of the 1933 Lucerne Plan, its deliberations will result in a report which must be considered by a European Conference of Governments to be held in Switzerland next February.

A new Plan can hardly come into force before the autumn of 1939.

Direct Measurement of Micro-Waves



AN interesting sidelight on ultra-short-wave radio experiments by a well-known research organisation (Westinghouse Research Laboratories) is the actual measurement of the wavelength by hand with a metric rule or yardstick. The procedure is as follows: A vertically positioned metal sheet, placed some distance out from and parallel with the front of the transmitter, serves to combine the direct and reflected waves into standing waves. At certain points along the beam no oscillation can be detected, while other points have a maximum oscillation.

The distance between any two adjacent points of minimum oscillation is exactly one-half the wavelength. In the accompanying photograph, the measurement is 4½ centimetres, or slightly less than 2 inches, thus making the total length 9 cm., or 3.543in.

Negative Feedback in R-C Amplifiers

A "SERIES" CIRCUIT FROM AUSTRALIA

THE circuit arrangement described in this article has been developed in Australia, where it is widely used in resistance-coupled amplifiers employing pentode AF and output valves.

By the Laboratory Staff of Amalgamated Wireless Valve Company, Sydney, Australia

OF recent years the pentode output stage has, because of its power efficiency and high amplification, come into popular use. However, as is well known, the pentode has its limitations. Distortion is usually greater than that introduced by a correctly matched triode; it is mostly due to third and higher odd-order harmonics and therefore difficult to cancel by push-pull operation. Changes in load impedance are known to cause serious changes in both volume and quality of power output, both output and distortion increasing with an increase of the load. As most loud speakers have impedance characteristics rising with an increase of frequency above about 400 c/s the pentode tends both to accentuate and to distort the higher frequencies. A similar effect is also found to occur at the bass resonance frequency of the loud speaker, due to the high impedance at this point. Transient response is usually poorer with pentode output stages than with triodes, due to the reduced damping of the speech coil by the anode resistance of the valve.

The shortcomings of a pentode stage may be attributed solely to the high and variable nature of the anode resistance of the valve. By operating the valve in a manner calculated to reduce its effective output resistance, pentode reproduction may be made comparable with that of a triode, with added power efficiency at the anode. An early and rather unsatisfactory method of improving the stage regulation (that is, of reducing the increase in output voltage as the load is increased) relied upon an extra resistance-capacity filter shunted across the output load. At middle frequencies the reactance of the condenser was high enough to make the total shunt impedance much higher than

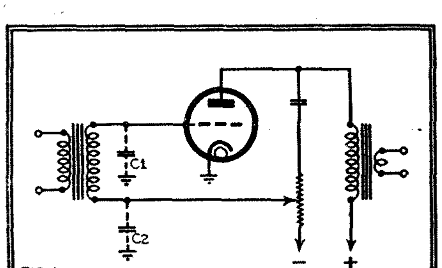


FIG. 1

A conventional method of applying negative feedback to a transformer-coupled amplifier. C1, C2 represent stray capacities to earth.

the load. At higher frequencies, where the load impedance became much higher, the reactance of the condenser had fallen and the resistance in the filter tended to take charge of the total output. The high-note accentuation and distortion were reduced; but, at the main resonant frequency of the speaker, where damping was required most, the reactance of the condenser was too high for there to be any appreciable current flowing in the filter.

In many cases the condenser was made too large, and the higher frequencies were attenuated seriously, although the overall receiver response curves suffered little, for the higher modulation frequencies had been attenuated almost out of audibility in the tuned circuits prior to detection.

A more modern method of improving the stage regulation is the application of negative feedback, which at the same time tends to reduce amplitude distortion.

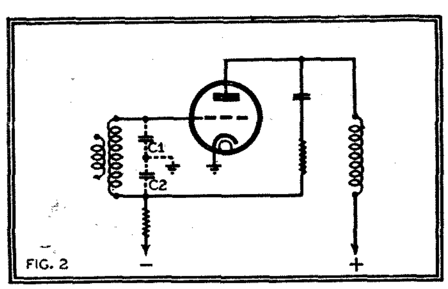


FIG. 2

The circuit of Fig. 1 may become a generator of parasitic oscillations.

Negative feedback, by tending to increase the rise in anode current due to rise in anode voltage, makes it possible to reduce the *effective* anode resistance of the output stage at *all* frequencies. There is a consequent loss of gain, and the pentode becomes somewhat similar to a triode in its sensitivity and regulation, while retaining its high anode efficiency.

The customary method of feeding a portion of the output voltage back to the grid of the output valve uses a transformer with a secondary returned to a tap on a potential divider fed from the anode of the valve, as in Fig. 1. If there are capacities to earth at either end of the secondary, the circuit assumes the form of Fig. 2—that of the well-known Colpitts oscillator. Such an arrangement may oscillate at some supersonic frequency and tend to draw grid current long before its normal overload point is reached.

Though many transformers may have capacities small enough to eliminate this trouble, where available in this country (Australia) they are prohibitively costly, and their use by receiver manufacturers is limited. It was necessary for engineers to find an inexpensive yet effective feed-

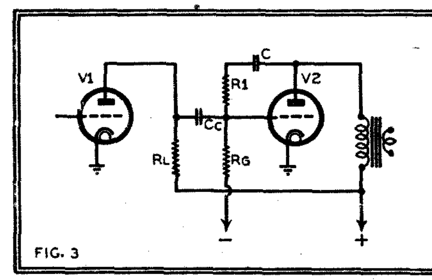


FIG. 3

Experimental negative feedback circuit. The effective grid resistance is low and Cc must be of high capacity.

back circuit using resistance-capacity coupling.

The first system to be tried was that shown in Fig. 3. It was realised that the anode resistance and anode load of V1 and the grid resistance of V2 in parallel constituted one arm of the potential divider across the speaker. To avoid the use of a low value of feedback resistance, V1 had to be a pentode.

There was another and more important reason for that choice. It is evident that the feedback resistance R1 provides a path for AC from anode to grid after the fashion of the anode-to-grid capacity of a valve. In a manner similar to the increase of input capacity by Miller effect, the input *conductance* of the valve V2 is increased by feedback and there is, in effect, a conductance equal to $(m+1)/R1$ in parallel with the grid resistance Rg. If V1 were a high impedance triode, it

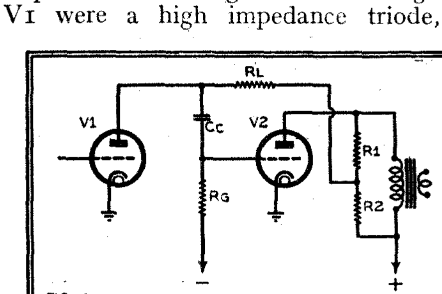


FIG. 4

The "series" circuit finally chosen. The feedback voltage developed across R2 is fed in series with the output of V1 (which must be a pentode) to the grid of V2. Typical values: R1, 0.1 megohm; R2, 11,000 ohms; RL, 0.25 megohm; Rg, 1 megohm; Cc, 0.02 mfd. Valves: V1, 6C6 (pentode); V2, 42 (pentode).

Negative Feedback in R-C Amplifiers—

would have an AC load equal to, if not less than, its own anode resistance, and its output voltage might be reduced to a value too small to excite the output valve V2. The normal output voltage of a resistance coupled pentode stage is usually very much higher than that available from a high-impedance triode, and a reduction by the same factor usually results in sufficient output to swing most pentode output stages.

Although the choice of V1 may solve the problem of excitation there is still the effect of the reduction of Rg on the frequency response of the amplifier. To retain an even bass response it was found necessary to increase the capacity of the coupling condenser Cc to an abnormally high value.

Though it gave satisfactory operation, the system was not an unqualified success, and it was finally abandoned in favour of the circuit shown in Fig. 4.

The gain reduction in Fig. 3 is caused by a current from the anode of V2 being fed back through the grid leak in parallel with the current due to the signal. In Fig. 4 a portion of the output is fed in series with the voltage developed in the anode load RL of V1 to the grid of V2. The number of components is only increased by the resistors R1 and R2, all other values remaining unchanged.

In this case again there is a reduction of the load on V1. In fact, it is hard to imagine any resistance-coupled feedback circuit without a reduction of load, for the peak value of signal voltage at the grid of V2 must never exceed its bias, and

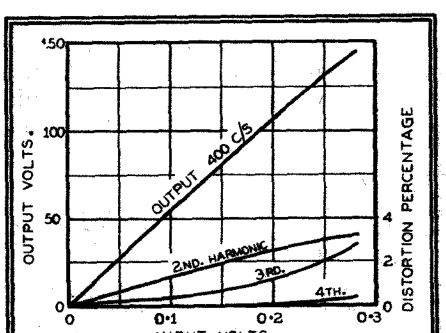


FIG. 5

Output voltage and harmonic distortion plotted against input voltage for the amplifier shown in Fig. 4.

the gain must be reduced in the penultimate or some previous stage by load reduction. The charm of Fig. 4 lies in its ease of application. Wherever a pentode output stage is excited by a pentode resistance coupled stage the simple addition of two resistors may improve the reproduction surprisingly.

The operation may be explained more fully as follows:—

When a signal is applied to the grid of V1 an alternating voltage is developed at either end of the anode load RL. As the alternating voltage on the anode of V2 is approximately 180 deg. out of phase with its grid voltage, there is a kind of see-saw voltage effect along RL. At all times there will be some point about which the voltages swing, but it does not follow necessarily that the point is fixed throughout the cycle. All amplitude distortion may be regarded as being caused by changes in amplification from point to point as the grid voltage varies. When the actual gain of V2 decreases toward the peaks of the alternating voltage, the point of steady potential moves along RL away from the

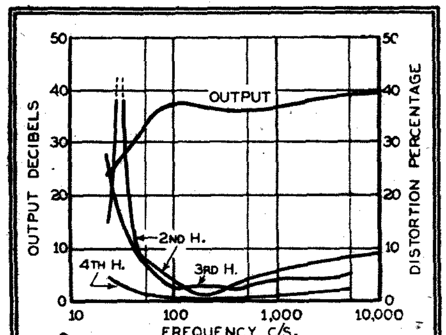


FIG. 6

Frequency characteristics (output and harmonic distortion) of the amplifier of Fig. 4.

anode of V1, thereby increasing the effective load on V1, increasing its gain, and tending to reduce the distortion.

When the overall gain attempts to rise at high frequencies the reverse action takes place, and the gain of V1 is reduced, so that the amplifier, as a whole, tends to rid itself of both amplitude and frequency distortion. Though the distortion introduced by V1 may be greater than it would be without feedback the net result is a substantial reduction, and the amplifier has no tendency to accentuate or distort higher frequencies.

The reduction of the effective anode resistance improves the transient response of the amplifier, and provides the reproduction with much of that delightful crispness so familiar to users of triodes.

Figs. 5 and 6 show curves of linearity and frequency response of an amplifier of the type shown. Both curves were taken with a typical MC speaker as an anode load on the output stage. The rise in second harmonic output below 100 c/s is largely caused by the tendency of the speaker to act as an harmonically tuned circuit below its main resonance.

The circuit has been well tried in this country, and has proved to be of utmost value to those who, requiring about 3 watts of quality output, were not prepared to go to the expense of increasing the size of the power units of their receivers to accommodate less efficient power triodes.

APPENDIX.

Showing the increase in rise of anode current due to increase in anode voltage and consequent reduction in apparent anode resistance.

When the anode voltage is increased by a small increment, δe_a, the anode current tends to rise by an amount equal to $\delta e_a/R_a$, where R_a = anode resistance of the valve. If a ratio β of the anode voltage increment is fed back to the grid, the increase in grid voltage will be $\delta e_g = \beta.\delta e_a$.

Any increase in grid voltage tends to increase the anode current to the extent of $G_m.\delta e_g$ where G_m = mutual conductance of the valve. But $\delta e_g = \beta.\delta e_a$, and the anode current tends, thus, to rise by $\beta.G_m.\delta e_a$.

It is evident, then, that there are two tendencies for an increase in plate current when the plate voltage is increased. By the theory of total differentials, the total variation when two independent changes occur may be expressed as the sum of the two independent changes, or $\delta i_a = \delta e_a/R_a + \beta.G_m.\delta e_a$.........(1) where δi_a = total difference in anode current and δe_a is very small.

The ratio of change of anode voltage to the change of anode current is the output resistance, or apparent anode resistance, and from (1) it is found to be

$$R_o = \frac{\delta e_a}{\delta i_a} = 1/(1/R_a + \beta.G_m)$$

which is always less than R_a where $\beta.G_m$ is positive.

It is equivalent, also, to a resistance equal to $1/\beta.G_m$ in parallel with the anode resistance R_a.

Television Programmes

An hour's special film transmission intended for demonstration purposes will be given from 10 till 11 a.m. each weekday.

Sound 41.5 Mc/s. Vision 45 Mc/s.

THURSDAY, NOVEMBER 17th.

3, The Comedian Harmonists. **3.15,** Cartoon Film. **3.20,** British Movietonews. **3.30,** 191st edition of Picture Page.

9, Cabaret. **9.35,** Gaumont-British News. **9.45,** 192nd edition of Picture Page. **10.50,** News.

FRIDAY, NOVEMBER 18th.

3-4.30, "Gallows Glorious," a television adaptation of the play by Ronald Gow, with Neil Porter as John Brown.

9, "November Laughter," with the Dorchester Hotel Cabaret. **9.30,** British Movietonews. **9.40,** "Picture Story," No. 1.—"The Seventh Man," a story told by Robert Gibbings. **9.45,** Film. **9.55,** Rex Harrison in "Villa for Sale," a comedy. **10.20,** News.

SATURDAY, NOVEMBER 19th.

3, Demonstration of Australian Aboriginal sign language and fire-making. **3.10,** Film. **3.20,** Cartoon Film. **3.25,** 7th edition of Re-View, including Queenie Leonard.

9, Diana Ward. **9.10,** Gaumont-British News. **9.20,** "General John Regan," a three-act play by G. A. Birmingham. **10.50,** News.

SUNDAY, NOVEMBER 20th.

8.50, News. **9.5,** "Queens of France," a play by Thornton Wilder. The scene is laid in New Orleans in 1869. **9.25,** Interest Film. **9.35,** Music Makers. **9.45,** Cartoon Film. **9.50-10.20,** Definition Bee.

MONDAY, NOVEMBER 21st.

3-4.30, "The Wind and the Rain," by Merton Hodge.

9, Cabaret. **9.30,** Gaumont-British News. **9.40,** News Map V—Rumania. **10,** Film. **10.10,** Florence Hooton, 'cello. **10.20,** News.

TUESDAY, NOVEMBER 22nd.

3, "The Padlock," an operetta with music by Charles Dibdin and lyrics by Isaac Bickerstaff. **3.40,** Gaumont-British News. **3.50,** "This Cruising"—talk by Reginald Arkell with cartoons by Allan d'Egville.

9, British Movietonews. **9.10,** "Gallows Glorious" (as on Friday at 3 p.m.) **10.40,** News.

WEDNESDAY, NOVEMBER 23rd.

3-4.30, "Love from a Stranger," by Frank Vosper, from the story by Agatha Christie.

9, Diving. Viewers will see John Snagge being instructed in the art of submarine diving, direct from the Siebe Gorman diving tank, Westminster Bridge Road, London. **9.25,** Eskimo Idyll, talk by Peter Fruchen. **9.35,** Cartoon Film. **9.45,** Golf demonstration by Ernest Bradbeer. **9.55,** Gaumont-British News. **10.5,** The New English Ballet in "Divertisement." **10.25,** News.

Post Office Wireless

SOME RECENT ENGINEERING DEVELOPMENTS

AS recorded briefly in last week's issue, Mr. A. J. Gill, Assistant Engineer-in-Chief of the Post Office, recently reviewed before the Wireless Section of the Institution of Electrical Engineers some of the more important developments of the last year or so that have been carried out by the Post Office Engineering Department, or with which that Department has been associated.

Ultra-short-wave links between outlying islands and the mainland, and across estuaries, etc., have become such an important part of our national telephone system that something approaching standardisation has apparently been reached in the equipment used.

For short-distance services up to 40 miles, a transmitter designed for frequencies up to 80 Mc/s has been developed; the unmodulated output is 1 watt. For longer distances there is an amplifier, to follow this small transmitter, which provides a 10-watt carrier. A 100-watt transmitter is used for distances of 100 miles, while still higher power is needed for the service to the Shetlands.

The receiver designed to work on these services is a superheterodyne, operating on an intermediate frequency of 3,000 kc/s, and provided with a crystal-controlled oscillator. A recent development is the substitution of two acorn pentodes in push-pull for the original first detector. The pre-set tuning system of the receiver operates by movement of a shorting clamp sliding on parallel copper tubes.

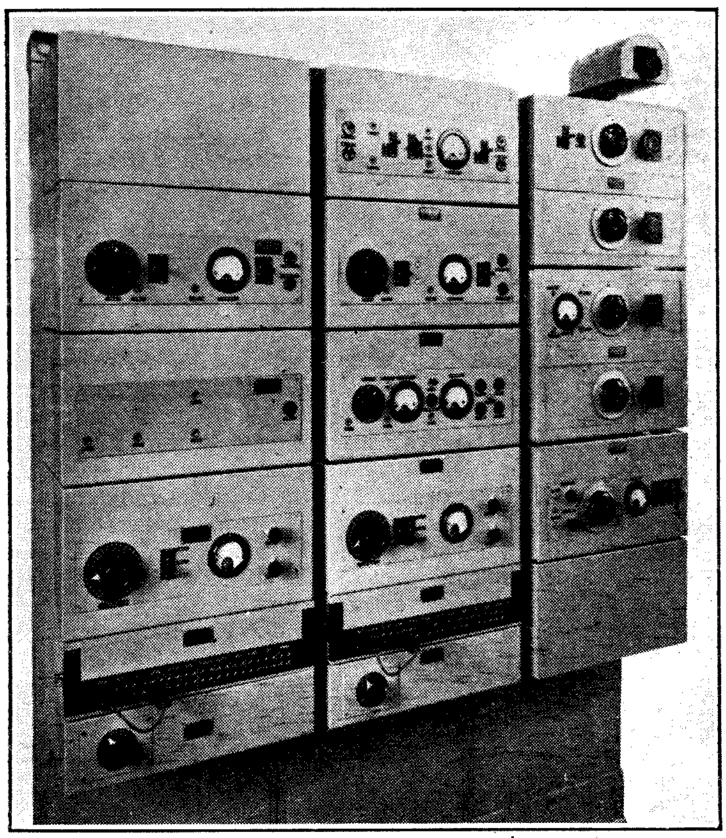
The results of studies made in the propagation of the higher frequencies (as used by the telephony links) are not yet available, but continuous graphical records of signal strength have been made for some time on the Channel Islands commercial service, which works on 37.5 and 60 Mc/s; the distance and elevation of the aerials is such that the path is non-optical. Severe fading—up to 60 db.—has been recorded, particularly on the higher frequency, but fortunately the fades are of short duration, and do not seriously interrupt the service.

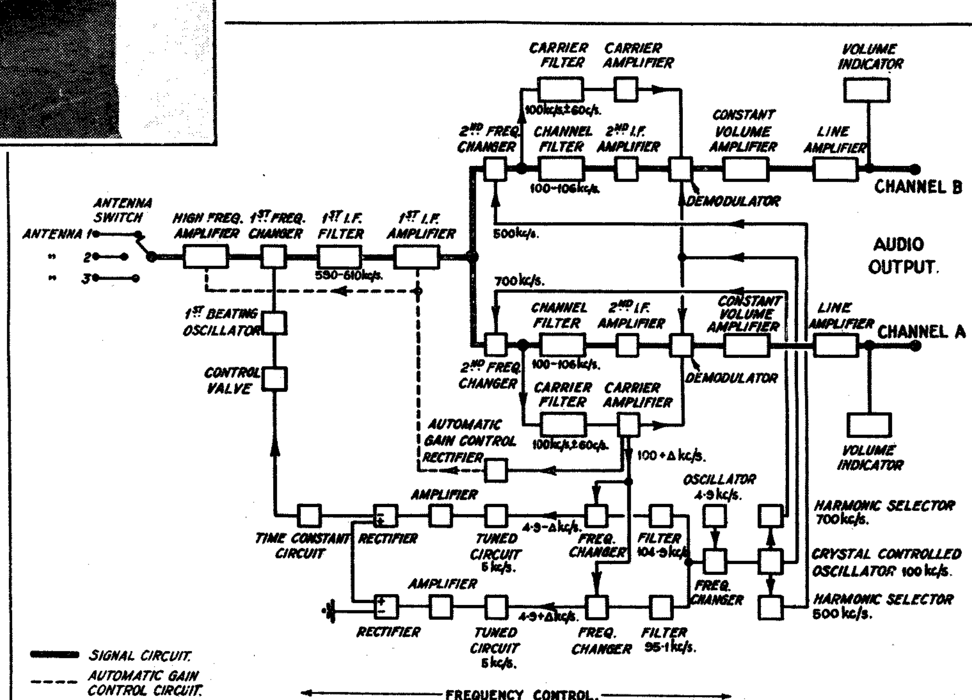
In the sphere of anti-interference a portable field strength and voltage measuring set has been developed and the design has been freely communicated to manufacturers. A second set has been produced for measuring interference on ultra-short waves; it has been found that commercial traffic may be seriously affected by motor ignition systems at distances up to quarter of a mile from the receiving aerial. The important fact emerges that at wavelengths of about 2 metres car interference falls off very rapidly and thus every incentive is provided for developing the use of these extremely short waves.

After dealing with improvements in frequency standardisation and describing some of the important work done on quartz crystals, Mr. Gill went on to discuss developments in transatlantic telephony, opening the matter with a discussion of those short-wave propagation phenomena that have led to the adoption of the single side-band method and the Musa Aerial System, which will be used by the P.O. station now being erected near Rochester. It is estimated that the total improvement in signal-noise ratio due to the use of single side-band may be taken as equivalent to from 9-12 db. (in other words, equal to raising the transmitted power from 8-16 times) as compared with the double side-band system.

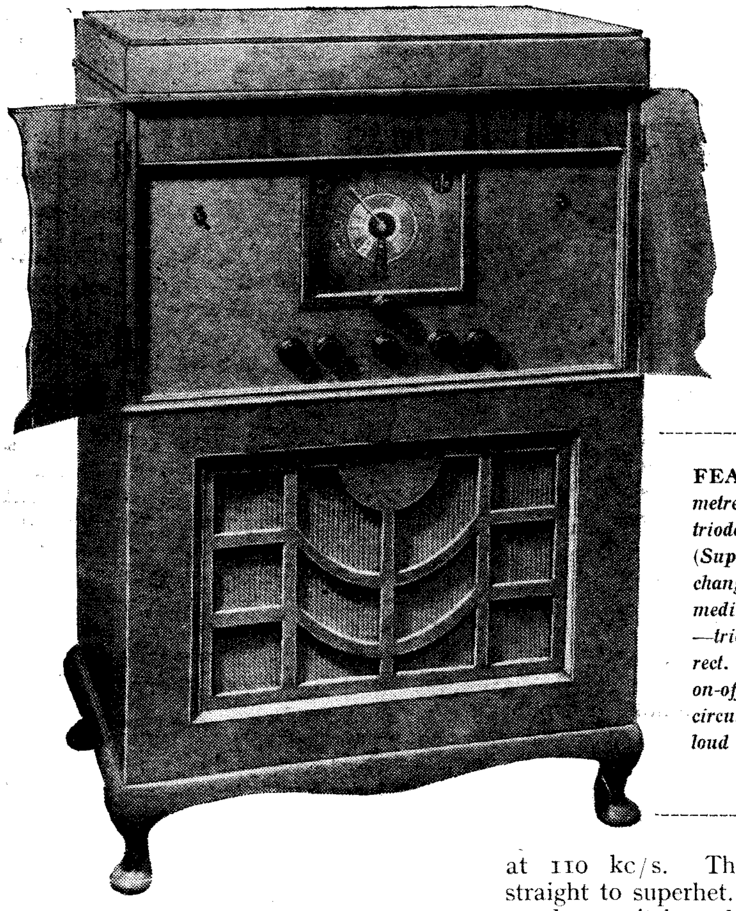
The receiver used for double-channel single side-band working across the Atlantic was described at length. Double frequency change is employed, the first frequency being in the neighbourhood of 600 kc/s and the second about 100 kc/s, thus good image-channel discrimination and adequate adjacent-channel selectivity are secured.

Mr. Gill closed by saying that the cost of the receiver for a long-distance phone service now approaches that of the transmitter—a very different state of affairs from that prevailing a little while ago.





OUTSIZE IN RECEIVERS. Apparatus designed for double-channel reception of single sideband telephony on the transatlantic public service. The block schematic diagram shows the basic circuit arrangement.



Halford

PHANTOM XV

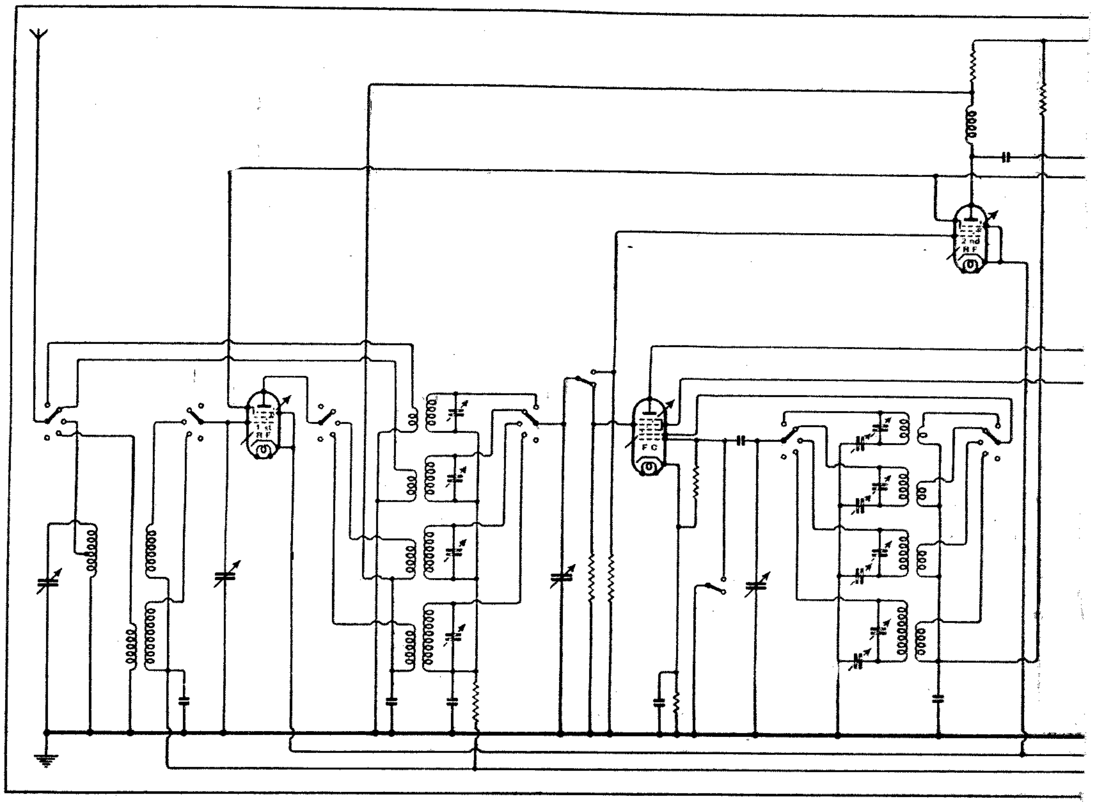
Separate Circuits for Long Distance and Local Quality Reception

FEATURES. ***Waveranges.***—*(1) 11-32 metres. (2) 28-75 metres. (3) 205-555 metres. (4) 850-2,000 metres.* ***Circuit.***—*(Straight) Two pentode RF ampl.—triode grid detector—triode first AF ampl.—push-pull double-triode output valves. (Superhet.) Pentode RF ampl. (medium and long waves only)—heptode frequency-changer—separate two-stage pentode IF ampl., 465 kc/s for short waves, 110 kc/s for medium and long—double-diode-triode second detector, AVC rect. and 1st AF ampl.—triode 2nd AF ampl.—push-pull double-triode output valves. Full-wave valve rect. Cathode ray tuning indicator.* ***Controls.***—*(1) Tuning. (2) RF gain and on-off switch. (3) AF volume control. (4) Waverange. (5) "Superhet.-straight" circuit switch. (6) Tone and selectivity switch.* ***Price*** *(chassis, power pack and loud speaker), 75 guineas.* ***Makers.***—*Halford Radio, 31, George Street, Hanover Square, London, W.1.*

ONE of the principal activities of this firm is the design of special cabinet work to ensure that the wireless receiving installation will blend satisfactorily with period and other expensive furnishing schemes. There is a wide range of more or less standard designs at prices ranging from 17 to 150 guineas, but when none of these exactly fulfils individual requirements alternative designs are submitted and the cabinet is made up specially. For example, an order was recently received to install a radio-gramophone in an ocean-going yacht and a gymbal mounting had to be evolved for the record-changing mechanism to keep it on an even keel.

It goes without saying that the foundation of this work must be a receiver chassis of the highest possible standard, and in their latest design the makers have shown a refreshing individuality of thought which distinguishes it from the ordinary run of mass-produced multi-valve sets. Not only are separate superheterodyne and straight circuits available for distant reception and high-quality reproduction from the more powerful stations, but separate IF amplifiers are used for short-wave and normal broadcast reception, the former working at 465 kc/s and the latter at 110 kc/s. The change-over from straight to superhet. is made by an independent switch and the IF frequency is selected automatically by the waverange switch.

In the interest of quality on medium waves, a band-pass input filter precedes the first pentode RF amplifier. When using the straight circuit a second RF stage is switched in and the output from this is taken to the triode section of the second detector stage, which is modified to operate as a power grid detector. With the superheterodyne circuit in action the output from the heptode frequency-changer passes through one of two pairs of IF valves to the double-diode signal and AVC rectifiers. The upper pair of valves in the circuit diagram are coupled by iron-cored transformers tuned to 465 kc/s and are in the circuit on the short-wave ranges. The lower pair are tuned to 110 kc/s and have air-cored transformers. In the latest production models two degrees of selectivity are provided by a third tuned circuit. The alternative band-



The change from superheterodyne to straight circuit (the latter with power grid instead of diode detection) is effected by a single control knob on the front panel. Separate IF amplifiers operating at 465 kc/s for short waves and 110 kc/s for medium- and long-wave reception are automatically selected by the waverange switch.

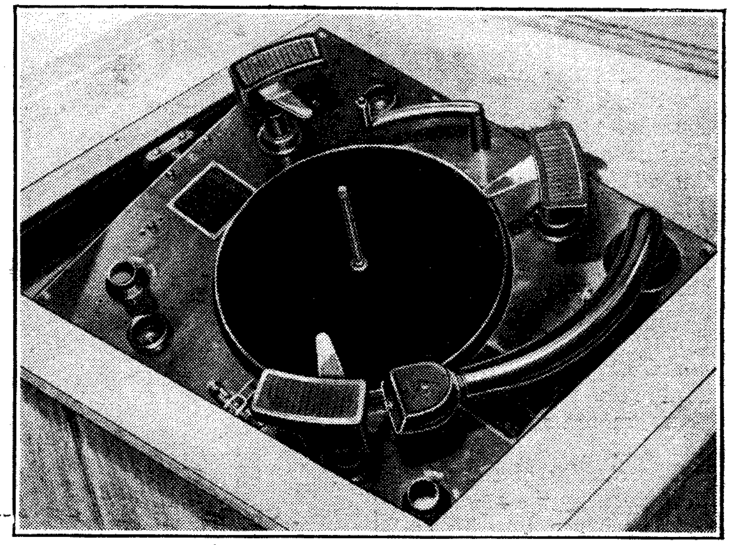
Halford Phantom XV—
widths are 6 kc/s and 9 kc/s, and the switching is combined with the tone control. Thus, the first two positions of the switch give maximum and medium high-note response with 9 kc/s bandwidth and the remaining three studs, maximum, medium and minimum response with 6 kc/s bandwidth in the IF amplifier.

Alternative Volume Controls

Both audio- and radio-frequency volume controls are provided, the latter controlling the RF stages in the straight circuit and both the RF and IF stages of the superhet. circuit for medium and long waves. To avoid all possibility of detector overload distortion in the straight circuit, no audio-frequency volume control is fitted and volume is regulated by the RF input. On an average aerial with the RF gain available there is quite an appreciable minimum, but this can be reduced at the time of installation by the service engineer.

A pentode valve connected as a triode acts as second AF amplifier in the superhet. and first AF amplifier in the straight circuit. It is followed by a parallel-fed transformer, the split secondary being connected to two double-triode output valves in push-pull. The HT voltage is 400 and under the conditions of operation the power-handling capacity of the output stage is 20 watts. Current for the 2,500-ohm loud-speaker field is fed through a resistance from the main HT line. A single full-wave power rectifier supplies the whole equipment and smoothing is by a two-stage filter making use of a total smoothing capacity of 45 mfd.

The combined audio- and radio-frequency resources of the superhet. circuit provide an overall magnification which was never fully extended during the course of our tests. On all wavebands more than enough volume was available with one control at maximum and the other anywhere up to half-way. The signal-to-noise ratio is good throughout, and as far as sensitivity is concerned, the absence of the RF stage on short waves would pass unnoticed. Double tuning points on the lower wavelengths, characteristic of the single tuned input circuit, were well marked. While they tend to congest the already crowded broadcast bands, it must be admitted that they often provide an alternative setting which is free from interference.



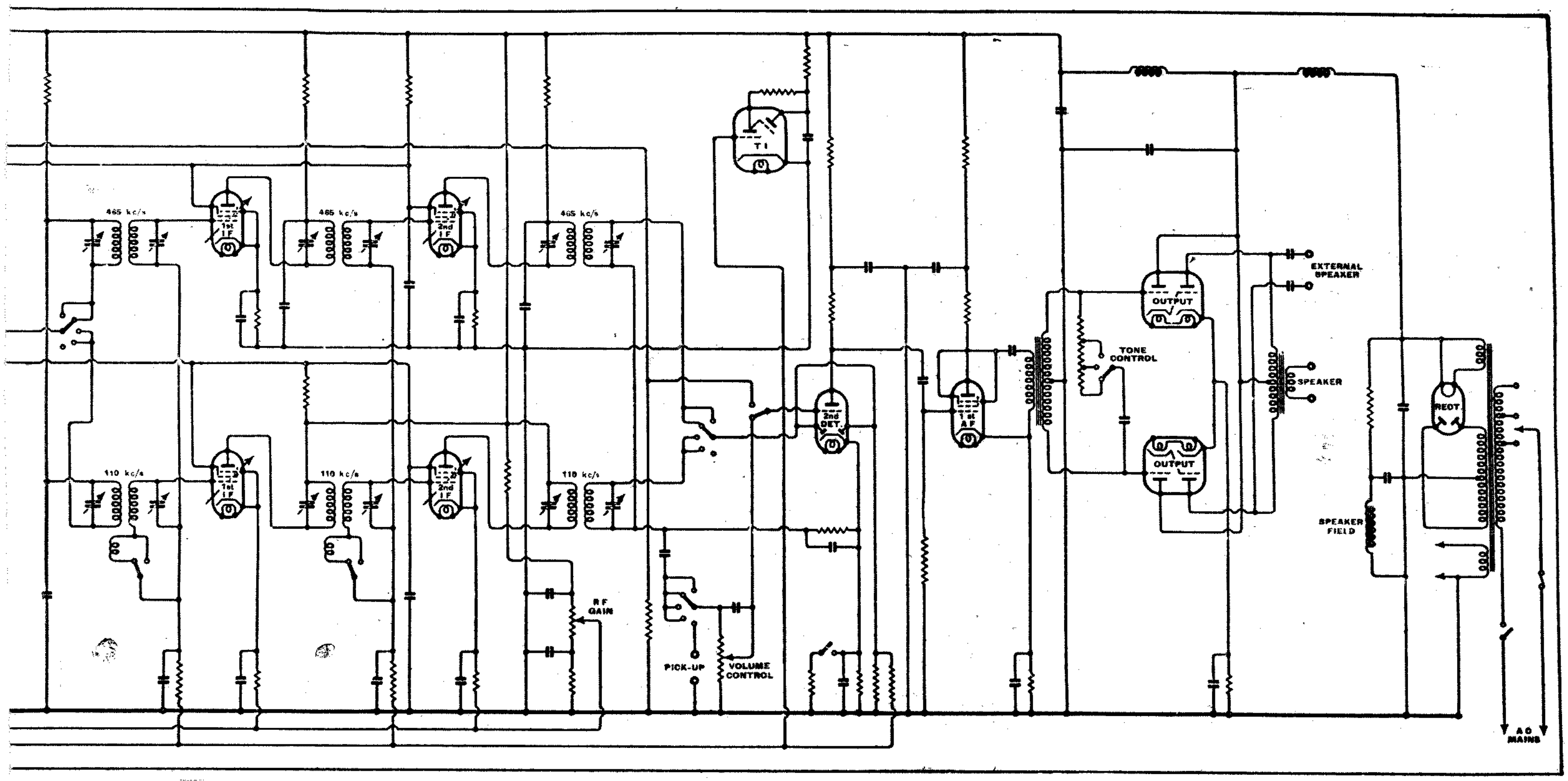
Gymbal mounting for the record-changer in a Halford radio gramophone supplied for use on board ship.

Maximum selectivity on the medium-wave band using the superhet. circuit permits an approach to the London Regional transmission with one channel of its normal setting at a distance of 15 miles. With the straight circuit only $2\frac{1}{2}$ channels are lost on either side of the "local" station, and elsewhere in the range the selectivity is just right for the type of transmissions for which the straight circuit was introduced. The sensitivity provided by the two RF stages is surprisingly good and for most of the worth-while Continental programmes it is quite unnecessary to use the superhet. circuit.

On long waves a slight background from Droitwich was noticeable when receiving Radio Paris with the straight circuit, but this would normally be corrected by the service engineer when installing the set finally on a given aerial system. With the superhet. circuit, on the other hand, clear-cut reception of the Deutschlandsender at full volume was possible without a trace of interference from either Droitwich or Radio Paris.

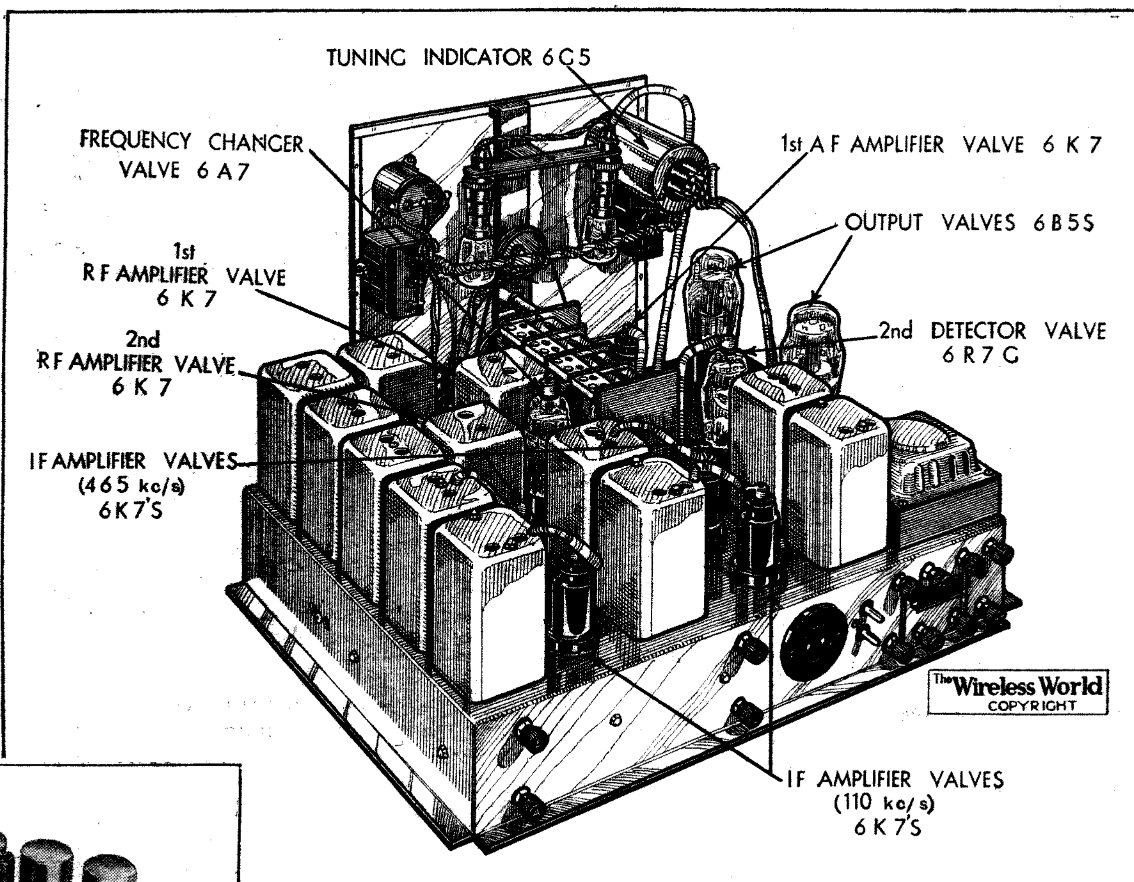
At maximum sensitivity a tendency to instability was noted in the vicinity of 1,350 metres (twice the intermediate frequency). Fortunately, this does not interfere with the enjoyment of any of the long-wave stations which are of programme value in this country.

Perhaps the most striking feature of this

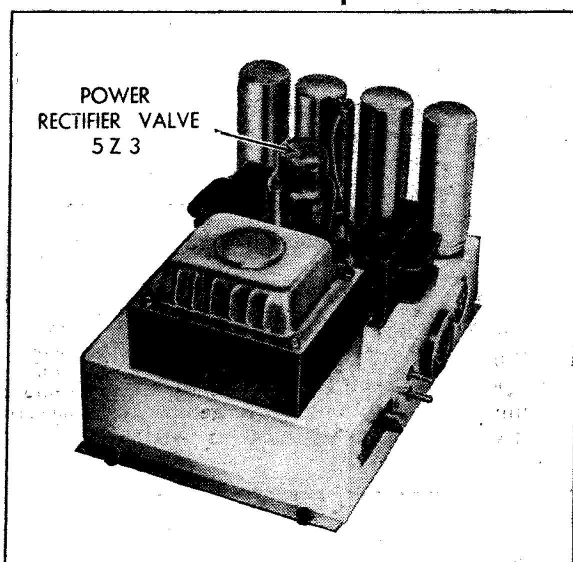


Halford Phantom XV—
receiver is the marked improvement in quality when the circuit is changed from superheterodyne to straight. This is not solely a question of frequency response. Transient reproduction and the segregation of instruments in orchestra are both strikingly clarified by the change-over and there is no doubt that this feature, which has been used in Halford sets now for many years, more than justifies its added cost.

The quality of reproduction given by the 14in. loud speaker has a breadth and firmness which is singularly well adapted to deal with all



Including the rectifier and tuning indicator, there are eleven valves in the receiver and power supply units. Six of the valves are of the "all-metal" type.



types of programme. The edge of the diaphragm is flexibly supported on an oiled silk surround and the apex is reinforced to sustain the high note response. An unusually massive electromagnet is fitted and the speaker seems well able to handle the 20 watts which is the rating of the output stage. This level is reached with very little apparent distortion and the makers have evidently mastered the technique of using these double-triode output valves to the best advantage.

A 6in. diameter tuning scale with 340-deg. rotation for the pointer is printed in different colours for each wave-band. The medium-wave scale carries close on sixty station names. Surrounding the tuning scale, which is set on a rectangular black background, are groups of lettering illuminated by pilot lights which show which circuit is in use and on which waveband. The 33 : 1 slow-motion drive is exceptionally smooth and quite free from back-lash.

As one has a reason to expect in a receiver of this calibre, the quality of components, workmanship and finish are beyond reproach.

New Books

Testing Television Sets. By J. H. Reyner, B.Sc. Pp. 128 + viii. Published by Chapman and Hall, Ltd., 11 Henrietta Street, London, W.C.2. Price 9s. 6d.

IN this book the author tackles the problem of television from the point of view of servicing, and theory is not considered in any detail. Emphasis is laid chiefly on testing methods as applied to the CR tube circuits and the time-base, it being rightly considered that purely receiver problems can be tackled on the usual lines adopted for broadcast sets.

The book is well illustrated by photographs which show the visible effect on the raster of many faults. Errors are unusually few, but one misstatement occurs on page 62. It is said that a slow line fly-back affects the right-hand side of the picture, whereas it is normally the left-hand side which is affected.

Complete Dynamic Testing. By Kendall Clough. Pp. 16. Available from Leland Instruments, Ltd., 46, Bedford Row, London, W.C.1. Price 1s. 6d.

THIS booklet is of American origin, and although intended as an aid to the use of Clough-Brengle cathode-ray gear, it contains much useful information of assistance to those using CR equipment for servicing. The uses of CR gear in adjusting and fault finding are explained, and the visible effects of many faults as shown on the screen are well illustrated.

CLUB NEWS

Radio, Physical and Television Society

Headquarters: 72a, North End Road, London, W.14.
Meetings: Fridays at 8.15 p.m.
Hon. Sec.: Mr. C. W. Edmans, 72a, North End Road, London, W.14.

On November 4th Mr. Edmans delivered a lecture in which he dealt mainly with the testing of transformers. Mr. Edman approached the subject from a completely non-mathematical viewpoint, and was successful, by the liberal use of vector diagrams, in stripping the mathematical bogy of many of its terrors.

Exeter and District Wireless Society

Headquarters: Y.W.C.A., 3, Dix's Field, Southernhay, Exeter.
Meetings: Mondays at 8 p.m.
Hon. Sec.: Mr. W. J. Ching, 9, Sivell Place, Heavitree, Exeter.

Mr. V. Searle, of the Physics Department of the University College of the South West, lectured before the Society on October 31st, his subject being "Pioneers of Radio." He dealt mainly with theorists and the way in which their ideas had been put into practice.

Eastbourne and District Radio Society

Headquarters: The Science Room, Cavendish Senior School, Eastbourne.
Hon. Sec.: Mr. T. G. R. Dowsett, 48, Grove Road, Eastbourne.

At the last meeting held by the Society Mr. G. Parr, of the Ediswan Co., gave a lantern lecture entitled "The Cathode Ray Tube and its Applications." He dealt with all the more customary uses to which the tube can be put and also explained the method in which the tube was used for the measurement of heart beats and of muscle strength.

Bradford Experimental Radio Society

Headquarters: 66, Little Horton Lane, Bradford.
Hon. Sec.: Mr. S. Hartley, 7, Blakehill Avenue, Fagley, Bradford.

A ciné lecture will be given at 8 p.m. on November 23rd on the subject of "Short-Wave Activities."

The annual subscription to the Society is 2s. 6d.

Band Spreading

A USEFUL TRICK

By G. C. F. WHITAKER

As the author of this article points out, the ideal tuning arrangement in a short-wave receiver would provide the same frequency range on the band spreading dial for all settings of the coarse-tuning control. The simple method of electrical band spreading described approaches much more nearly to this ideal than does the conventional system.

FOR many classes of work a set-up is required whereby the frequency of a given circuit can be quickly varied over a considerable range while at the same time a vernier or slow-motion adjustment is required to cover more precisely a small portion of the range—in common parlance, we need a "band spread" over the part of the range in use at the moment.

Methods of providing such a band spread can be divided into two classes, mechanical and electrical.[1] Of the mechanical arrangements there is little to be said. They consist simply of an adequate mechanical step-down gear ratio between the single condenser rotor covering the main range together with a suitable indicating device to enable accurate logging to be carried out over the vernier range. Their practical effectiveness depends entirely on the workmanship of the device, and the main frequency range to be covered, and varies from good to extremely poor with, on the whole, a tendency towards the latter.

Of the electrical methods of producing such an effect, by far the most common is the connection of a second variable condenser of limited capacity range in parallel with the main tuning condenser. Such a device is incorporated in a number of modern "communication" receivers, the supplementary band spread condenser being frequently built as an integral part of the main or "band set" condenser and using the same stator plates.

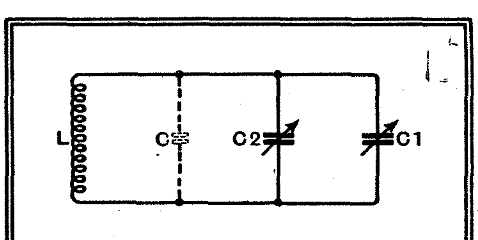


Fig. 1. The classical band spread circuit. C represents the stray valve and socket capacities, assumed as 33.7 m-mfds; C2 is the band set condenser, 15-350 m-mfds., and C1 the band spread condenser, 6.5-40 m-mfds. L, 1.74 microhenrys.

While this arrangement can be very effective, it suffers from one very considerable drawback unless the tuning range of the main or "band set" condenser is considerably restricted.

Consider the circuit of Fig. 1, which shows constants of the order likely to be encountered in a modern all-wave receiver on the higher frequency ranges. Calculating the frequency ranges covered by a full swing of the "band spread" condenser at full, half, and minimum capacities of the "band set" condenser we get the results shown in Table I.

A glance at these figures reveals the main objection to the method. It will be seen that at the minimum setting (a) of the band setting condenser a full swing of the band spreading unit covers a frequency range of 3,420 kc/s, whereas at the maximum setting of the main capacity the range covered by the band spread is only 260 kc/s. It is obvious that if a tuning dial ratio is selected for the "band spread" condensers which will give a suitable rate of tuning at the minimum setting of the band set condenser, it will be absurdly low at the maximum setting. Moreover, for calibration purposes, if the range of frequency covered at the minimum capacity of C is considered satisfactory, it will be far too small at maximum capacity.

Equalising Band Spread Ranges

Practical experience shows that this difficulty is a very real one. It can be met to a certain extent in receivers designed for short-wave use only by limiting the capacity of the band set condenser which will, of course, result in a reduced ratio between the band spread available at the two extremes of the scale. In practice, however, even if band set capacities of the order of 100 or 150 m-mfds. are used, it is found that the difference in band spread available at the two ends of the main condenser scale is still too large to be convenient.

The ideal arrangement would be one where the frequency range covered by the band spreading dial was identical at all settings of the band setting dial. It is not easy to achieve this ideal without a good deal of additional complication. There is, however, a simple arrangement, apparently not well known, whereby the ratio of band spread at the extremes of any band set range can be greatly reduced.

Consider the circuit of Fig. 2. L is the tuning inductance; C the valve, socket, and other residual capacities across the coil; C1 the band spread condenser, and C2 and C3 two identical sections of a two-section ganged condenser. It will be noted that the band spread condenser, instead of being connected directly in parallel with the main tuning condenser, is now connected in series with an identical condenser ganged to it. For convenience in comparison we will adopt the values used in the case of Fig. 1, thus L has a value of 1.74 microhenrys, C, 33.7 m-mfds., C2 and C3 a range each of 15-350 m-mfds., and C1 a range of 6.5-40 m-mfds.

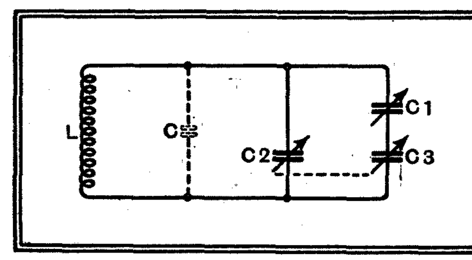


Fig. 2. Band spread system advocated by the author. Values: L, 1.74 microhenrys; C, valve and stray capacities, 33.7 m-mfds.; C1, band spread condenser, 6.5-40 m-mfds.; C2, C3, 2-section ganged band-set condenser, each section 15-350 m-mfds.

1 (a) With the band set condensers and band spread condensers all at minimum capacity the total capacity across the coil is :—$33.7+15+\left(\frac{6.5\times 15}{6.5+15}\right)=33.7+15+4.5=53.2$ m-mfds. Calculating the frequency we find it to be 16,530 kc/s. It will be noted that it is higher than that obtained in Table 1, due, of course, to the fact that the resultant capacity of C3 and C1 (both at minimum settings) in series is lower than the minimum setting of C1 connected straight across the coil.

1 (b) Advancing the band spread condenser C1 to maximum, the capacity

TABLE I.

Capacity Range.	Frequency Coverage.	Band Width.	Remarks.
	kc/s	kc/s	
(a) 55.2 — 88.7 = 33.5 mmfds.	16,220—12,800	3,420	Minimum setting of "band set."
(g) 256.2 — 289.7 = 33.5 mmfds.	7,530— 7,080	450	Mid-way setting of "band set."
(h) 390.2 — 423.7 = 33.5 mmfds.	6,110— 5,850	260	Maximum setting of "band set."

[1] See "Band-Spread Tuning," *The Wireless World*, July 28th, 1938.

Band Spreading—
across the coil becomes:—$33.7 + 15 + \left(\frac{40 \times 15}{40 + 15}\right) = 33.7 + 15 + 10.9 = 59.6$ m-mfds. Frequency is 15,620 kc/s; band spread, 16,530 – 15,620 = 910 kc/s; and capacity range, 59.6 – 53.2 = 6.4 m-mfds.

2 (a) Turning the band set condensers C2 and C3 to maximum and the band spread condenser C1 to minimum we get:—Capacity across coil – $33.7 + 350 + \left(\frac{350 \times 6.5}{350 + 6.5}\right) = 33.7 + 350 + 6.4 = 390.1$ m-mfds. Frequency, 6,103 kc/s.

2 (b) Advancing the band spread condenser to maximum the capacity across the coil becomes:—$33.7 + 350 + \left(\frac{350 \times 40}{350 + 40}\right) = 33.7 + 350 + 35.9 = 419.6$ m-mfds. Frequency is 5,438 kc/s; band spread, 6,103 – 5,438 = 665 kc/s; and capacity range, 419.6 – 390.1 = 29.5 m-mfds. The results are shown in tabular form in Table II.

TABLE II.

Capacity Range.	Frequency Coverage.	Band Width.	Remarks.
	kc/s	kc/s	
(a) 53.2 – 59.6 = 6.4 mmfds.	16,530—15,620	960	Minimum setting of band set.
(b) 390.1 – 419.6 = 29.5 mmfds.	6,103— 5,438	665	Maximum setting of band set.

Circuit constants as in Fig. 2.

Comparing these results with Table I we see that the effective capacity ratio of the band spread condenser now varies according to the setting of the band set condenser and that as a result the ratio of band spread at maximum and minimum settings of the band set is reduced to $\frac{960}{665} = 1:1.44$, as compared with $\frac{3420}{260} = 1:13.15$. Furthermore, far from having reduced the total tuning range by the addition of condenser C3, we have increased it slightly, the relative figures being 16,220 – 5,850 = 10,370 kc/s for the circuit of Fig. 1 and 16,530 – 5,438 = 11,092 kc/s for the circuit of Fig 2.

The actual value of band width covered by the band spread condenser can, of course, be adjusted by selecting an appropriate value for C1. For general purposes a maximum coverage on the band spread condenser of, perhaps, 2,000 kc/s per swing is convenient and permits the use of a dial with a 10:1 ratio.

One special point calls for attention. Both rotor and stator plates of condenser C1 are above earth potential. It is therefore necessary to mount this condenser on an insulated support and to drive it through an insulated shaft and coupling. This presents no difficulty, the requisite components for mounting and driving the condenser being readily available from most of the firms specialising in the sale of short-wave equipment. The arrangement is thoroughly practical and is worthy of more general adoption.

Transmitter's Jargon

SOME ABBREVIATIONS USED BY AMATEURS

ANYONE listening for the first time on the short waves to amateur transmitting stations may well be puzzled by the strange jargon used by some operators when describing portions of their equipment, or gear as it is generally called, or explaining some effect to the man at the communicating station.

Most of the terms employed are abbreviations arising out of the use of the Morse code, and they are employed to avoid sending more Morse characters than are absolutely necessary to convey an intelligible message.

For example, the listener may have heard some of the following: "My RX has three valves"; or "the TX does not appear to be working as well as usual." Another less common expression heard on telephony, but used extensively when sending Morse is "the WX here is. . . ."

To decipher these few: RX is an abbreviation for receiver and TX refers to the transmitter, while WX is an abbreviation for weather.

One may have heard "I had a long QSO with so and so." Well, QSO means that communication had been effected with whoever so and so happened to be. QRM is another commonly used expression and signifies interference with the received signals either from another station or from electrical appartus in the vicinity.

There are others in common use, but these are the principal ones, so that a knowledge of their meanings will be useful if one takes an interest in the activities of amateur transmitters.

Admiralty Handbook of Wireless Telegraphy, 1938. Vol. I: "Magnetism and Electricity." Pp. 144; figs. 216. Price: 4s. net. Vol. II: "Wireless Telegraphy Theory." Pp. 288; figs. 400. Price 6s. net. Published by His Majesty's Stationery Office, Adastral House, Kingsway, London, W.C.2.

THIS supersedes the single-volume edition of 1931. Volume I contains the same matter as the first seven chapters of the previous edition, with very little change, the remaining chapters VIII to XX of the old edition have been considerably expanded to form the new Vol. II, and the whole has been rearranged in sections, each distinguished by a letter of the alphabet, and each section subdivided into paragraphs numbered afresh from 1 in each section, there is no page numbering. The new volumes have a larger page than the old (11in. × 9in.), and contain many new figures.

One of the most noticeable increases is in the chapter on wireless telephony, which has more than doubled in size; there is also very much more information on receivers and amplifiers, both for telegraphy and telephony, than before.

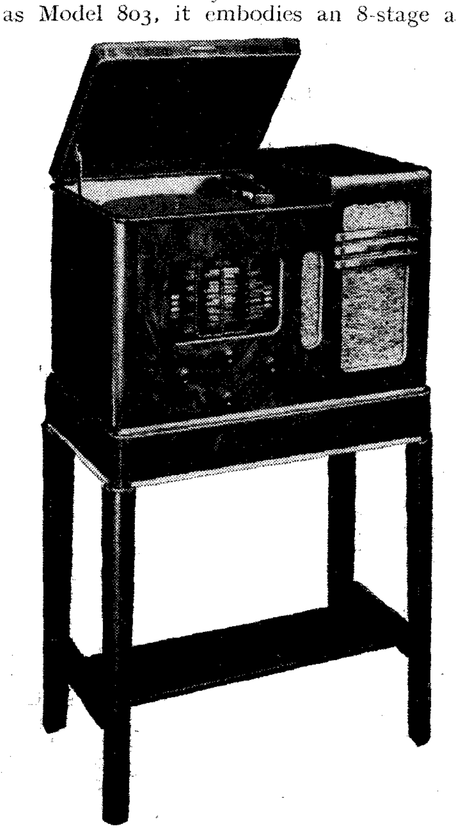
It should be noted that the Admiralty have now abandoned the use of the *jar* as a unit of capacity, it is unfortunate that this reform does not extend beyond the paragraph in which it is mentioned, and therefore the table of corresponding frequency, wavelength, and LC values (in "mic-jars") is less useful than it might be.

C. R. C.

McMichael Radio-gramophones

THREE NEW MODELS

A COMPACT radio-gramophone which can be used as table set or, with the help of a stand, as a floor model, has just been introduced by McMichael. Known as Model 803, it embodies an 8-stage all-



wave chassis (short waves 19-50 metres) with a triode-hexode frequency changer and a beam tetrode output valve rated at 5 watts. There is a 4-position tone control; the volume control is tone-compensated. Designed for AC mains operation, the set costs 16½ gns.; stand, 2 gns. extra.

A DC model of the existing McMichael 386 upright radio-gramophone has been added to the series; this is Model 386U at 22 gns. The AC Model 386 is also now available with a record-changer at 26 gns.

Letters to the Editor

The Editor does not necessarily endorse the opinions of his correspondents

Car Aerials

I MUST thank Dr. Lewis for his kind remarks, published in your last issue, and for putting forward his own speculations regarding the increase of signal pick-up of an under-car aerial when it is moved nearer to the ground.

Upon further reflection I am of the opinion that while an optimum position lies somewhere between the chassis and the mid-point from chassis to ground, there may be another maximum when the aerial actually touches the ground, since it introduces immediately a new set of conditions.

Although for obvious reasons the matter is of academic rather than of practical interest I will carry out further experiments in this connection when time permits.

F. R. W. STRAFFORD.

Belling & Lee, Ltd.,
Enfield, Middx.

An International Fellowship

I MUST congratulate you on your broad-minded outlook on the problem of the transmitting amateur, but there is one point which you do not appear to have made. In addition to the fact that the amateur ranks provide a potential source of trained operators in time of national stress, one must remember the very potent "ham spirit" which is a universal factor in good fellowship and international understanding. I am not an idealist by any means, but experience of the "ham spirit" is a thing never to be forgotten.

An "L" licence would doubtless reduce much of the shortage of CW experts, and for my part I should not regret the complete abolition of 'phone hash.

I am hoping to put in for an artificial aerial licence, and then for a full "ticket," in the course of the next few months, so that I may have a hobby which I may enjoy during my short periods of spare time.

London, S.E.18. H. J.

The Transmitting Amateur

I FEEL that such drastic suggestions as those made in your recent Editorials on Amateur Transmission should not go unchallenged, and I therefore trust you will forgive me for a few observations I should like to make.

The whole point appears to me to revolve round the question whether the majority of radio amateurs are amateur transmitters just for the amusement of pounding a key evening after evening or using their stations as a sort of private telephone system, or whether they adopt radio as a hobby because they are intelligently interested in wireless and kindred scientific matters and wish to extend their knowledge of the subject by practical experience. I somehow think that whilst the first group make the most noise they constitute merely a highly vocal minority, and that the majority of amateur transmitters in this country really are interested in building their own gear and "experimenting" with it. Whether the experiments the majority of them do are of much value in adding to the advancement of the science of radio communication is open to doubt. But there can be no doubt about one thing, and that is that every now and again out of this body of experimenters something of value does come. One has only to look back at the history of wireless communication to obtain proof of this.

Whilst commercial concerns can undoubtedly put more money and better brains into the field of research than any amateur organisation could hope to do, there are definite jobs which a commercial concern would never dream of doing which can be done by amateurs and which are of definite experimental value. I might mention as an instance the sort of work which is being done by active experimenters now on 56 Mc/s, where many listeners are keeping a patient watch on the band "just in case something of interest turns up." Something of interest has turned up for some of them, and it seems to me that by pooling the results obtained by these experimenters, as is done by the various societies concerned, something of real value must result.

For those interested solely in operating, excellent channels for such activities already exist. The Naval and Army Reserves, the R.N.W.A.R., and the newly formed Civilian Wireless Reserve, all want men whose chief interest is operating. These organisations have the proper machinery for training skilled operators, and they can do it far more efficiently than radio societies. The amateur radio organisation was never intended to be "a school for W/T operators."

Whilst I agree that the licensing regulations do need a drastic revision, I suggest that instead of ruling out the question of experimental work it should be encouraged and more care should be taken by the authorities to see that applicants for transmitting licences are genuinely interested in radio as a scientific hobby, and that they should severely discourage those who intend to use their stations solely as an easy means of chatting to friends a few miles away.

As regards increasing the popularity of amateur transmitting, I would suggest that the right type need no encouraging. The type that look upon it as a popular hobby —a new kind of amusement—are, in my opinion, definitely not an asset to the traditions of amateur radio.

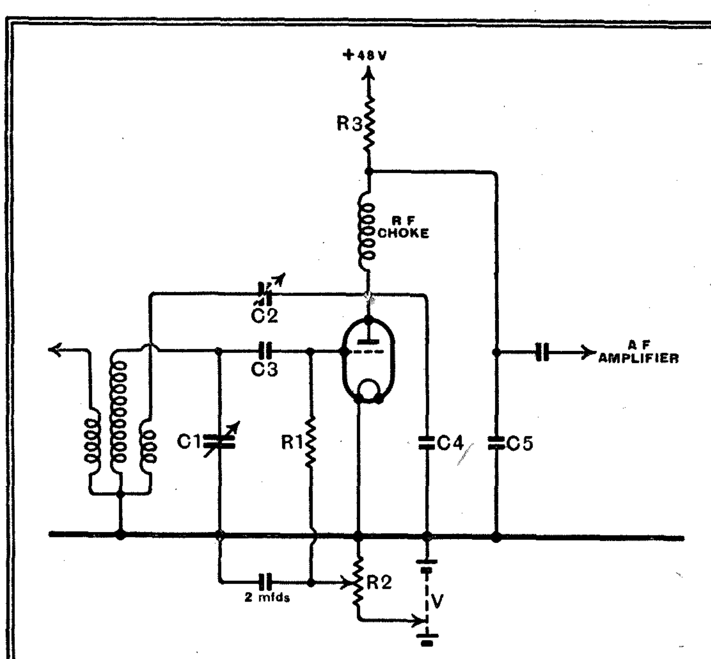
I might add that in spite of my call sign I am not an "old-timer."

A. C. GEE (G2UK).

Southend-on-Sea.

Short-wave Reaction Control

FOR some time past I have been experimenting with a view to obtaining a reaction control which would have no effect whatever on the tuning of a short-wave receiver. The well-known expedient of varying the screen voltage of an RF pentode used as a grid detector has the disadvantage that the detector is not always working at maximum efficiency. After many trials I decided that a condenser control was out of the question, as the change in capacity inevitably altered the tuning. A resistance control was then tried in various positions, *e.g.*, across the reaction coil, RF choke, etc., but in all these positions the control suffered from noisiness. A resistance control of the detector anode voltage suffered from the same defect as the original screen voltage adjustment. Finally, variable bias on the detector applied through the grid leak was tried and was found to be satisfactory in every way. The circuit used is shown in the diagram.



Reaction control circuit having negligible effect on tuning. Values: C1, 150 m-mfds.; C2, 100 m-mfds. max.; C3, C4, 100 m-mfds.; C5, 0.002 mfd.; R1, 2 megohms; R2, R3, 10,000 ohms; RF choke, 100 microhenrys; valve, Hivac D210.

A larger by-pass condenser than 2 mfds. can be used, but leads to some lag in the control. It is surprising that the control has no apparent effect on detector efficiency, but the sensitivity of the receiver to weak signals is indistinguishable from that of one having a more orthodox reaction control.

Summarising, the advantages of the control are as follow: (1) Absolutely noiseless; (2) applicable to a triode detector; (3) no hand capacity; (4) as the detector always has a −ve bias the control is exceptionally smooth; (5) range of control is easily adjustable by varying "V"; (6) absolutely no effect on tuning even at high frequencies; (7) no obvious effect on detector efficiency.

I hope that this will be of service to

Letters to the Editor—

others among your readers who may have been working along the same lines with the simpler types of short-wave receivers.

GEORGE A. HAY.

Newcastle-on-Tyne.

Television Service

I THINK your Editorial on the above subject may lead prospective purchasers of television receivers, even in the present service area of "A.P.," to assume that, in the event of the receiver needing repair or adjustment, they will be compelled to get into touch with the manufacturers, and generally go to a considerable amount of trouble to get it put right.

Actually, this is not necessarily the case. There are, in spite of a general impression to the contrary, a certain number of retailers (admittedly a minority) who regard servicing in all its aspects as a serious part of their business, and are prepared to employ an adequately trained staff, equipped with reasonable apparatus, to maintain a high degree of efficiency. As an instance, my own firm, working in a small village, has been installing television aerials and servicing receivers with complete success practically since the opening of "A.P.," and we have no reason to suppose that we are an isolated case.

If the radio listener (or television viewer) would use the same amount of discrimination in his choice of a dealer as the average housewife displays when she deals with a particular baker or grocer, a great deal of the dissatisfaction which undoubtedly exists at present might be avoided. Unfortunately a large number of people continue to deal with the firms who advertise the lowest charges, when it is obvious that servicing expenses are one of the first to be cut to allow low price levels.

Dorking. F. K. BARNETT,
Fellow of the Radio Engineers' Association.

Pick-up Resonances

IT was with great interest that I read the article on pick-up design in your issue of October 27th. I should like, however, to comment on the statements regarding the major resonances.

Resonance No. 2 mentioned in the article, i.e., medium frequency resonance due to mass of armature plus needle controlled by the springiness of suspension, can only take place when the needle is not resting on the record. As soon as the needle is resting on the record the springiness of the needle described as producing resonance No. 3 is effectively in parallel with the springiness of the suspension. Under working conditions resonances Nos. 2 and 3, therefore, merge, and become the main top resonance.

In addition to those described, there is a second tone arm resonance, usually slightly higher than the main tone arm resonance. The main tone arm resonance is due to the tone arm plus pick-up head moving laterally. The second one is caused by the fact that vibration of the needle can also apply a twisting force to the pick-up head and tone arm, the frequency being determined by the moment of inertia of the turning parts, and the torsional control exerted by the tone arm (this latter being modified slightly by additional restoring force via the needle).

With regard to high frequencies, I am glad to see that attention is being paid to the question of needle buzz. This I consider far more undesirable than the degradation of frequency response as such. There are, unfortunately, many records in which high frequencies have been recorded so loudly that even a new needle cannot follow the groove accurately. The resulting buzz renders high-quality reproduction of these records unsatisfactory. The trouble is greatly aggravated as soon as the needle develops flats, since a worn needle cannot follow high-frequency waves faithfully, no matter how perfectly they are recorded.

The trouble is not really due to the mechanical noise radiated by pick-up and record (easily "killed" by padding the inside of the lid), but to the fact that the inaccuracies in wave form appear in the electric output of the pick-up and, if faithfully reproduced, sound so much like a rattling diaphragm that the loud speaker is nearly always blamed.

P. G. A. H. VOIGT.

London, S.E.19.

Nation-wide Television

IN reply to some inquiries and criticisms of my suggestion as to the use of film recording as a means of establishing a national system of television, I beg to be allowed to add the following points:—

The suggestion being for the establishment of a number of stations, self-contained except for their dependence for supply of material from a central organisation, there is, I think, general agreement that such a system *would* be a solution to the problem, which in the absence of a better, and in accordance with the policy that a system is to be established, might be given a trial with such resources as are available.

It offers as a beginning the undenied advantage that it permits the establishment of the framework of a system, which, already complete in itself, might also be developed to prove such measure of direct scanning or cable-linking as demand required and finances permitted.

A perplexing point in the attitude of technicians towards television is the view that prevails in some quarters that a material medium of any sort is undesirable. It is perhaps explainable as a desire to pander to that obscure public taste—that fallacy that television would enable mother to see what father was up to. Considering the numerous forms and changes undergone by a scene on its way to the screen of the viewer—photo-electric, magnetic, electric, electronic, static, cathode-ray—it seems illogical to object to the chemical change involved in the use of film. There is further the fact that a three-dimensional scene has, of necessity, to be presented in two-dimensional form. Hence, a transition through a two-dimensional medium whose contrast is corrected with a view to the final effect, ought, theoretically at least, to render a more faithful reproduction.

Another peculiar feature in the launching of television has been the policy pursued of disregarding the principles followed with such success by similar-functioned institutions, such as the Press, broadcasting, cinema, theatre, thereby adding to the difficulties of a new mechanism that of obliging it to create a taste for a new kind of entertainment. If, instead of broadcasting on the one hand, scenes from raw self-conscious life, and, on the other, enlivened scenes from random-chosen pages of the *Encyclopædia Britannica,* television were to adopt the film medium, its programmes would embrace the topicality and picture interest of the Press, the flexibility of the cinema, the availability of world talent and the stability of a recorded programme.

With regard to the cost question, a rough estimate of the cost of a single station might be ascertained by considering the amount necessary to replace the Alexandra Palace Station minus its O.B. apparatus and associated maintenance, and considering it supplied with the necessary film material. On this basis the cost would be modest indeed. The public, I think, is ready and willing to pay extra for television. If the long view is taken that sound and vision will one day be inseparable a scale of licence charges might be so arranged that at the outset the licensee paid extra for television, and later a single fee for the combined services.

As to practical steps towards the inauguration of the system, there can be no useful purpose served in the continuance of the Alexandra Palace experiment in so far as the station is supposed to be the model from which provincial stations are to be designed. It is inconceivable that, on the one hand, such a station might be established in, say, Aberdeen, and, on the other—if the relaying principle were adopted—that its local character would have lasting popularity in Hull.

Lastly, it might be that in the introduction of television to the provinces there might be less of that lack of enthusiasm which has characterised the London debut of the art. And, enthusiasm being infectious, one might look to see a little of that spirit prevalent which marked the inception of radio and the "talkies."

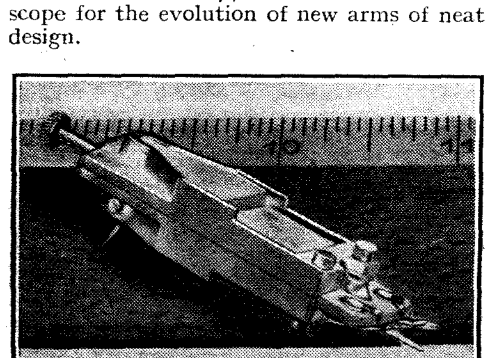
L. STAPLETON.

Greenford, Middlesex.

Crystal Cartridges

IN the majority of piezo-electric pick-ups the crystal element is mounted directly inside the tone arm housing, and replacement in the case of breakage involves work comparable in cost with that of manufacture. With the new Astatic bi-morph crystal assembly which is available (to manufacturers only) through Frank Heaver, Ltd., Bush House, Aldwych, London, W.C.2, not only are the costs of assembly reduced, but replacements can be made by the general serviceman.

The crystal is completely enclosed in a split die-cast case with a reinforced bakelite terminal strip clamped firmly at one end to support the foil output leads. Pre-set stops limit the movement of the needle and prevent damage to the crystal through careless handling. The width is only ⅝in. and the thickness 7/16in. so that there is scope for the evolution of new arms of neat design.



Astatic crystal cartridge for pick-up manufacturers. The major divisions of the scale in the background are inches.

Crystal Band-Pass Filters

Part III.—NARROW-BAND SYSTEMS FOR TELEGRAPHY

FOLLOWING upon the discussion of quartz crystals and their holders in the earlier articles of this series, the author now turns to the circuits in which they are used. A simple band-pass filter suitable for CW telegraphy reception is described and its advantages over a single crystal gate are discussed.

By E. L. GARDINER, B.Sc.

HAVING now obtained crystals of suitable type and in holders which will give consistent results, it becomes possible to combine a pair of these into a band-pass filter on the lines explained in the preliminary article. To a close approximation the width of the pass-band obtained will equal the frequency difference between the two crystals.

It will be convenient to consider, first, a very narrow band suitable for CW telegraph reception, since this illustrates the principle most simply. If, therefore, the filter is to be used in the IF amplifier of a receiver having a nominal frequency of 465 kc/s and a band-width of 0.5 kc/s (500 c/s) is selected, then crystals ground to natural frequencies of 465.25 and 464.75 might be used. As a rule, the intermediate frequency of a receiver need not be exact to within a fraction of a kilocycle, and hence it will meet the case to choose two crystals differing by a few hundred cycles and resonating at about 465 kc/s. One might, for example, be of exactly 465 kc/s and the other 465.5 or 464.5 kc/s. We can term the former at 465 kc/s a "reference crystal," and can choose any desired band-width by selecting another crystal with the appropriate frequency difference from it, which is often the most convenient method. For the present example the two crystals should not differ by more than 1 kc/s at 465 kc/s, or about 0.2 per cent. of any other frequency at which we may be working.

The crystals X and Y may now be placed in a circuit of the type shown in Fig. 7, where V1 might be the frequency-changer of a receiver and V2 the first IF stage. In adjusting this arrangement it will first be necessary to adjust the tuning of the input coil L until maximum response is obtained from a signal closely tuned to the intermediate frequency, and it will naturally be helpful if this can be obtained from a very stable signal generator, although many commercial radio signals can be employed successfully.

The curves to be given for this and other filters have all been measured by simple equipment which closely reproduces the conditions existing in a radio receiver. To the grid of V1 was applied an RF signal from a signal generator suitably modified by the addition of a very small band-spread condenser, which enables the frequency to be set and read off to within 0.1 kc/s upon a full scale of 10 kc/s. The majority of commercial signal generators can hardly be adjusted with the accuracy necessary to measure so narrow a band-bass curve, and it was found best to construct one specially for the work, in which the Franklin type of oscillator circuit was used to ensure stability and freedom from frequency drift.

The output voltage from the filter was measured by means of a sensitive diode voltmeter, incorporating a 0-120 micro-ammeter, and having a resistance of the order of 100,000 ohms. The peak voltages usually read were of the order of 5 to 10 volts. In most cases, including the present example, the diode voltmeter replaced V2, but in measuring some of the wider filters, to be described later, and in which there is a noticeable loss of voltage, V2 was retained as an amplifier.

It cannot be too strongly emphasised that the usual commercial method of measuring the response curve of receivers, namely, by means of a signal modulated at 400 c/s, and by working with a constant rectified audio output of perhaps 50 milliwatts with an adjustable input, is perfectly useless in the case of highly selective quartz filters. To be reliable, readings must be carried out with unmodulated radio-frequency voltages, because the filters are capable of picking out the side-bands and even the higher harmonics of the modulating frequency. As a result, these are read in place of the desired total signal, giving very irregular curve shapes.

It is quite easy to use a narrow crystal filter to pick out the side-bands of a modulated wave, and the side-band spectrum can be explored in this way with very interesting and instructive results. This ability to separate the side-bands from the carrier of a transmission is also easily observed in a receiver when a filter of a few kc/s or less in width is used to receive a telephony transmission. Measurement by modulated waves might be permissible if a very low modulating frequency, such as 50 c/s were chosen and if the modulation were strictly sinusoidal; but it is felt that the radio-frequency method is more reliable.

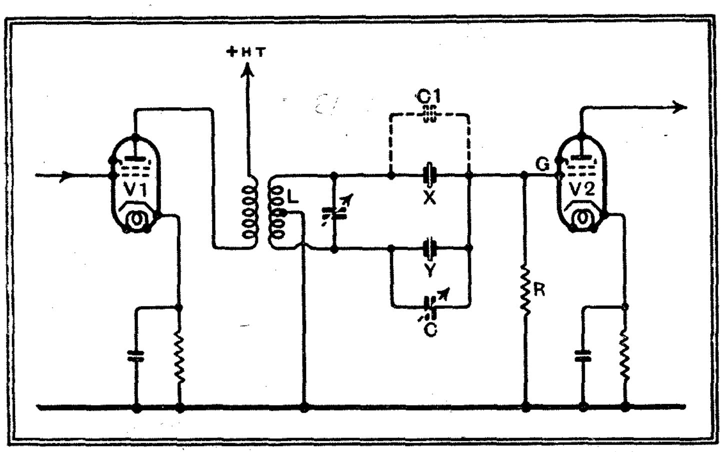


Fig. 7.—This diagram shows a typical crystal filter connected between two valves. The condenser C is adjustable and is used for balancing the crystal capacities.

Measuring the Resonance Curve

The best way of measuring a band-pass filter curve is undoubtedly that of substitution, the filter being replaced by an adjustable attenuator at each frequency tested, and the attenuator being set to reproduce identical input and output voltages to that shown by the filter. The loss introduced by the latter at each frequency is then given directly from the attenuator readings and under identical conditions of voltage, current and loading. The method demands, however, the use of an attenuator which is accurate at high radio frequencies, and, since this was not available, it was thought that the direct method described will truthfully represent the performance of the filters under radio-receiving conditions.

Having adjusted the input circuit L of Fig. 7, we now turn to the condenser C. It was pointed out in the preliminary article that if the parallel capacities (C1 of Fig. 4) of X and Y are equal, which include the capacities of their respective holders and the associated wiring, then no additional balancing condenser is necessary. Practically, however, this exact match is not likely to occur, and it will be helpful to join a small condenser of about 5 or 10 $\mu\mu$F across whichever crystal has the lower capacity, so that it can be adjusted to give exact balance.

Actually, certain advantages occur in having an adjustable balancing condenser, since later curves will show improvements with a slight departure from the balanced condition, as is well known in single crystal filters where the balancing or

Crystal Band-Pass Filters—

"phasing" condenser is used to eliminate interference. Hence, if the two crystals are so nearly equal as to provide insufficient range of adjustment, a small fixed capacity of a few $\mu\mu$F may be joined across the other crystal, as shown at C1 in Fig. 7. This will be chosen so that balance occurs near mid-scale on C, providing a range of adjustment on each side of the position which corresponds to a true capacity balance of the bridge. In a later article the validity of this balancing effect will be shown, and the important effects of unbalance explained in detail, with the help of performance curves.

To determine the balance point, the input to the filter is adjusted to a frequency several kc/s from the pass region, and well outside the response of the crystals. Theoretically, this should be infinitely remote from resonance, but in practice 5 or 10 kc/s will be found quite sufficient, and gives a value of C indistinguishable from that which would be obtained at an infinitely different frequency. When this is done it will probably be found that some energy is reaching G, and at a certain setting of C this should vanish completely, or be reduced by much better than -60 db. Should it not do so, there is an error in the circuit, or a source of stray coupling between V1 and V2, such as might be set up by insufficient screening or decoupling. It is useless to proceed with the filter until any such trouble has been cleared up, since naturally the more perfect a band-pass filter becomes the more serious will be any stray path by which energy can by-pass the filter. The balance point found in this way has been termed by the writer the condition of "balance at infinity," which seems a convenient term by which it can be described. Having got the condenser C to this setting, it should be left there whilst the curves of the filter are measured, being treated as a pre-set adjustment.

A measure result from the circuit of Fig. 7 is given in Fig. 8, the crystals actually being used at 465.0 kc/s and 465.2 kc/s. They were vacuum mounted, and had an effective Q of the order of 20,000. The balancing condenser was set to give zero response over the whole outside region, being "balanced at infinity" as described.

Practical Results

It will be seen that the curve approaches the ideal for telegraphic use, and would be exceedingly difficult to obtain from filters built up of normal coils and condensers. It is not flat across the pass-band, but the dip of about 3 db. would be hardly noticeable to the ear. We shall see later how it can be removed where necessary. The filter cuts off to -60 db within about less than 250 c/s on each side of the pass-band, and signals more than half a kilocycle from the intermediate frequency would be virtually inaudible unless of very great strength. Measurements below -40 db are not fully reliable from the equipment used, and the dotted portion of the curve is estimated from theory, practical performance, and the results of other workers. It is undoubtedly very near the truth, but depends very much upon the care with which the filter is set up, and upon the setting of the condenser.

Band-Pass Advantages

With careful design it is possible to improve quite appreciably upon the curve shown, for all the results reproduced in these articles have been measured from typical filters set up on the bench or in receivers, and much time has not been spent in adjusting the components to the best possible advantage. A feature of the filter is its extreme simplicity, which has been found in practice to make the circuit very reliable. A number of similar filters have been set up from time to time, and have given very similar results without trouble or long adjustment. A second feature is that the band-width can be quickly varied by changing or switching one or both crystals, whilst selectivity is concentrated into one coupling, a decided convenience in the design of receivers.

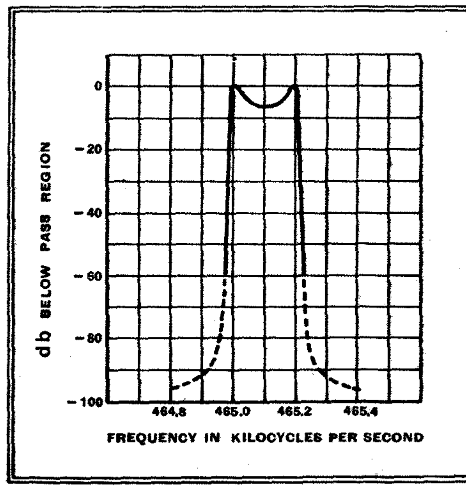


Fig. 8.—The resonance curve obtained with the filter of Fig. 7 is shown here. The extraordinary steepness of the sides of the curve is noteworthy.

It might be asked, what is the advantage of a narrow band-pass over the single crystal gate, which is also able to lift the wanted signals far above the majority of interference? In the case of low-speed signalling by hand, which involves a very narrow side-band indeed, the improvement in selectivity is not great, but there is a decided gain in practical convenience. The response curve of a single crystal is very sharply peaked, and we have already commented on the fact that tuning a signal to it by hand is a skilled operation.

If both the transmission and the receiver are perfectly stable, this tuning can be accomplished, and maintained. Under such conditions, however, the band-pass will yield a better ratio of signal to noise or interference, which has been approximately estimated at about $+60$ db. This is due to the fact that outside the band-pass the two crystals are in opposition, which is to say that both are assisting in the removal of interference. Hence the sides of the band-pass are steeper than those of a similar single crystal curve, and moreover adjustment of the balancing condenser will steepen both sides simultaneously, whereas in a single crystal gate one side-band can only be reduced at the expense of an increase of the other. As a result, under comparable conditions, the band-pass curve occupies less area than the single crystal curve as against 40 db. for a single crystal, which is much wider at the "skirts." It is well known that the reduction of noise by a selective circuit is approximately inversely proportional to the area of the resonance curve, and will, therefore, be greatest for the band-pass filter.

Under practical conditions the absolute stability assumed in the preceding paragraph is seldom achieved. The oscillator of a superheterodyne may or may not be stable, but a large number of transmissions are certainly far from perfect, especially in the case of amateur signals from distant countries. These signals may drift in frequency, often show traces of frequency modulation, or may be tone modulated. Many commercial signals employ interrupted or modulated continuous waves. In neither case is satisfactory reception possible through a single crystal. Should the transmitted frequency drift, constant readjustment of tuning becomes necessary, and is a great annoyance to the listener. Frequency modulated signals, or those which "chirp," cannot always be read through a crystal at all, whilst modulated signals lose most of their side-bands and are demodulated by the crystal.

CW Morse Reception

These difficulties disappear when a band-pass of half to one kc/s is employed. A reasonable degree of drift in either the transmitter or receiver is now possible before retuning becomes necessary, whilst frequency modulation will not matter seriously so long as the signals remain within the filter-width. Also, the side-bands of modulated signals will pass through the filter, if they do not exceed about a 500 c/s tone, and the character of the signals is retained.

When we come to consider the commercial case of high-speed automatic telegraphy the case is, of course, still more in favour of band-pass reception, since the single crystal will be unable to deal adequately with the band-width transmitted, and the code signals tend to run together and become blurred. Users of efficient crystal gate receivers will have noticed an unpleasant "ringing" effect which occurs when an efficient crystal is used at high selectivity. This is due to the very low damping of the crystal, which tends to continue vibrating after the exciting voltages have ceased. The effect also makes signals difficult to read, particularly if the sending is rapid. The use of two crystals in a band-pass circuit greatly reduces this defect, presumably because the carrier frequency now falls between that of the crystals instead of coinciding with one of them. As a result the crystals show little or no tendency to ring.

NEWS OF THE WEEK

BROADCAST EDUCATION

Ultra-shorts for School Broadcasts

ULTRA-SHORT waves are being increasingly used for educational broadcasting in America. Recently the Federal Communications Commission allotted twenty-five channels for this purpose. The New York City Board of Education is erecting a 500-watt station working on 41.1 Mc/s, and the Cleveland (Ohio) Board of Education is following suit with a similar 41.5-Mc/s transmitter.

According to *Education by Radio* (published in New York), the transmitter used by the Cleveland Board will serve 150 crystal-controlled receiving sets, each capable of operating up to thirty loud speakers.

Excluding the cost of three studios and two control rooms, Cleveland will spend approximately 24,000 dollars for the complete transmitting and receiving equipment.

REGIONAL BROADCASTS

Increased Power Contemplated

IN a letter to *The Times* on the subject of regional broadcasts, Sir Noel Ashbridge, B.B.C. Controller of Engineering, stated that plans for the contemplated increase in power have been prepared, but their execution has had to be deferred until the decisions of the European Regional Wavelength Conference, to be held in Switzerland early in 1939, are known. Apart from improvements (outlined in these pages last week) which the B.B.C. hopes to make at the London Regional station, the alternative programme service to listeners on the south coast will be materially improved when the new 100-kW transmitter at Start Point is brought into service in the spring of next year.

INTERNATIONAL RELAYS

A Geneva Broadcast Exchange ?

DESPITE the increasing sensitivity and selectivity of modern broadcast receivers, the movement to extend international relays in Europe is developing on ambitious lines.

At the meeting of the International Broadcasting Union now being held in Brussels, between twenty and thirty liaison officers from the principal broadcasting organisations are discussing the interchange of programmes.

The outcome may be the formation of a general programme pool. It is not difficult to envisage the time when this "broadcast exchange," situated probably at Geneva, would supply broadcasting organisations with a choice of programmes each day.

"AIR ON THE G STRING"

American Testimonials to Daventry

THE B.B.C. Empire Department hopes that all New Yorkers share the opinion so admirably expressed by the *New York Sun*. Describing October reception of Daventry, the journal says: "Good, bad and indifferent conditions made no difference when GSC went on the air. Sterling quality plus excellent programme material has made the G string the attraction of short waves. We know many a listener is lured away from the American commercials at 9.20 p.m., because England comes on the air at that time and continues to have a consistent signal until 11.20."

Chicago's *Radio Guide* said: "Best European reception in the late afternoon is now being afforded by GSP or GSD, DJB or DJD." The last two are, of course, the Zeesen transmitters.

N.B.C.'s HOLLYWOOD HEADQUARTERS

"The Ideal Broadcasting Plant"

AN interesting acoustic device in the four auditorium studios of the National Broadcasting Company's new Radio City in Hollywood is the provision of seats upholstered with material which absorbs the same amount of sound per seat when empty as that absorbed by a person when occupying the seat.

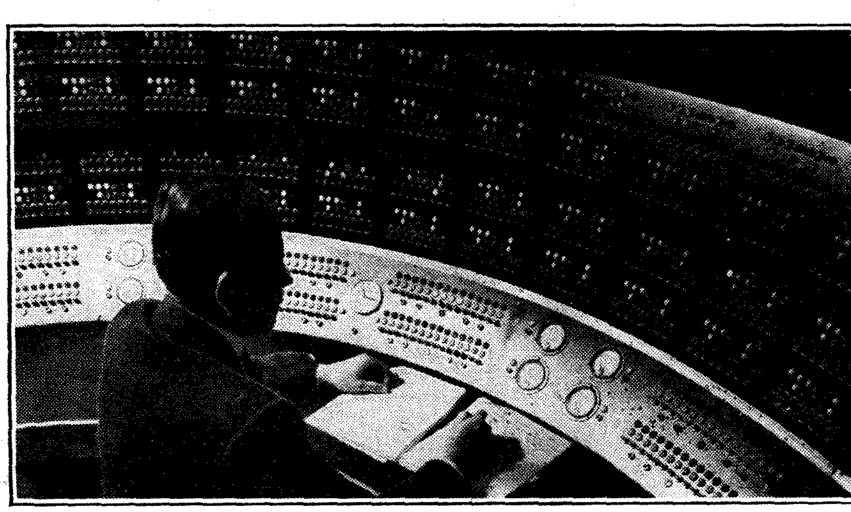
Each of the four studios, accommodating an audience of 340, is built as an individual unit on the same plan as a film studio but actually linked together with glass brick walls.

O. B. Hanson, the N.B.C.'s Vice-President and Chief Engineer, considers that Hollywood Radio City has given the engineers their first opportunity to build the ideal broadcasting plant. This is shown by the introduction of a system of pre-set switching whereby complicated switching from one set of channels to another can be prearranged, and when the time comes for a programme change merely to press a button. Each studio is equipped with twenty-one microphone plugs, nine of which can be in circuit at one time.

MORNING TELEVISION

OWING to the temporary closing down of Studio A at Alexandra Palace, the usual television film transmission, for demonstration purposes, from 11 a.m. to 12 noon, is, from Monday last, being temporarily given from 10 to 11 a.m. There being fewer telecine channels in Studio B, and as these are needed for rehearsals, it has been found necessary to change the transmission time until normal conditions are restored.

A SECTION of the Master Control Desk in N.B.C.'s New York studios through which programmes are sent to the N.B.C. short-wave transmitter as well as to 154 affiliated stations in the United States. The desk is linked with 14 programme circuits, including those to the N.Y. station transmitters, R.C.A. communications, and short-wave stations W3XAL, W2XAD, W8XK and W1XK.



THREE NEW TRANSMITTERS FOR TURIN

Is It a Record ?

ON October 28th three new transmitters were put into operation at Turin. Is this the first time a city has been furnished with three new transmitters in one day?

The transmitters are housed in the building which has been the home of the 7-kW Turin station since 1928. A 30-kW transmitter is operating on Turin's old wavelength of 263.2 metres. The 0.2-kW transmitter installed in 1933 has been replaced by one of 5 kW and will work on the Italian common wavelength of 221.1 metres. A second 5-kW transmitter will work on the same wavelength as Milan III, 209.9 metres.

CINEMA TELEVISION

BAIRD large-screen (8ft. by 6ft.) television was again demonstrated at the Tatler Theatre, London, on the occasions of the transmission by the B.B.C. of the Lord Mayor's Show and the Armistice Day ceremony at the Cenotaph. Using a new projection receiver the definition was extremely good.

It may be that some readers wonder how it is that these demonstrations can be given in spite of the B.B.C. ban on the public showing of television. The fact is that on such occasions of national importance as these the B.B.C. ban is lifted and it must also be remembered that no charge was made for admission to either of these performances.

441-LINE TELEVISION

New Schedule for Berlin Transmitter

AFTER the close of the Berlin Radio Exhibition in August, the city's television station limited its experimental transmissions to an hour of film excerpts broadcast every weekday evening on 441 lines, which was repeated on 180 lines.

On November 1st a series of trial broadcasts was introduced between 8 and 10 p.m. each week-day. These transmissions, consisting of studio and film productions, are given on 45 Mc/s, sound, and 47.8 Mc/s (441 lines), vision; they will continue until the service is officially opened.

A BIRTHDAY IN GERMANY

THE completion of fifteen years of service was celebrated by the German broadcasting authorities on October 29th, and it is interesting to

News of the Week—

examine the increase in Germany's total aerial power during that period. In 1923 it was 0.25 kW; in 1928 it had risen to 74.5 kW. By 1933 it had increased to 668.25 kW., and now, in 1938, it is 949.75 kW, which total, with the addition of the Austrian transmitters, now reaches 1,114.25 kW.

B.B.C. TELEVISION DEFINITION

SIR STEPHEN TALLENTS, B.B.C. Public Relations Controller, gave this definition of television in a recent after-dinner speech:

"Excited by impulses borne on a carrier wave which vibrates 45,000,000 times a second, a spot of light $\frac{1}{32}$in. in diameter, travelling at a rate of 6,000 miles an hour, and varying in its illumination up to four million times a second, traces 25 times a second in alternate lines, a page of 405 lines on the opposite and sensitised end of a cathode-ray tube. The sight and sound signals are synchronised to within one four-millionth of a second."

WINTER WAVELENGTHS FOR DAVENTRY

DAVENTRY has switched over to its winter wavelengths. At the beginning of October many Empire listeners noticed that the signals were spasmodic, due to disturbances in the ionosphere. The effects were accentuated by the seasonal fall of the ionisation levels.

To cope with the changed conditions, Daventry has reverted to lower frequencies with practically every transmission, and it is hoped that the standard of transmission will be maintained at an efficient level.

FROM ALL QUARTERS

A New Moravska-Ostrava ?

IT is rumoured that Czechoslovakia is to build a new transmitter to take the place of the Moravska-Ostrava station which was in the territory ceded to Germany and is now known as Schönbrunn. The studios in the town are, it will be remembered, still the property of Czechoslovakia.

Another Czech Station Lost

HAVING occupied the territories which have been ceded by Czechoslovakia, Hungary has now assumed control of the Kosice (now called Kassa) 10-kW 259.1-metre transmitter. The number of Czech stations has thus been reduced from seven to five: Prague, Melnik, Brno, Bratislava, and Banska-Bystrica.

German Anti-interference Division

IN the course of the six years since its introduction, the German anti-interference service has dealt with nearly one and a half million cases, and of these some 850,000 have been suppressed. The Post Office maintains a staff of 3,000 on this important branch of its work, and, apart from 2,000 portable interference detectors, 300 detector cars are used.

Peoples' Sets in India

MR. C. W. GOYDER, Chief Engineer of All-India Radio, on his return from a European tour, stated that he had informal discussions with radio manufacturers in Europe regarding cheap radio sets for India. The production and marketing of these, however, was found to be a difficult problem both from the commercial and economic point of view, and it was therefore improbable that cheap receivers would be available for some time to come.

Indian Economy

As a result of an economy drive by the Government of India, the opening of the All-India Radio stations at Trichinopoly and Dacca will be delayed, and it is unlikely that they will be inaugurated until after the commencement of the next financial year. The opening of the Karachi and Patna stations will be postponed indefinitely.

A STUDIO GROUP in the new short-wave station erected by the Italian authorities at Addis Ababa. The 5-kW transmitter (a section of which is shown right) replaces a temporary 1-kW station and will be largely used to retransmit programmes from Italy; its power can be increased to 25kW

Philips Transmitter for Burma

THE Burmese Government has ordered a 10-kW Philips short-wave broadcasting transmitter for installation at Rangoon. It has a wave range of 30-90 metres and is of the same type as the four Philips transmitters in use in British India. A studio installation will also be supplied by Philips.

Licence Fee Reduced

THE Government of India, in a further endeavour to popularise broadcasting, has reduced the annual licence fee from Rs10 to Rs8 (15s. to 12s.).

Wireless Reserve Controller

THE Reading representative of the Radio Society of Great Britain, Mr. A. E. Lambourne, G5AO, has been appointed Regional Controller of the Berkshire, Buckinghamshire, and Oxfordshire sections of the R.A.F. Civilian Wireless Reserve.

Skegness Beam Station

WITHIN the next two years the Skegness beam wireless station will, we learn, be dismantled. The reason given is the centralisation of the Post Office services.

Foire de Paris, 1939

THE 31st Paris International Trade Fair will be held next year from May 13th to 29th.

Amateurs in America

SPEAKING recently in Washington, the Hon. Frank R. McNinch, Chairman of the U.S. Federal Communications Commission, stated that the United States had 80 per cent., or 49,000, of the world's amateur transmitting stations.

Electrotechnical Vocabulary

THE first edition of the International Electrotechnical Vocabulary, which was announced some months ago, has now been published by the International Electrotechnical Commission. About two thousand technical terms in English, French, German, Italian, Spanish, and Esperanto are included. The terms, under various headings which include radiocommunications and telegraphy and telephony, are defined in both English and French. Copies, price 10s., or 10s. 6d. post free, may be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1.

Italy's SW Centre

IN addition to the five powerful transmitters at the Italian short-wave centre at Prato Smeraldo, opened by Signor Mussolini on October 31st, it is now made known that there are three 1-kW transmitters. Each of these is experimental, and can therefore be operated on various frequencies and aerials.

New 120-kW Station

FOLLOWING the decision of the Lithuanian Cabinet to replace the present long-wave transmitter near Kaunas with a new high-power station, an order has been placed with Standard Telephones and Cables for a 120-kW transmitter to be erected at Babtai, about 20 miles from Kaunas.

How Many Do You Hear ?

BROADCASTING stations throughout the world numbered 1,550 at the end of 1937, according to the Bureau of the International Union of Telecommunications.

Berlin Radio Exhibition

THE 1939 Berlin Radio Exhibition is scheduled to run from July 28th to August 6th. It will be held in the Berlin Exhibition Halls.

New Radio Beacon

AT this month's meeting of the Tyne Improvement Commission it was stated that the Harbour and Ferry Committee was satisfied with the report from the Marconi Company on the proposed wireless beacon at Tynemouth Pier lighthouse. The project has now been submitted to the London Trinity House and Board of Trade for their approval.

Mushrooms in the Sky

IT is reported from Berlin that fungus has appeared on the wood of a 160-metre mast of the Berlin regional transmitter. The Post Office has started repairs which entail the dismantling and rebuilding of the top half of the tower. An auxiliary aerial is being operated until the work is completed.

Radio Publications

SWEDEN is now the only Scandinavian country in which the State broadcasting organisation publishes its own journals. It has just absorbed one of the private radio weeklies, *Radiolyssnaren*, which, as from January 1st, 1939, will be merged with the official programme weekly, *Roster i Radio*.

Radio Cinemas

CINE PARIS-SOIR-RADIO-37 is the name of a new theatre that opened in Place Clichy, Paris, on November 2nd. It is the first of five such theatres which will combine presentations in the forms of both radio and films.

A New Set

AN AC push-button receiver at the low price of 10½ guineas was released by Philips at the beginning of this week. Known as Model 555, it gives unrestricted automatic selection of six stations by the recently introduced "sliding condenser" mechanical system and embodies a 3-band superheterodyne circuit. A DC model, with built-in converter, is available at 11½ guineas.

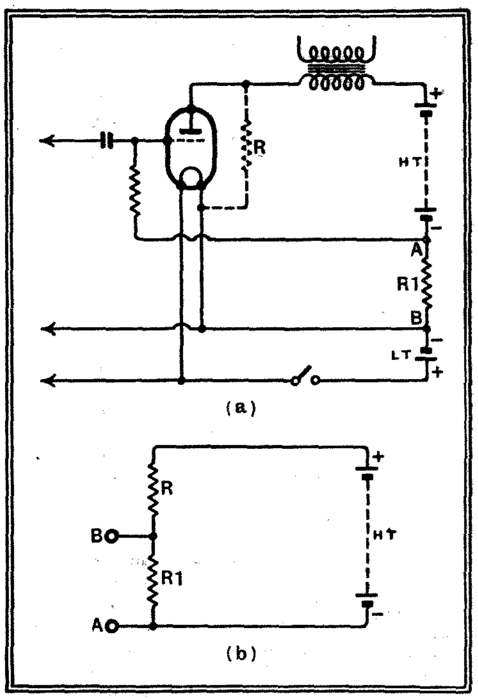
Readers' Problems

A Selection of Queries dealt with by the Information Bureau, and chosen for their more general interest, is published on this page.

Automatic Grid Bias Set

WE are asked to explain how grid bias is obtained in a battery set by joining a resistance between the negative of the HT and LT batteries, and if there is any easy way of remembering to which end of this resistance the grid return lead of the output valve should be joined.

Circuit (a) shows a typical case of this kind, resistance R1 being the bias resistance. It will perhaps be easier to understand how R1 provides a negative bias by reference to circuit (b). Here the anode-filament path of the valve is represented by a phantom resistance R, which is in series with R1, both being joined directly across the HT battery. Obviously the point A is the most negative part of this circuit, while B is some positive value, since R and R1 form a potentiometer. Now as the filament of this valve is joined in circuit (a) to point B, by returning the grid lead to point A the grid becomes negative in relation to the filament.



By re-drawing circuit (a) as shown at (b) it becomes easier to understand the automatic bias scheme used in battery sets.

It need only be remembered that the most negative point in this circuit is the negative terminal of the HT battery.

Valves for 2-RF Set

IT is proposed to build the 2-RF set modified for use with the Push-Pull Quality Amplifier, as shown in *The Wireless World* of March 17th last. As four-volt valves are suggested for the detector and phase-splitting stages in this revised circuit, our assistance is asked in the choice of this class of valve for the RF stages.

In choosing the 4-volt type valve for the RF stages in this set it has to be borne in mind that those used originally were the top-grid variety. Valves having as near as possible similar characteristics should be used, and those of very high mutual conductance are best avoided or instability will be encountered.

On this basis satisfactory substitutes would be the Marconi or Osram type W42, which can be used in both stages. The only alteration necessary will be to change the bias resistance in the cathode circuit of the second RF stage for one of the same value as that used in the first RF stage.

Modernising New Monodial Super

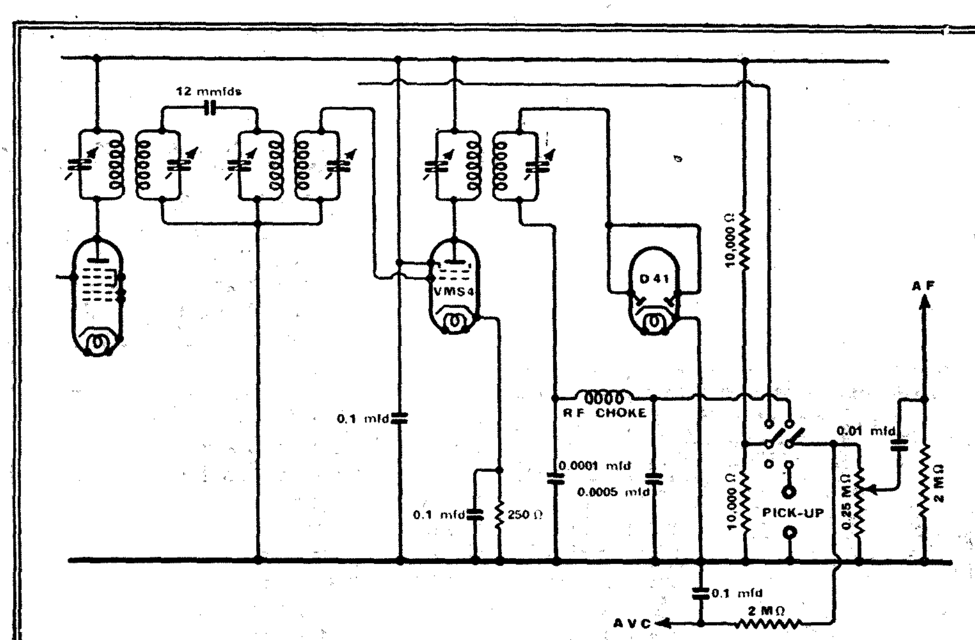
MANY old receivers still continue to give highly satisfactory results, and, until some defect develops, or a valve burns out, are allowed to carry on without attention.

When such time arrives that the chassis has to be removed from its cabinet, then the possibility of making a few improvements is considered, which has no doubt prompted a reader to enquire what modifications of not too drastic a nature one would advise to a New Monodial Super now being overhauled.

In order to bring this set more in line with modern practice, the DD Pen valve can be replaced by an ordinary diode for detection and AVC, and this portion of the receiver rearranged as shown in the circuit reproduced here.

This change leads to a certain loss in AF amplification, but it is not suggested that any further amplifiers be included, and the output from the detector can be fed into the existing MHL4 valve.

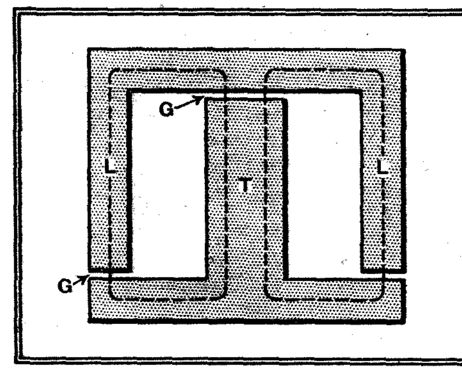
As the receiver has an RF stage, its sensitivity is adequate for most purposes, and full loud speaker output will still be obtainable on all the regularly received stations by turning up the AF volume control a little more than hitherto. It has to be remembered that the AF gain of this set was exceptionally high indeed, so that a little reduction can quite well be tolerated.



Modified detector circuit for the New Monodial Super using a diode for detection and for AVC.

Air Gap in Iron Core

THE design having been worked out from *The Wireless World* Data Charts for a smoothing choke, a figure of 0.002in. has been obtained for the air gap. The laminations to be used being of the T and U shape provide three joints, and we are asked if each of these joints should have a gap of 0.002in. or if this figure should be divided by three.



Iron core for which individual air-gap sizes are required.

If the figure quoted for the air gap is the total air gap as we suspect, then each joint in the core must be spaced 0.001in. From the drawing it will be seen that with a core of this kind there are two magnetic paths, as shown by dotted lines. The total flux in the core traverses the centre limb T, after which it divides, one-half traversing each of the outer limbs L. Thus there are two magnetic paths in parallel, so that one could actually cut the core down the middle of the centre tongue T and fold the right-hand portion over on to the left-hand part without altering the general characteristic of the core.

Thus it will be seen only two gaps now exist, marked respectively G, G, and the figure for total air gap is divided equally between them.

UNBIASED

By FREE GRID

Radialchemy

THERE are occasions, as we all know, when even Homer nods, a thing which he did pretty often, judging by the regrettable ignorance he displays in his thriller, "The Odyssey," concerning the colour of the Mediterranean Sea. However, it is not Homer this time but myself that has overlooked a point, and readers have not been slow to bring it to my attention.

Not Homer.

I referred the other week to the fact that modern scientific thought inclines to the view that there are only two things in creation, namely, electrons and ether waves, and if we sent out the correct etheric waveform from a transmitter in London which was "beamed" on New York, the result would be that at the receiving end in the latter city the waves would so mould the electrons that they formed chalk or cheese or whatever else it was that we desired to send. My correspondents rightly point out that such a possibility has a great deal more in it than might appear to be the case at first sight, since it obviously means that the problem of transmitting power by wireless is definitely solved.

Hitherto, as is well known, scientists have concentrated on the idea of building a transmitter of enormous power so that at the receiving end the resultant current set up in the aerial circuit would, when rectified, be sufficient to provide enough electric power to supply a whole town with light and heat. Such a transmitter would have to be of tremendous power, and would be very expensive to run. It would be far simpler and less expensive, as my correspondents rightly point out, to build a comparatively low-powered transmitter and use it to send out the correct waveform to cause the electrons at the receiving end to form themselves into coal and oil which could be used in a generating station in the ordinary way.

Somehow I can't help thinking that, although I personally cannot detect it, there must be a snag somewhere in this scheme, as it seems to me to be too simple to be true; perhaps one of you can see it. If there is no snag, I shall be glad if one or two company promoters would write to me, as I am not very conversant with modern financial methods.

Since writing the foregoing I have been taken to task rather unworthily by certain critics for mis-spelling the word "odoriferous" when writing my original treatise on this subject, and also for making use of a hybrid Greek and Latin word like "teleolfaction." With regard to the first charge I cannot do better than to quote the words uttered recently by the Archbishop of York when speaking at one of our great seats of learning, namely, "Intellectually, spelling doesn't matter." As for the word "teleolfaction," it absolutely goes against the grain for me to use it, and I did so merely because I am compelled to pander to the low and vulgar tastes of the illiterate masses, to whom also the equally distressing word "television" is more acceptable than the more correct "telescoption."

"The Cheeserwitch"

IF there is one thing more than another which gets my goat about the B.B.C. it is the air of pseudo-culture and education with which they endeavour to surround themselves. This comes out particularly strongly in their blundering attempts at pronouncing words of foreign origin. A typical instance of the sort of thing I mean occurred recently when the Cesarewitch was front-page news. To my way of thinking this should be given its traditionally anglicised form of pronunciation, but if an attempt is to be made to use the correct Russian method it should at least be accurate. It is, however, evidently too much to expect the B.B.C. to lose caste by using such vulgar and "unrefained" language as holds sway in Newmarket or Moscow. Italian is, however, a language of culture, and so the word was Italianised. But what else can you expect from people who refer to the late Emperor of Russia as the "Char"?

A Lament for the Past

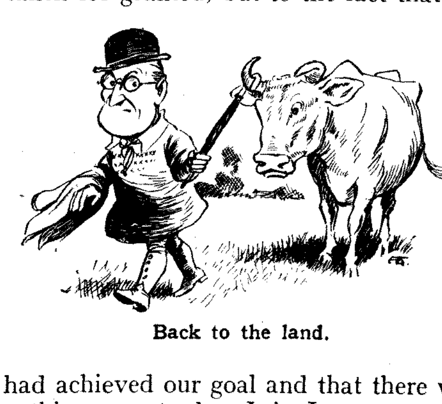
IT is astonishing how often in the brief but chequered history of broadcasting the "distortionless" receiver has been invented. I well recollect about fifteen years or so ago being taken at dead of night to the factory of a well-known manufacturer to hear the experimental model of a receiver he was developing which he claimed to give "absolutely perfect reproduction." I was sworn to secrecy concerning the set, which had nothing very wonderful about it when judged by modern standards, but to my ears at the time the results were amazingly good.

It was resistance-coupling which was doing the trick, and I suppose that the reason that I thought it was so wonderful was simply that it *was* wonderful after the ghastly row I had been used to. To-day such a set would sound utterly impossible. From time to time during the past few years various new sets have been introduced which have been hailed as perfect until some further improvement was discovered.

I am wondering, therefore, if we shall ever attain perfection, and whether in ten years' time the very best quality receiver of to-day will sound intolerable, even to a jazz-lover. It is all very well to say that perfection will be attained when the receiver reproduces with absolute faithfulness the sounds in the studio, but when are we going to get to that stage? It is useless saying that we are not very far off it nowadays, for it must be remembered that the last lap of anything is always harder than all the others put together. The little more, and how much it is, as Julius Cæsar is reputed to have said when he had marched across Europe, only to be held up by a strike of dockers at Calais.

Of late years, of course, the "tempo" of improvement has slowed down considerably, and there is never any startling move forward such as was the case even a few years ago. The chances of any really drastic new step being made in the realm of quality of reproduction, for instance, is so remote as to be almost negligible. It is a great pity, I think, that we have advanced so far along the road of progress, for it does take half the joy out of life.

It is rather analogous to the old days when we were engaged in building one of the gargantuan and monstrous engines of reception which so delighted our hearts. All was high excitement when we were in the throes of construction, but as soon as we had driven the last screw home with a hammer we felt dissatisfied. I am not referring to the results obtained, or rather not obtained, for, of course, they were taken for granted, but to the fact that we had achieved our goal and that there was nothing more to do. It is, I suppose, only another instance of the old saying about the joy being in the chase rather than in the achievement.



Back to the land.

I feel it so much that I am thinking of giving up wireless altogether and going in for something that is less near perfection, such as farming, which they tell me is still conducted by the same old inefficient method of relying upon Nature for results as it was in the days of our grandfathers.

Random Radiations

By "DIALLIST"

Apologies to S.A.

WHEN I wrote recently that I believed India to be the only country in the world to use short-wave broadcasting for its internal programme services I rather expected that I should have letters telling me that there were several others doing or about to do the same thing. A letter has just come from a Johannesburg reader, who gives me some particulars of the extensive short-wave system in use in his country for relaying the broadcast programmes to out-of-the-way places within her borders. There is a transmitter at Pretoria and another at Klipheuvel, near Cape Town. These are fairly powerful stations and work on the 31- or 49-metre bands, according to the time of day. Lower-powered stations are situated at Maraisburg, near Johannesburg, and at Durban. My correspondent tells me that if I care to run over the 31-metre band between 04.45 hours and 05.45 hours G.M.T. I shall no doubt hear the larger powered stations giving morning P.T. It's seldom, I'm afraid, that I am so late in going to bed, or so early in rising from it! Most probably readers who are later sitters-up, or earlier risers, have heard the stations. If so, they will have noticed that the language used is Afrikaans, or Cape Dutch. This is because the station serves a widely spread country population, mainly Afrikaans-speaking, which lives out of range of the medium-wave stations.

Seeing Morse

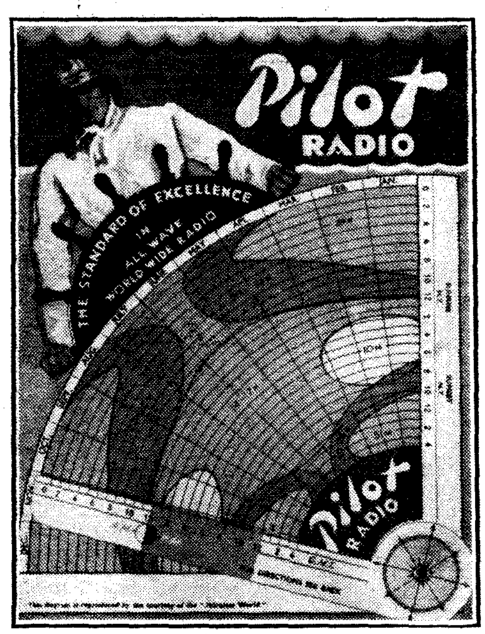
MY Johannesburg correspondent used to live on the coast in North-Eastern England before he went to South Africa. He tells me that he was about a mile from GCC, the old Cullercoats ship-to-shore spark station. As he was using a crystal set at the time, he probably didn't hear much else when GCC was at work. His wireless reception of the station was completely immune from breakdowns, for if the receiver went out of action, as receivers were prone to do in those days, he could look out of the window and read the messages by eye from the flashes of the spark!

Norway, Too

Norway, I think I am right in saying, is another country which makes use of the short waves for relaying the regular broadcast programmes to some of its inhabitants who live beyond the reach of medium-wave stations. From the wireless point of view, the extreme north of Norway is not unlike some parts of India, since it contains a sparse population scattered in small settlements over a wide area of difficult country, consisting largely of high hills interspersed with deep valleys. I seem to remember reading some time ago an account of the erection of a short-wave station at either Vardö or Vadsö, on the Varanger Fjord, close to the Finnish border. Perhaps some Norwegian reader can confirm or correct?

The Scare Play

IT is rumoured that the B.B.C. people are considering the possibility of broadcasting H. G. Wells's play, "The War of the Worlds," as adapted for radio by one of the big American broadcasting chains. Readers may remember that when it was put on in the United States the play caused something very like a panic. In the script the place-names had all been altered to those of actual American cities, towns and villages. Numbers of listeners thought that war had really broken out, and rushed out of the towns to seek safety from the horrors which they thought were coming. I very much hope that the B.B.C. won't treat us to the play in its radio form without very carefully revising it and making sure that no unfortunate misapprehensions can take place here.



CHOOSING THE BEST WAVELENGTH. An indicator (based on a graph published in *The Wireless World*) showing the best transatlantic waveband to choose at any time and date has been issued by Pilot Radio, Ltd., 87, Park Royal Road, London, N.W.10. Readers may obtain a copy by sending a 1½d. stamp to the firm.

Care Needed

It isn't a bit of good imagining that you've taken all the necessary precautions against alarming listeners if you carefully explain in preliminary announcements both in print and over the radio that it's only a play and that there's nothing to be afraid of. Hundreds and hundreds of people will switch on by chance when the play is under way and without having seen or heard these announcements. If it were presented as realistically in this country as it was in America, I don't think there would be a panic, but I do believe that there'd be great risk of giving numerous listeners a severe and unnecessary shock. At any rate, so strong was public opinion in America on the subject that the Columbia Broadcasting System announced that in future no news bulletins will be simulated in any programme if they are of the kind that could possibly cause alarm among listeners.

Television in France

IT was announced recently in *The Daily Telegraph* that the French Government had purchased a complete Marconi-E. M. I. television transmitting system for use at the Eiffel Tower high-definition station. The apparatus has mostly been made in France by the French Thomson-Houston Company, which controls the E. M. I. rights in that country. This is a great compliment to Britain, for it is recognition that we have the best transmitting system in the world to offer to our go-ahead friends across the Channel. The number of lines and frames to be used is not stated, but one hopes that the French will adopt the same standards as those that we use. It is unfortunate that in Germany and in the United States 441 lines are used, for it would have been a great advantage to have had one standard system throughout the world. There is very little doubt that under specially favourable conditions the Paris broadcasts would be received in the south-eastern part of this country. Is it looking too far ahead to foresee the time when, by means of relays with radio and cable links, we shall be able to see in our own homes events as they happen in European countries? I don't think that that's a far-fetched expectation.

Hair-Raising

THEY patent some queer things in America! A recent issue of *The Wireless Trader* contained a description of something entirely new in television screens, for which a patent had just been granted in the States to its inventor. It consists of a sheet of plate glass covered with many fine hairs, all of equal length. One end of each hair is fixed to the glass. When nothing is happening the hairs lie flat, overlapping one another and allowing no light to pass. When television reception is afoot the idea is that the electron beam, whizzing over the screen, charges the hairs and causes them to stand on end. When they do so, light, of course, passes through the gaps that they leave. Ingenious, but there seems to be one outsize in snags. For the screen to work, wouldn't the hairs have to straighten themselves and fold up again with uncanny speed? Somehow I can picture that screen still showing the villain alive and kicking long after the loud speaker had delivered the noise of the shot that killed him. And what *would* happen if the screen were placed in a draughty spot? For the present I think I'll stick to the fluorescent kind myself.

Ignition Systems

WRITING from Holte, a Danish chemical engineer is kind enough to send me a new suggestion about car ignition interference, which, we are agreed, is more severe from a vehicle going up hills than from one running easily on the level. His idea is this—I quote him verbatim and congratulate him on the excellence of his English—"When a car goes up hill it naturally consumes more fuel than when going on an even road. This heavier consumption of fuel causes a correspondingly greater quantity of ionised gases to be produced at the ignition. This, again, will cause a more heavy current in the high tension part of the ignition system, which is thus capable of transmitting a larger amount of interference." Any comments from readers will be welcomed both by me and by the author of the suggestion.

Recent Inventions

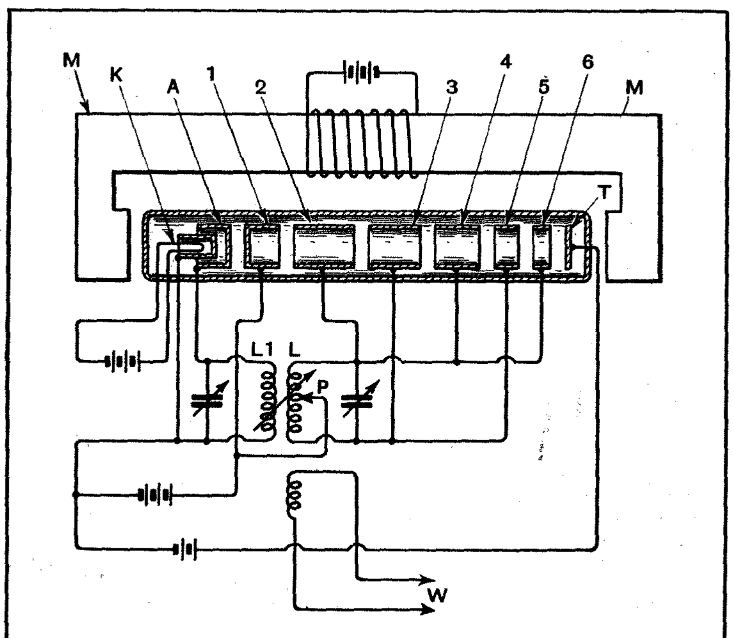
Brief descriptions of the more interesting radio devices and improvements issued as patents will be included in this section

GENERATING ULTRA-SHORT WAVES

RELATIVE to the generation of frequencies so high that the transit time of the electrons between grid and anode becomes a limiting factor in the case of the ordinary valve.

The device shown in the Figure resembles a cathode-ray tube, the electron stream from the cathode K passing through a perforated anode A towards a target T, and is subject to the field from an external magnet M.

Between the anode A and target T are interposed a number of tubular electrodes 1-6, the "even" numbers being connected to one side of an oscillatory circuit L, and the "odd" numbers to the opposite side. The circuit L is connected to the HT supply through a mid-point tapping P on the tuning inductance. A similarly tuned circuit L_1, back-coupled to the circuit L, is connected across the grid and cathode of the tube.



A cathode-ray tube working in a magnetic field and designed for the generation of oscillations of extremely high frequency.

Under these conditions, the relative phases of the voltages on the electrodes 1-6 will be such that energy is abstracted from the electron stream in its passage towards the target. The output current thus built up in the circuit L can be applied to any suitable load W.

Marconi's W.T. Co., Ltd., (Assignees of G. A. Morton). Convention date (U.S.A.), December 24th, 1936. No. 488817.

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

TELEVISION RECEIVERS

RELATES to means for separating the "line" and "frame" synchronising impulses in a television receiver.

Both sets of signals are applied through a relay network to a common amplifier. Simultaneously, both are also applied to the "line-frequency" saw-toothed oscillator, because this can easily be arranged not to respond to the framing impulses. The line frequencies do, however, get through, and during each subsequent "flyback" movement produce voltage impulses which are fed back to the common amplifier. Their effect is to "block" the line frequencies, so that the amplifier can only pass the slower impulses to the "framing" oscillator. In this way both "timing" oscillators are triggered by the appropriate synchronising signals, neither being affected by impulses of the wrong frequency.

Baird Television, Ltd., and P. W. Willans. Application date, January 19th, 1937. No. 489102.

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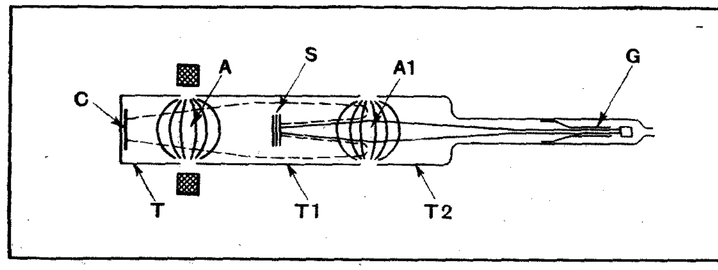
ELECTRON-OPTICAL "MIRRORS"

A "ZERO" equi-potential surface is formed across the adjacent ends of two oppositely charged tubular electrodes in a cathode-ray tube and is used as a "mirror" to reflect the electron stream. The stream is first retarded as it enters the terminal field, and is finally reflected when it reaches the equi-potential "surface" between the two oppositely curved fields.

In the arrangement shown in the Figure, the mirror effect is used to allow a photo-sensitive mosaic screen S to be scanned directly, instead of at an angle, by the electron stream from a cathode-ray television transmitter. Light from the scene to be transmitted is focused from outside the tube on to a transparent photo-electric cathode C. The electrons emitted from it are focused by the field at A, and reflected back by the "mirror" at A_1, on to the mosaic or signal-generating screen S. This is then scanned by the main stream from the gun G of the tube. The electrode T is at zero potential, the electrode T_1 is at 400 volts positive, and the electrode T_2 at 600 volts negative. Under these conditions the "mirror" A_1 acts as a focusing lens to the scanning stream.



Arrangement whereby a mosaic screen may be scanned by a reflected electron stream.

F. H. Nicoll. Application date December 24th, 1936. No. 489428.

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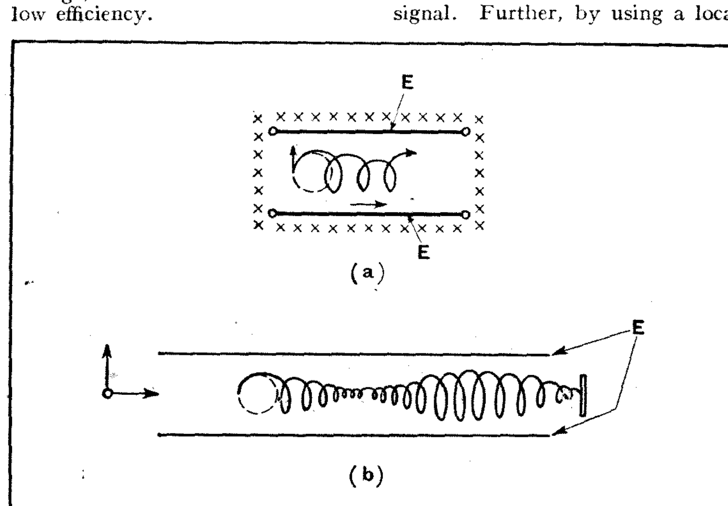
SHORT-WAVE VALVES

IN the production of oscillations of very high frequency, the time taken for the electrons to pass across the electrodes of the ordinary three-electrode valve operates as a limiting factor. This can to some extent be overcome by using the so-called Barkhausen-Kurz circuit, in which the grid of the valve is given a highly positive potential whilst the plate carries a zero or slightly-negative voltage, but such circuits have a low efficiency.



Spiral paths followed by electrons in a short-wave valve.

According to the invention, use is made of the effect illustrated in the Figure. An electron subjected to the action of a transverse electric field as illustrated in (a) by the small crosses, and also to a magnetic field which is perpendicular to the plane of the paper, will tend to move in a circular path, which gradually takes the form shown. This is due to the opening-out of the circular path near the top of its orbit and to the closing-in near the bottom as it "reverses" its direction of movement relative to the applied field. If an AC voltage is applied to the tubular electrode E, the electron will travel along the path shown in (b), and energy can then be drawn off from it, at equally spaced points along that path, and fed into a tuned output circuit.

Telefunken Ges. für drahtlose Telegraphie m.b.h. Convention date (Germany) November 30th, 1935. No. 489608.

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DIRECTION FINDING

A DIPOLE aerial is mounted at each end of the wing-spread on an aeroplane, the two dipoles being coupled through a shielded transmission line to a common receiver. If the coupling is such that the two aerial voltages are fed in opposition to the receiver, the pilot knows he is heading straight towards the distant transmitter when the indicator shows zero deflection. Alternatively, the two aerials can be coupled in series to the receiver for "broadcast" or non-directional reception.

As a third alternative, both the sum and difference of the aerial voltages are fed to the receiver, through a reversing switch, so as to produce a heart-shaped curve, which gives the "sense" as well as the direction of the incoming signal. Further, by using a local oscillator, the heart-shaped curve can be rapidly reversed and the resultant voltage applied to a zero-centre ammeter. This will then give a direct visual indication of the direction of a distant transmitter.

J. I. Heller. Application date, November 16th, 1937. No. 488823.

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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

Editorial Comment

About Ourselves

A Problem of Finance

As our readers are very well aware, it has always been the policy of *The Wireless World* to recommend to the radio industry the importance of putting quality first, and we have constantly urged that an increase in the price of broadcast receivers is to be preferred to maintaining prices at a low level where this would mean impairing quality and efficiency. Circumstances have now arisen which make it necessary for us to practise ourselves what we have for so long preached to others.

It is common knowledge that papers of a specialised character, such as *The Wireless World*, are far more dependent on the revenue derived from advertisements than are popular papers of a general appeal. Unfortunately, the income available from that source has proved inadequate to support a journal so expensive to prepare as an accurate and authoritative wireless paper, for which the preparation of a single article occupying perhaps two pages may entail weeks of laboratory work by experts.

Increased Costs

Now, in addition, the cost of paper and printing for all classes of publications has increased to an extent which obliged most periodicals to advance either their advertisement rates or their selling price. With the limited amount of advertising carried in *The Wireless World* an increase in advertisement rates would not meet the case, and the only other source of revenue is the price at which the paper is sold. As we have explained, it would not be consistent with our policy to impoverish the paper by economies which could only result in a journal of less value to our readers, and, therefore, however reluctantly we do so, we feel there is no alternative but to increase the price from 4d. to 6d. and so maintain the present standard of *The Wireless World*, with its organisation, staff, and laboratory facilities unimpaired.

Readers' Views

In taking this step we are supported by the knowledge that when, some months ago, we issued a questionnaire to our readers there was overwhelming evidence that the general wish was that we should maintain the standard of the paper and make no changes which would render it less valuable to the serious reader. The suggestion was volunteered by a large number of those who filled in the questionnaire that an increase in price would be preferred to any reduction in the quality of the articles and service which *The Wireless World* has always tried to maintain.

Readers may rest assured that given their support our endeavour will be not only to maintain the standard of the paper, but to do all that we can to increase its usefulness to them in many directions in the future. We look forward in particular to being able, if circumstances permit, to introduce a free service of replies to readers' problems. Some addition to the present number of editorial pages is also contemplated.

In conclusion, we feel sure that readers will readily accept the increase in price, which takes effect next week, realising that the facts explained above render the change necessary if the future of the journal is to be secured.

Small Service Workshop

ALTHOUGH the use of suitable instruments is essential to servicing, their full advantage is not secured unless they are correctly arranged so that they are accessible and can be brought rapidly into action. In this article the layout of a small service shop is discussed and one arrangement which has proved satisfactory in practice is described

LAYOUT CONDUCIVE TO EFFICIENCY

By "TROUBLE SHOOTER"

IN the early days servicing was given little attention, but radio has now become such a vital necessity to the general public that repairs have to be carried out with the utmost despatch. Minutes saved are precious, and receivers ten times as complicated as those of a decade ago have to be serviced in a fraction of the time. For this, good instruments are essential.

The necessary apparatus is not inexpensive, but even when it has been acquired its possession is not the end of the matter. There is a further important requirement which is often overlooked—the necessity for the instruments being readily available.

If the components of a first-class receiver were strewn haphazard on a board and then wired together correctly, it is conceivable that they would function together sufficiently well to receive signals. But no one would expect a performance comparable to that given by the same components in a carefully designed receiver; the operation, too, would be more difficult and involve far more time. As a parallel case, however, the writer has visited service departments boasting of first-class equipment but where one had to hunt behind a pile of junk to find a vacant mains socket to which to connect, say, an oscillator. Yet this instrument was in hourly use!

Design, therefore, is as essential to the smooth working of a service workshop as to that of a receiver. Every instrument must be capable of being brought into use *immediately*, as it is needed, and also must be able to make itself generally useful in as many directions as possible.

The average service department has, however, grown from modest beginnings. At intervals test gear has been added here and there and fitted up as quickly as possible; with a full day's schedule of receiver repairs ahead, opportunities for a major upheaval are, of course, zero. It tends to degenerate, therefore, into a collection of bits and pieces, figuratively lashed together with bootlaces and string.

When such a state of affairs exists, it is highly advisable to call a temporary halt: make a list of the various instruments used and then design (on paper) the best layout for ease of handling. Finding the time in which to translate the paper work to practice is a matter for individual decision. Two ways which suggest themselves are as follows:—Either set aside a few days in the slackest part of the season, or keep one half-day (or better still a whole day) per week till the overhaul is completed.

No hard-and-fast rules can be laid down regarding the actual layout of a service workshop, as this will obviously depend to a great extent on individual rooms, requirements and gear already on hand.

In Fig. 1 an attempt has been made to give a plan for an average room. Note that the test bench is at right angles to the window and placed as far as possible to get the natural light over the engineer's shoulder, or at the side, but never in his eyes. With the bench *parallel* to the window, the sunlight can be very trying on a very bright day. Incidentally, the walls should either be whitewashed or coated with a light distemper to get the maximum amount of reflected light.

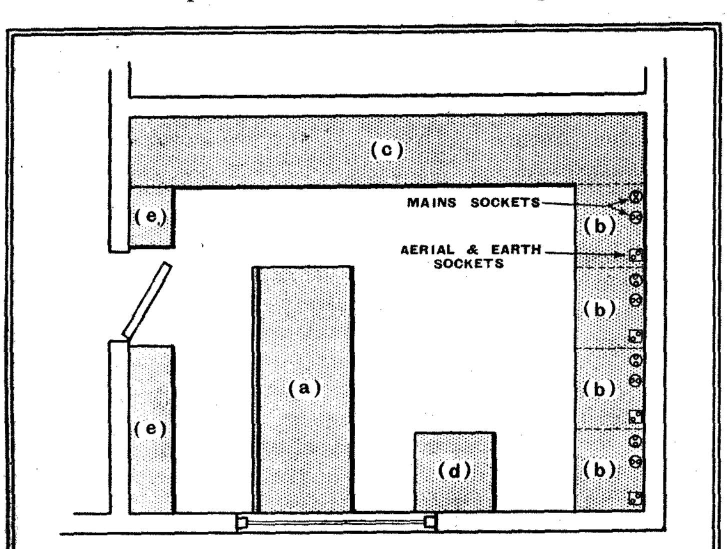


Fig. 1.—In this layout the main test bench is shown at (a) and benches for "soak" tests at (b). These benches have racks underneath for repaired sets. More receiver racks are fitted beneath the bench (c) which carries tool racks and filing cabinets. A valve tester is fitted at (d) with a gramophone motor and pick-up on shelf below, and finally there are shelved cupboards at (e) for valves and components.

Referring again to Fig. 1, the bench (b) is intended for soak tests, where sets with intermittent faults can be kept on test without dislocation of work. It should be wired in duplicate (AC and DC) for at least three mains points and also for a similar number of aerial/earth points. If

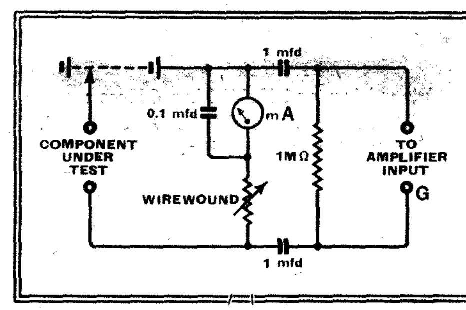


Fig. 2.—The circuit of a tester for intermittent faults in components is shown here and is self-explanatory.

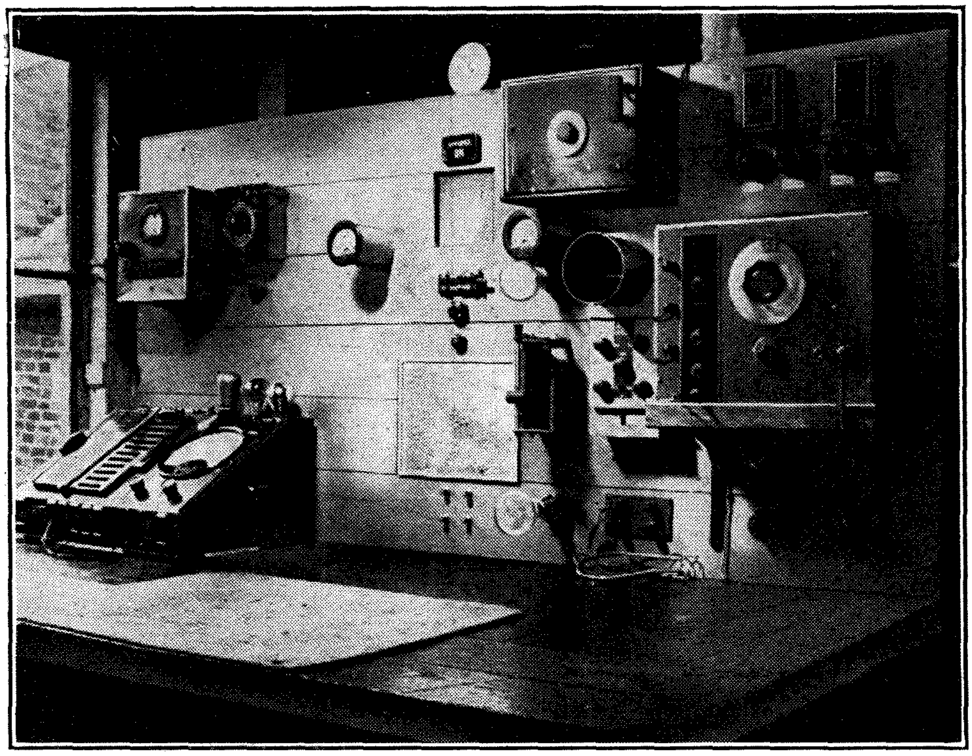
the latter are wired to standardised sockets (not 5 amp. sockets, to avoid confusion) three sets of A/E leads with terminals at one end and the standardised plugs at the other end can be made up for use as required. There are then no loose A/E leads floating around the bench.

Permanently Wired Gear

Now for the test bench proper. Here again circumstances alter cases, but, in general, it is a wise plan to keep a really good portable tester or analyser for outside service only, and to concentrate the rest of the gear in a more or less permanent form on the test bench. As a general rule, time is saved by tackling only relatively minor troubles at the customer's house; anything involving dismantling of the chassis can usually be done far quicker in the workshop.

The accompanying photograph, reproduced by permission of the owner, shows a test bench developed on the lines indicated. It is not suggested that it cannot be improved upon, but it represents one layout that has been found satisfactory in practice.

As will be seen from the photograph, this bench is of the back-panel type. The writer favours this particular form for many reasons, two of which are that (a) practically all gear can be bolted to it, thus keeping the bench free for work, and (b) the various instruments can be wired together, or to their power sup-



A general view of the main test bench showing the main apparatus mounted on the back board.

plies, from the back of the panel. The only wires then visible at the front are the test prod leads.

The power input (both AC and DC) is brought to the bench *via* two "iron-clad" double-pole switches with 2-amp fuses in each side. The advantage of this system is that, provided these switches are turned off, there is no fear of any instrument or soldering iron being left on overnight. Immediately below are the instrument switches. All these and the power points at bench level are colour-coded red for AC, blue for DC.

Next comes the oscillator; this is mains driven and covers from 8 Mc/s to 0.1 Mc/s. It is designed to give either amplitude or frequency modulation, and for ganging purposes is permanently wired to the cathode-ray oscilloscope on the left. The oscillator output is brought along the underside of the bench by screened cable, ample length being allowed to reach a chassis on the bench. When not in use, this cable is hooked up out of the way under the bench. Both the oscillator and oscilloscope are by Messrs. A. C. Cossor.

Immediately over the oscilloscope is a Pye life-test alarm; this is wired to communicate with the soak-test bench. A receiver can then be put "on soak" in absolute silence, as an alarm is set going should the receiver output drop in the slightest degree: this is of great benefit when one is working on another chassis on the test-bench, as is nearly always the case. This life-test alarm, by the way, is "triggered" by another oscillator on the soak bench. This is an old home-made piece of apparatus which, though not quite accurate enough for modern ganging, is quite suitable for this duty. It also fulfils another function, as it has been modified to give a variable audio-frequency note if required; this is extremely useful in tracing speaker or cabinet buzz.

Next in order comes the gear for obtaining 110 V. AC or DC. This consists merely of a ballast lamp and series variable resistor with switching to bring in the required supply. The two meters mounted on the board are used for monitoring the home-generated AC and DC supplies.

The square aperture in the middle of the board is, of course, a grille for the test speaker. The latter is of the moving-coil type with an energised field which is part of the smoothing circuit of a two-stage amplifier mounted at the back of the board. Tappings are brought out from the high and low impedance sides of the speaker so that by a turn of the switch one can either test a speaker from the amplifier output (the test speaker being muted at will), or the test speaker itself can be coupled to the output of a receiver under examination, the field always remaining in circuit.

A Versatile Amplifier

A few words may perhaps be added concerning the amplifier, since it constitutes an important part of the equipment, and fulfils many functions besides speaker testing. It is by no means a super-quality job, being constructed to give approximately the same quality as the average receiver, in order to get a fair comparison. The input is derived from a pick-up, which together with the gramo-motor is mounted on a shelf near the bench, as in Fig. 1. In circuit with the pick-up is a throw-over switch whereby it can be either fed to the amplifier or direct to terminals on the bench for testing the AF side of a receiver. The amplifier also provides a source of voltage for a Baldwin condenser bridge and for other test-gear. The amplifier volume control is fitted just below the speaker grille, while a pilot sign immediately above gives an indication of when the amplifier is "on."

The condenser bridge is a commercial instrument which may be of some interest. checking a condenser is to adjust the dial while listening for the silent point of an AF note on phones. In the present case, however, the output from the instrument is fed via the amplifier to the oscilloscope which gives the wave-form pattern of the note. The bridge dial is then adjusted until the trace reverts to a straight line, when the capacity is read off the calibrated scale of the bridge in the normal way.

On the extreme left of the board is an instrument which may be of some interest. It is used (or rather, *was* used, for the oscilloscope has superseded it to a great extent) for the purpose of tracing intermittent crackles in suspected components, and in this respect is extremely useful. It can be constructed at little cost, being made of standard components. A skeleton circuit is given in Fig. 2, although various refinements may be added. By this means one can put a suspected component on test, and carry on with another job, as the warning of a fault is an audible one, and one does not have to concentrate on watching a meter for variation.

Lastly, comes the only instrument actually on the service bench. This is an AC driven Philips tester, and gives an excellent range of all normally required voltages and currents, both AC and DC; in addition, condenser capacities from 20 mfds. to 1,000 mmfds., and resistance from 5 MΩ to 1 ohm can be very accurately checked. 220 V. DC and 440 V. AC is provided for condenser breakdown tests. All readings are given on a 7in. diameter scale.

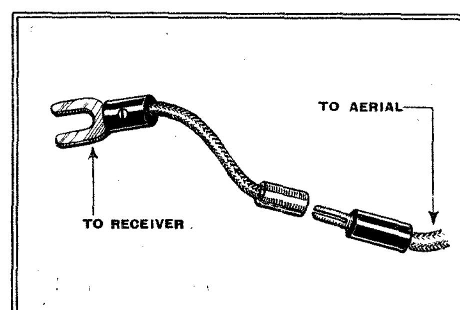


Fig. 3.—This drawing shows the construction of an adaptor to fit the standard aerial and earth plugs.

The aerial/earth system is of the anti-interference type, and is brought under the bench in the manner of the oscillator cable. One of a serviceman's minor troubles lies in the non-standardising of aerial sockets (or terminals). This has been overcome in the following manner: The aerial/earth leads are fitted with normal-sized wander plugs, and adaptors made to suit all types of socket or terminal. As shown in Fig. 3, an adaptor consists of 4in. of 3 mm. wire, one end of which has, say, a spade end fitted to it (to use when the receiver is fitted with terminals)

Small Service Workshop—

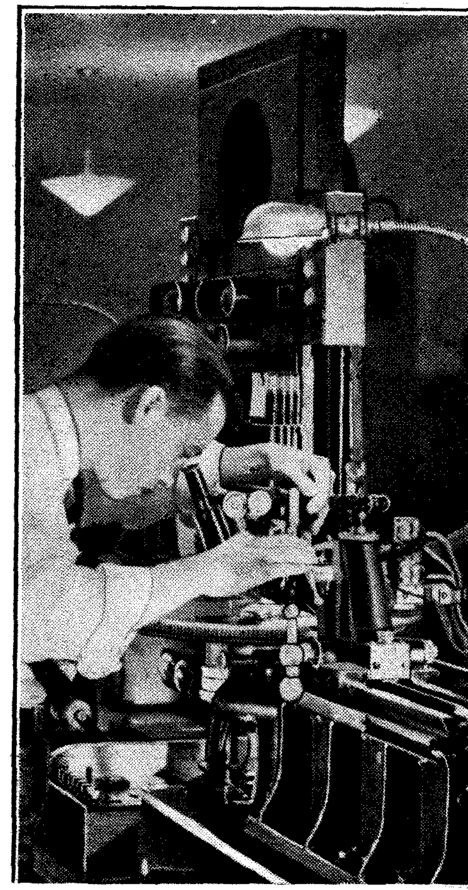
The other end has a socket soldered to it to fit the aerial wanderplug. Others can be made up with suitable ends as required; they should be made in duplicate for both aerial and earth leads. Placed in a box handy to the bench, they will save time and temper.

Bench lamps should be of the adjustable variety and capable of being focused on to the work in hand. An inspection lamp is often of great use, though many servicemen prefer a "fountain-pen" torch. For the side benches a good reflector can be easily made by cutting a fairly large sweet tin in half lengthwise, and then fitting a lampholder through one end, so that the lamp itself lies along inside the semicircular section. The outside can then be enamelled. This reflector throws the light straight down on to the bench, practically none being wasted in other directions.

These (and many other items which will occur to servicemen) all help to bring system into service work, and thus enable a saving of time to be effected. The main object of these notes is to point out that a service department need not of necessity be a wilderness of straggling wires. "Sticky" jobs involving, perhaps, several hours' hard work, will still crop up, but an orderly work bench and instruments which are both good and "get-at-able" will reduce time spent on these and routine jobs to the absolute minimum.

How Electrical Transcriptions Are Made

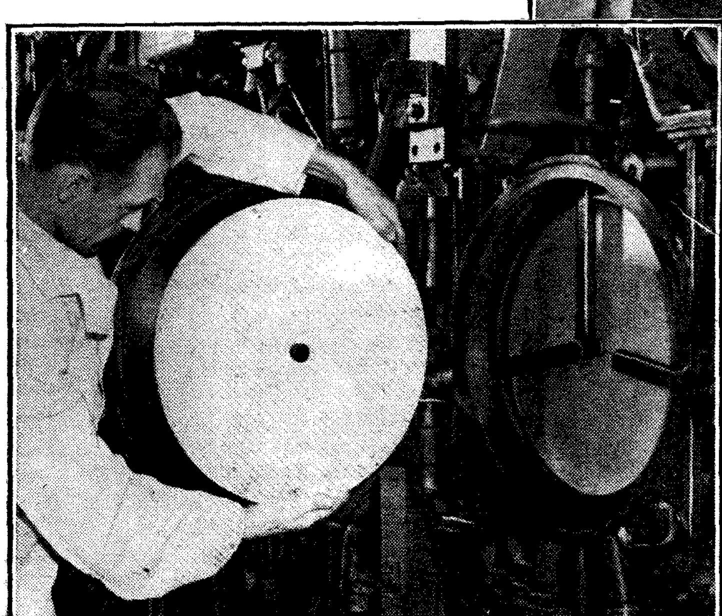
Recording in America by the Vertical Cut (or "Hill and Dale") Method



ELECTRICAL transcriptions are recordings of complete entertainments, mostly sponsored advertising programmes, specially made for broadcasting. This term implies, as a rule, cutting on 16in. discs at $33\frac{1}{3}$ r.p.m. and usually to-day the vertical or hill-and-dale method of recording is employed. The photograph on the right shows one of the several precision vertical recorders in the machine room of the World Broadcasting System in Chicago; the engineer is examining the grooves on the wax through a microscope. Each side of these slow-speed discs has a playing-time of about 15 minutes and it is claimed that the vertical recording method permits accurate cutting up to at least 10,000 c/s.

In the second photograph two members of the cast of "Judy and Jane," the oldest transcribed advertising programme radiated in America (this series has been broadcast since February, 1932), are seen reading their lines into a microphone in a studio of the W.B.S. The engineer in the foreground is manipulating one of the pick-ups on the record reproducer trolley, which enables sound effects to be "mixed in" on the recording channel.

After the wax blank has been cut it has to be processed. First, the blank is placed in a vacuum chamber, where for 20 minutes it undergoes electronic bombardment, or, as it is termed, cathode sputtering, *i.e.*, a film of gold, a few millionths of an inch thick, is deposited on the wax surface, thus



Photos by courtesy of World Broadcasting System, Inc.

ensuring conduction for the electrolytic copper-plating process that follows. (This "sputtering" technique, originally introduced by Edison in 1900, replaces the old method of dusting the wax with graphite powder, which, being granular, contributes to surface-noise in the final pressing.) Now the gold-plated blank is suspended in an electrolytic bath, where it slowly acquires a copper coating. Then it receives a second plating and emerges with a thick copper layer "grown" on its surface. The illustration on the left shows one type of plating equipment employed. Next, the copper master is carefully removed from the wax and trimmed, to be followed by chromium plating to prevent erosion. This copper master or stamper is now placed in an hydraulic press with a "biscuit" of plastic material and so the final pressing is produced. The records are pressed in "vinylite" (a plastic used for dental plates and motor car steering wheels) or cellulose acetate, instead of the loaded shellac composition normally used for the commercial production of records in quantities.

High-gain Television Amplifiers

IF Intervalve Couplings

By W. T. COCKING

METHODS of obtaining reasonably high gain per stage from a television IF amplifier are discussed in this article, and it is shown that the highest amplification is obtained with tuned anode type couplings. The tuning of the individual circuits must be correctly carried out, however, if the necessary band-width is to be secured.

THE difficulty of securing a reasonable gain per stage in a television intermediate-frequency amplifier is widely recognised and has led to two things. It has caused a more thorough investigation into the properties of various types of intervalve coupling and it has stimulated valve development.

The difficulties are brought about by the enormous band-width needed and by the inevitable stray circuit and valve capacities. For a given capacity it can be shown that with most circuits the impedance of an intervalve coupling is inversely proportional to band-width, and the stage gain is equal to the product of the impedance of the coupling and the mutual conductance of the valve.

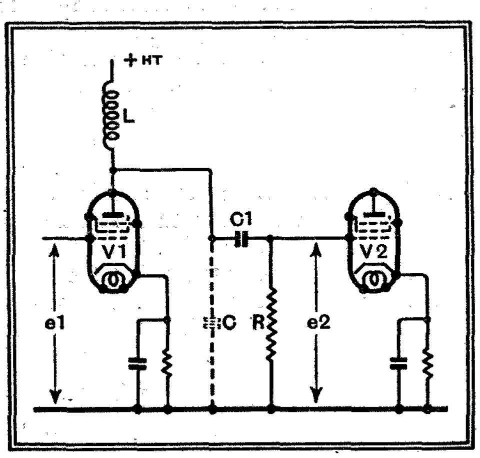


Fig. 1.—This diagram shows a single stage of tuned anode coupling.

The coupling impedance does not depend only on the band-width, however; it is also inversely proportional to the circuit capacity. It is clear, therefore, that the highest gain per stage is secured when the capacity is reduced to a minimum, the band-width is as narrow as possible consistent with the required picture quality, and the valve has as high a mutual conductance as we can get.

The simplest intervalve coupling is the tuned anode and is shown between a pair of valves in Fig. 1. The capacity tuning the coil is C and is not included as a condenser in the practical amplifier because it is made up of the various stray circuit capacities. In a typical case there will be the self-capacity of the coil (say 5 $\mu\mu$F.), wiring capacities (say 5 $\mu\mu$F.), the output capacity of V1, and the input capacity of V2. This represents the minimum capacity which cannot be reduced appreciably. Tuning is effected by making L variable, since as pointed out in a recent article,[1] the use of an adjustable capacity for trimming inevitably means a loss of gain.

The stage gain is reckoned as the ratio of the input e2 to V2 to the input e1 to V1; that is, A=e2/e1. The condenser C1 is assumed to be of large enough capacity to be ignored. Then the stage gain at resonance is given by A = gR, where g is the mutual conductance in amperes per volt and R is in ohms. The value of R is related to band-width by a very simple formula R = 1/6.28 nC for a drop of 3 db. at the edges of the pass-band. For any other drop R must be multiplied by $\sqrt{1/S^2-1}$ where S is the fractional response required. Thus, for 1.5 db. drop S is 0.84 and R must be 0.644 of the value for a 3 db. drop. In the above expression n is the band-width (c/s) and C the capacity (F.). The inductance $L=1/\omega^2C$ where ω – 6.28 times intermediate frequency.

In a typical case we might have a band-width of 4 Mc/s with an intermediate frequency of 13 Mc/s. A special television valve such as the Mazda SP41 has g=8.5 mA/v. with input and output capacities of 15.3 $\mu\mu$F. and 4.75 $\mu\mu$F. respectively.

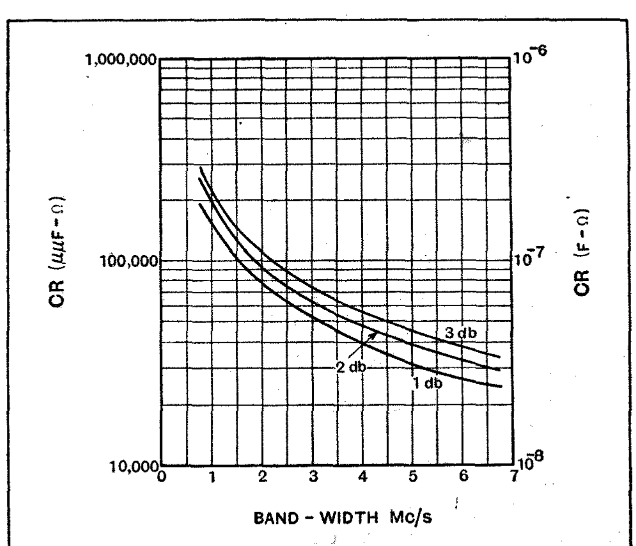


Fig. 3.—The circuit constants for a band-pass coupling can be obtained from these curves.

The total value for C becomes some 30 $\mu\mu$F. Inserting values in the formula we find that R must be only 1,325 ohms and the stage gain is 11.3 times. This is for a drop of 3 db. per coupling at the edges of the pass-band.

A typical IF amplifier should have a gain of 1,000-3,000 times, and it will be seen that at least three stages will be needed. There is one more coupling than the number of IF stages because of the coupling between the frequency-changer and first IF valve. Consequently, with three such stages we shall have a gain of 1,440 times, ignoring the frequency-changer, which may be a source of loss, for a drop of 12 db. at the edges of the pass-band.

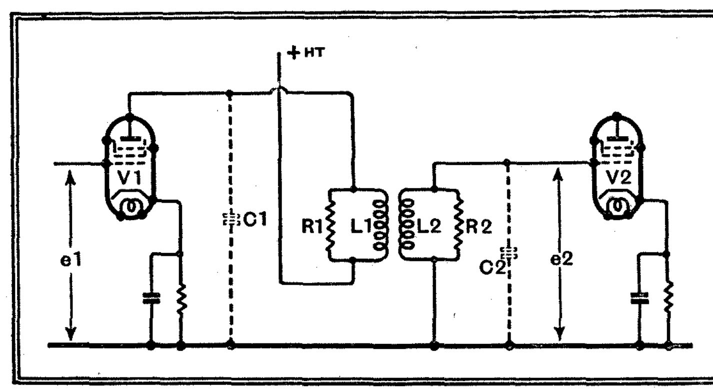


Fig. 2.—Coupled circuits of the band-pass type are often used as an intervalve coupling.

If we try to improve the response and allow only 1.5 db. drop per circuit, R must be 850 ohms only and the gain will be 7.25 times. Three stages will now give an amplification of only 380 times, so that we shall have to use four and the gain will then be 2,750 times. There will be five couplings and a drop of 7.5 db.

These results are obviously very poor, and it is necessary to find something better. The obvious thing is to use a band-pass circuit of the type shown in Fig. 2. At first sight there would be a loss of gain instead of an increase, for we know that in ordinary broadcast practice the use of such a coupled pair of circuits entails a loss of gain of 50 per cent. as compared with a single circuit. The conditions, however, are not comparable, for in a broadcast set we use the same value of inductance whether we have one circuit or two. Here the use of two circuits means that the capacity on each is re-

[1] *The Wireless World*, September 29th, 1938.

High-gain Television Amplifiers—

duced because there is only one valve connected to it. This means straight away that the resistance can be increased and a further increase is possible because of the broadening effect on the resonance curve of the circuit coupling. The net result is that the gain is higher appreciably with two circuits than with one.

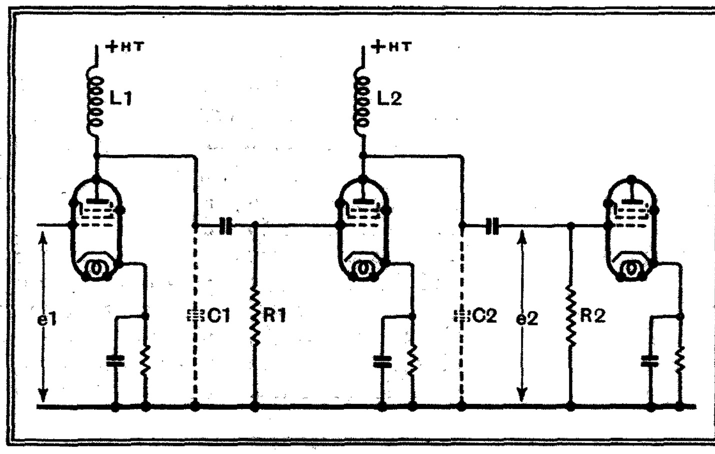


Fig. 4.—With tuned anode coupling, higher gain for a given band-width is obtained by mistuning circuits in opposite directions than by aligning them all at the same frequency.

The writer has previously dealt with this circuit in some detail.[2] No such simple design formula as in the case of the tuned anode coupling is possible, but the curves of Fig. 3 enable the value of CR to be determined for any band-width. They show that for 3 db. drop at the edges of the pass-band of 4 Mc/s CR should be 56,000Ω – μμF. The primary capacity C1 is likely to be about 7μμF. plus the valve capacity, or 11.75 μμF., say 12 μμF., while the secondary C2 will be about the same and so total about 23 μμF.

The resistance R1 will thus be 56,000/12 = 4,660 ohms, and R2 will be 2,430 ohms. The stage gain $A = g\sqrt{R1\ R2}/2$ or 14.3 times. Three stages will give a gain of 2,940 times as compared with 1,440 times with tuned anode coupling. The use of coupled circuits shows up to better advantage, however, when the drop per circuit is less. Thus for 1.5 db. drop, CR is 43,000, giving R1 = 3,580 ohms, R2 = 1,870 ohms and A = 11 times. This is nearly as good as with the tuned anode coupling and double the drop per circuit. The relative merits of the circuits depend in large measure on the amount of drop at the edges of the pass-band at which the comparison is made, and the smaller the drop that is allowed the better the coupled circuits show up in comparison with the tuned anode.

Stagger Tuning

In practice, it is not always possible to obtain as good results from the coupled circuits as theory would dictate. The chief reason for this is that it is almost impossible to use inductance tuning. The two coils must be coupled together to the correct degree, and it is extremely difficult, if not impossible, to devise a method of mutual inductance coupling between two variable inductances, so that varying the inductance of either coil affects neither the inductance of the other nor the coupling between them. It is, therefore, necessary to adopt capacity trimmers, or to adjust the circuits by a laborious trial and error method. The use of capacity trimmers will make the circuit lose much of its advantage from the point of view of gain, although its higher selectivity will remain.

Now the coupled circuits only enable higher gain to be secured through the reduction in circuit capacity and through the double-humping tendency of a pair of coupled tuned circuits which makes less damping necessary to preserve the band-width. These effects are so great that they more than counterbalance the loss introduced by using two circuits instead of one. If now we could by using one circuit per coupling obtain a double-humped effect, we should be in a still better position. The tendency to double-humping would broaden the resonance curve and make less damping necessary and so the gain would rise. Such an effect cannot be obtained with only one tuned circuit, but it can be obtained if we take the two tuned circuits of two couplings together. If we mistune one circuit in one direction and the other in the other, the overall resonance curve exhibits band-pass characteristics and eventualy becomes double-humped.

We call this system the staggered tuned anode circuit because the resonance frequencies of the circuits are not the same but are staggered about the required intermediate frequency. Two stages are shown in Fig. 4, and on paper the circuit looks no different from the ordinary one, a single stage of which is shown in Fig. 1. For a 3 db. drop at the edges of the pass-band *overall for the two circuits* $R = \sqrt{2}/6.28$ nC. Taking the same values as before, R = 1,880 ohms and the resonant gain of each stage is 16 times. The gain of the two stages, however, is not 256 times because the two resonance frequencies do not coincide. The gain is actually

$$g_1 g_2 R_1 R_2 \frac{(2\omega^2C^2R^2 - 1)}{(4\omega^2C^2R^2 - 1)}$$

Two stages of resonance tuned anode give a gain of 52.5 times, so that there is a definite improvement to be obtained by mistuning. Coupled circuits lead to a gain of 121 times for the same band-pass characteristics. In order of merit from the point of view of gain the circuits are stagger tuned anode, coupled circuits, and resonance tuned anode. Under this condition the gain per stage for stagger tuning shows an increase of 55 per cent. as compared with that for resonance tuning.

Theoretically, stagger tuning and coupled circuits lead to nearly the same gain. In practice, the former is likely to be the better because it is free from the disadvantages of coupled circuits which have already been discussed. Moreover, it has the practical advantage of using rather less material.

The resonance frequencies to which the circuits must be tuned for the correct results can be calculated quite easily. One circuit must be tuned to the intermediate frequency divided by a and the other circuit tuned to the intermediate frequency multiplied by a where a =

$$\sqrt{\left[\frac{2\omega^2C^2R^2 + \sqrt{4\omega^2C^2R^2 - 1}}{2\omega^2C^2R^2 - 1}\right]}$$

In the case we have discussed a = 1.11 so the two frequencies are 11.7 Mc/s and 14.4 Mc/s.

Still greater gain would probably be obtainable by damping the circuits less heavily and mistuning them so that the pair give a marked double hump to the resonance curve. A third circuit in another stage tuned to the mid-point and suitably damped could fill up the trough to give a single peak curve overall. The calculations for this case become quite complex. It is easy enough, if tedious, to calculate the performance of any given system. The difficulty lies in finding the circuit values for the best performance in a sufficiently simple manner to be useful.

In any case, it is possible that the extra gain would be dearly bought. The writer is rather chary of using circuits which give a double-humped characteristic, for experience shows that very small changes in circuit constants have a surprisingly large effect upon the shape of the resonance curve. Initial adjustment consequently becomes difficult and it is often more satisfactory in the long run to be content with somewhat lower gain and easier adjustment with the probability of greater permanence of adjustment.

[2] *The Wireless Engineer,* July, 1938.

Ediswan Lamp and Valve Exhibition

AN exhibition of historic lamps and valves was opened by Dr. A. P. M. Fleming on November 14th. Specimens of the early Swan incandescent lamps are shown with examples illustrating the development in the last fifty years. A collection of early valves, including the Fleming diodes, is also shown and well illustrates the evolution of the valve from the lamp. The exhibit is housed in the Ediswan showrooms in Charing Cross Road.

Sticky Thread

A SAMPLE of sticky thread has been received from V.G. Manufacturing Co., Ltd., of Gorst Road, Park Royal, London, N.W.10. Among the many uses to which such material can be put is the binding of the ends of battery cables and flex leads.

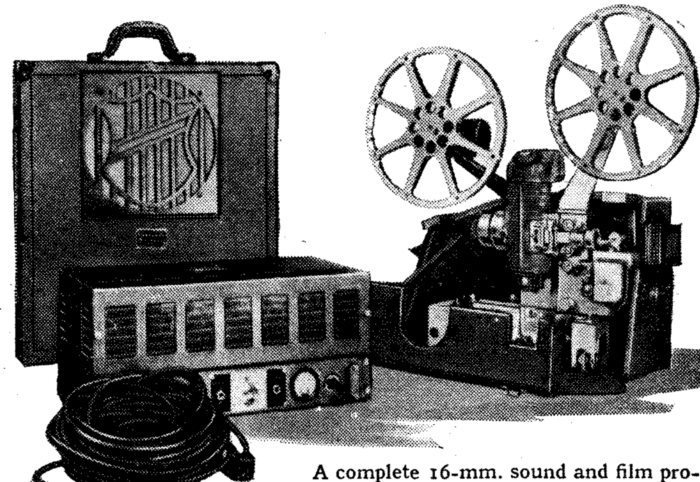
It is available in reels of about 100yd. and is priced at 1s. 6d. per reel.

Amateur Recording

ADDING SOUND TO THE SUB-STANDARD FILM

By
PERCY W. HARRIS
Mem. I.R.E.

NUMEROUS difficulties confront the home cine enthusiast when he attempts to provide a background of sound to his own pictures. The problems that arise in carrying out present-day methods of home recording and suggestions which indicate a more satisfactory system in the near future are outlined in this article.



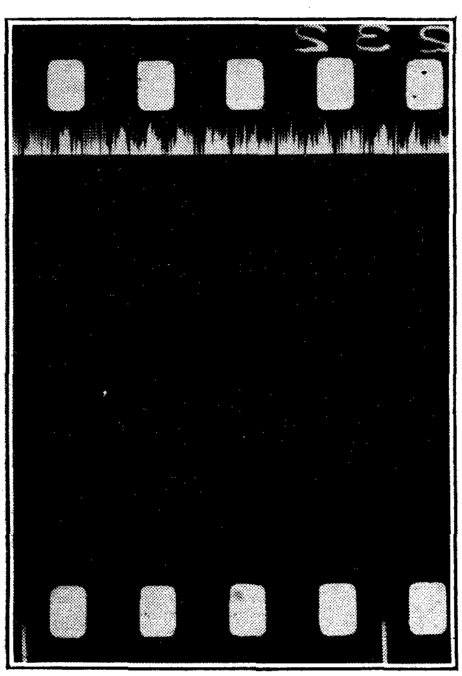
A complete 16-mm. sound and film projector outfit, the Filmosound Model 130.

THE technical problems of sound recording and reproduction are, of course, closely allied to those of radio. For this reason it is not surprising that many readers of *The Wireless World* follow any discussions on the matter with the greatest interest. Furthermore, many radio enthusiasts are also sub-standard film users themselves, and are thus tempted to try their hand at sound reproduction in connection with their own pictures. As there are many misconceptions surrounding the subject, and some aspects of it which are not sufficiently taken into account by the newcomer, it may be helpful to *Wireless World* readers to consider a few of the more fundamental facts from a practical aspect.

Assuming it is the aim of the home ciné enthusiast to obtain as high a quality in sound as he now can get in pictures (the quality of the modern sub-standard photography—at least in the 16-mm. size —is certainly beyond reproach), let us consider what can be done at the present time and what are the limitations, not only of equipment but also of operating technique.

Recording Quality

All modern 35-mm. work is done by the sound-on-film method. We need not trouble here to consider the various methods of recording as they have already been discussed adequately in these pages. The usefully recordable sound range in the 35-mm. sound-recorder is limited by the width of the slit, the speed of travel of the film and the fineness of grain and resolution of the film itself. Speed of travel has been standardised at 90-ft. per minute or 24 frames per second. If now we run a 16-mm. film at the same number of frames per second, the speed of film travel can only be two-fifths of that of the 35-mm. size and therefore, other things being equal, the upper frequency limit recordable is only two-fifths of that of the 35-mm. size. Assuming a practical upper limit of about 10,000 cycles for 35-mm., this makes about 4,000 for 16-mm.



From this enlarged reproduction of a piece of 35-mm. film, it will be seen that the sound track comes just within the perforations on one side. There are four perforations on each side to the picture frame. The white marks at the bottom show the picture division.

But what you can record and what you can hear in the average picture theatre are widely different matters. Anyone who has heard what a modern 35-mm. film is capable of, when the recording has been carefully done and the reproduction carried out on suitable apparatus, will admit at once that the reproduction in the average picture theatre is far below what it might be. The relative frequency response of the human ear differs considerably with different sound intensities, and too high a sound level in the picture theatre may have a disastrous effect on quality, quite apart from the inherent effect of many existing installations. In home talkie reproduction, where sound level can be accurately controlled and where amplifier distortion can be avoided, a good proportion of the recorded sound can be reproduced satisfactorily, which accounts for the fact that a modern 16-mm. sound-on-film projector compares favourably in results with that of many of the older picture theatres.

Of course, the size of the slit *can* be reduced in sub-standard apparatus, but not much progress is possible in this connection because of limitations inherent in the film material itself (irradiation, etc.) and lack of perfection of the optical equipment. Further, it is very difficult to keep a very narrow slit clean.

Next consider microphone technique and the trouble and expense to which the film studios are put to get satisfactory sound recording. The average amateur has to work in normal home conditions, not in a studio designed by acoustic experts, and the importance of this must not be overlooked.

Disc versus Film

Mr. Hamilton H. Pace, in an interesting letter published in *The Wireless World* earlier in the year, suggested that the sound-on-disc method is the ideal system of making sub-standard talkies and is unlikely to be superseded by the film method. This opinion is obviously based on the fact that it is possible to record better quality on a disc than is at present possible on 16-mm. film travelling at the standard speed. I grant this at once, but the fallacy in the argument lies in the fact that no fair comparison can be made between a separately running disc record, synchronised or not, and a film record which is part and parcel of the picture film. Once we agree to separate the sound track from the picture the inferiority of the sub-standard film sound track disappears, for one can easily arrange a separate film track to run at a much higher speed and thus reach, if not excel, the frequency range of the disc. Not that the frequency range of a synchronised disc is anything to enthuse about if its playing time has to be long enough to last out a 400-ft. spool of 16-

Amateur Recording—

mm. film! Running at "talkie speed" a 400-ft. spool of 16-mm. film takes roughly eleven minutes to pass through the projector. The only way to make a record to last for eleven minutes is either to increase its size or reduce its speed of rotation, which latter automatically brings about a degradation of quality. Anyone who has used the old 16-inch discs synchronised with a 16-mm. projector will agree with me that they are, to say the least, inconvenient, and if we reduce the speed of rotation then all the arguments about disc quality disappear. It is not practicable to use several short playing records and bring them into synchronisation one after the other, nor to bring in a synchronised record in the middle of a spool after accompanying the picture with non-synchronised records. If the ordinary 12-inch size of record running at 78 r.p.m. is used and synchronised, then your talkie film has the very short run of three or four minutes at the most.

A sound-on-film picture is, of course, automatically synchronised, although owing to the mechanical requirements of the machine the sound track is many inches ahead of the picture with which it is associated. This is due to the fact that the picture passes through the picture gate intermittently while the sound track must run through the sound gate at a steady speed. This change from a series of jumps to a smooth run is taken care of by a loop in the film and a heavy flywheel, or the equivalent.

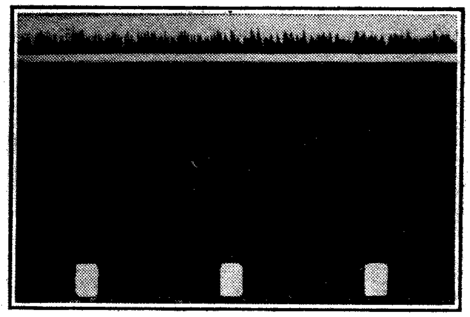
Synchronisation of picture and disc in the sound-on-disc method can be achieved both electrically and mechanically, but for home talkie apparatus the mechanical method is the simpler. It is not too simple, however, as both amateurs and manufacturers have found in the past. The needle must be placed on the correct point of the record and the correct frame placed in the picture gate, both the projector and the record-turning mechanism being started together. If it is started wrong one must begin all over again and in practice this is a great nuisance. In the best sound-on-disc sub-standard apparatus troubles of this kind have been reasonably well taken care of.

Practical Limitations to Both Systems

With the exception of one or two news-reel cameras all sound-recording apparatus used professionally is kept separate and distinct from the camera, being synchronised with it when necessary. Music, extraneous sounds, and numerous other effects are rarely recorded at the time the picture is made, the microphone on the set being used almost exclusively for synchronised speech. The recordist in a modern studio has a vast library of sound effects to draw upon, and when we hear a song with an orchestral accompaniment it is as likely as not the song was recorded to the accompaniment of a piano and the orchestral music subsequently recorded in synchronism with the picture projected on the screen in the band studio. Certain well-known films—"Man of Aran" is an example—were shot entirely as silent pictures, all sound—even speech—being recorded afterwards.

The final sound track chosen for a film after the picture editing has been completed may represent, in some parts of it, the "marrying" of half a dozen superimposed sound tracks. It will thus be seen that a separate sound track is an essential part of modern talkie technique.

It is impossible to produce a good film, amateur or professional, without a great deal of editing, rearrangement and cutting.



In the 16-mm. sound film, the sound track occupies the space which would otherwise be taken by one row of perforations in the "silent" 16-mm. film. With the 16-mm. film, there is only one perforation per frame against four in the 35-mm. size. Both this and the preceding illustration are taken from pieces of film produced on the Film Recorders Sound System.

Even if it were possible to shoot the scenes in the exact order in which one wishes them to appear on the screen, there are beginnings and ends of scenes, bad parts, repeats, mistakes and many other defects which have to be cut out. If the sound is recorded on the film at the same time as the picture, any editing is, to all intents and purposes, impossible. If, for example, there are three or four bad picture frames to be cut out—it is very easy to remove these and to resplice the film—it will be found on running the film through a sound projector that, owing to the separation between the sound and the picture, unwanted sound has been left in and some that it was desired to retain cut out. This is because, as indicated earlier in this article, the sound is recorded a number of frames ahead of the picture in order that it can reach the sound gate at the same time that the picture reaches the picture gate.

A similar problem faces the maker of the synchronised film by the sound-on-disc method, for it is not possible to cut out portions of the record, and the loss of even a single frame will upset the synchronism. With sound-on-film, where sound has been recorded at the same time as the picture, a limited amount of rearrangement of scenes is possible, provided the cutting does not separate the sound from its accompanying band of pictures, but a rearrangement of scenes in the disc method is totally impossible without re-recording.

Lack of realisation of the above points is the chief reason why a beautifully made amateur sound-on-film camera marketed a few years ago proved to be a commercial failure. This instrument was very well made, produced excellent 16-mm. pictures, and recorded quite well on the film; but it was found in practice that, no matter how carefully rehearsals were conducted, it was quite impossible to shoot the film and the sound in such a way that no editing was required. More than one 16-mm. camera for the simultaneous recording of sound and picture has been marketed, but none has achieved any success, nor, in my opinion, is this possible in the circumstances.

What is the Solution?

The solution would appear to be the use of a special synchronised sound camera in which the sound film would run at, say, 90ft. a minute, while the picture camera runs at the present speeds of either 16 or 24 frames per second. The sound film could be either 16-mm. stock or even a narrower width specially perforated, in view of the fact that the width of the sound track is much smaller than that of the picture. It has now been found possible to record satisfactorily on 9-mm. film and it should be practicable to use 8-mm. The moving parts in a film-recording camera can be made very much smaller and lighter than those of a disc recorder, and one advantage of this scheme is that two films, picture and sound, could be processed separately with the greatest advantage to both. Automatic compensation for exposure errors is made use of in developing modern "reversal" films, but any tricks of this kind would completely upset the quality of the sound track, which in any case would be uniformly exposed throughout. By keeping the sound and picture separate the best-quality pictures could be obtained, using the compensating process, while the development of the sound film would not be injured by any such modifications.

This scheme would have the further advantage that both picture and sound could be cut, edited and rearranged with just the same freedom as we have with the silent film. If the negative-positive process were used a spoiled picture film would not necessarily mean a spoiled sound track and the breakage of one would not injure the other, a new copy of either being available when required from the original negative. The library problem would also be greatly simplified, as the transport of large discs, or even small ones, is much more difficult than packing a couple of spools of film. The amateur would also have a wide field thrown open to him in combining and re-recording sound tracks, as is done in the professional studios, and, of course, running commentaries, lectures, etc., could all be very easily synchronised with the picture film after taking.

We thus come to the conclusion that, provided the sound track is separated from the picture, all of the advantages of disc recording can be obtained with substandard sound-on-film in addition to many advantages with which the disc method cannot compete.

Crystal Band-Pass Filters

PART IV—TELEPHONY RECEPTION WITH QUARTZ CRYSTALS

By E. L. GARDINER, B.Sc.

IN this article band-pass filters which are suitable for the reception of telephony are discussed. Such filters tend to exhibit a dip in response at the mid-band frequency; methods of avoiding this effect and producing a flat-top to the characteristic are described.

IT is probable that most readers of *The Wireless World* are more interested in the reception of telephony or broadcasting than of telegraphic signals, so it will now be best to pass on to consider the former problem. It is convenient to review crystal filters in the order of increasing band-width, and hence narrow filters of a kilocycle or less in width have been described first. Similar methods can be used for widths of from 2 to 10 kc/s, however, provided that certain modifications are made in the circuit to reduce the "dip" between the two peaks which is noticeable in Fig. 8 (Part III).

Since the width of band-pass is very nearly equal to the frequency difference between the crystals chosen, it will be instructive to examine the kind of curve which results when the separation is increased from the 500 c/s of Fig. 8 up to 4 or 5 kc/s, namely about 1 per cent. of the working frequency.

A typical example of this curve is shown in Fig. 9. The exact shape will depend upon a number of factors, some of which will be dealt with shortly, but in general there will be a pronounced dip between the crystal peaks when the circuit of Fig. 7 is employed at such an increased band-width. Anticipating somewhat, it may be said that the curve shape is profoundly affected by the nature of the output load impedance, R of Fig. 7. The curve of Fig. 8 is typical when a resistor is used in this position. The effective load will, however, be largely capacitive, since there will be the grid-cathode circuit of a valve acting in parallel with R.

Mid-band Response

Consideration of the principle upon which these filters work will readily explain this dip within the pass region. Between the crystal frequencies it has been shown that phase is nearly constant, while the sideband responses of the crystals are additive. Externally to the pass region, phase is also nearly constant, differing by 180 deg. from that within the pass region, and the sideband response of the two crystals is in opposition. There will be a narrow region close to the resonant frequency of each crystal where phase is rapidly varying with frequency, but when the band-width becomes several kc/s we can safely neglect these regions since they affect only a small portion of the useful band.

Now if the two crystals are very close together in frequency, the mid-point (shown as M in Fig. 9) will not be far down the side of the response curve of either crystal, and each will contribute considerable output in the pass-band. Their combined effect will therefore be large, and the drop in response at M slight, as typified by the curves of the narrow filter in Fig. 8. It may be from 2 to 6 db. down relative to the peak response, and this drop will hardly be noticeable to the ear, being negligible for the majority of uses.

As the crystals are separated further in frequency, the response of each at M becomes less, and the combined response at the centre of the band-pass will fall. It would be expected that the further apart the crystals are placed the lower will be the response at M, and this contention is borne out in practice. As an example of typical figures, there may be a fall of from 6 to 20 fold or more relative to the peak response when the filter works into a reactive load. This would, of course, be a serious defect were there not several effective methods by which it can be overcome, and the most useful of which will be explained in the following paragraphs.

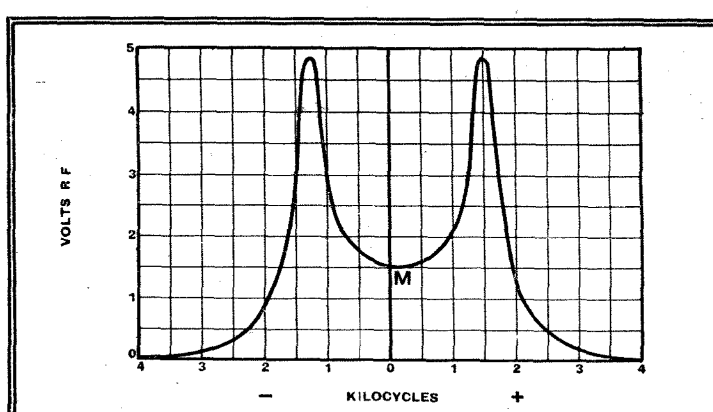


Fig. 9.—This curve shows the response of a pair of crystals when their frequency separation is fairly large.

The curve of Fig. 9 is not unlike that produced by the pair of coupled circuits used in an ordinary IF transformer, except that it is more extreme in shape. Now it has been shown by Cocking[1] that the curve produced by two over-coupled circuits, each of "Q" equal to Q_1, can be corrected and rendered most nearly flat if the trough be "filled in" by a following circuit of "Q" $=Q_2$, such that $Q_1 = 2\,Q_2$. This is a recognised principle of design, and could doubtless be applied to obtain a moderately level pass region from the filter of Fig. 9.

In this case, however, the two crystals which correspond to the two over-coupled circuits have a Q of from 10,000 to 20,000. Hence the circuit required to correct this curve would possess a Q of from 5,000 to 10,000. Unfortunately this is just the range which is most difficult to attain, being considerably higher than can be reached with the best coils and condensers, and hence the method is a difficult one to apply.

Obtaining a Flat-topped Curve

It would no doubt be possible to employ a number of highly efficient circuits in "cascade," but to do this would defeat that simplicity which should be one of the chief advantages of the crystal filter. The use of a third crystal of lower Q for correction has been found very difficult, because a parallel type of resonant circuit is needed, whilst the crystal is inherently a series resonator. It might be possible to raise the Q of a circuit to the required region by reaction, but since other and better methods of correction are available there seems little reason to dwell at length upon such inconvenient expedients.

It should not be forgotten, however, that under practical conditions a certain amount of correction of this type invariably takes place, because the crystal filter will form part of an amplifier which is almost certain to include one or more other tuned coupling circuits. Even if the Q of these circuits is not very high, their combined response curve will influence that of the amplifier as a whole, and if it

[1] *The Wireless Engineer*, March, April and May, 1936.

Crystal Band-Pass Filters—

is desired to obtain a flat band-pass response from the latter, then it will be necessary to select a somewhat concave shape for the crystal filter curve itself.

It will be noticed that most of the filters described show some drop in response near the middle of the pass band. This should not be regarded as a defect, and can be obviated in most cases when necessary. It is retained so that a flat overall characteristic will result when the filter is included in a practical amplifier. Were the filter curve quite flat, then the addition of other coupling circuits would bring about a hump-shaped pass band, which is not at all a desirable condition.

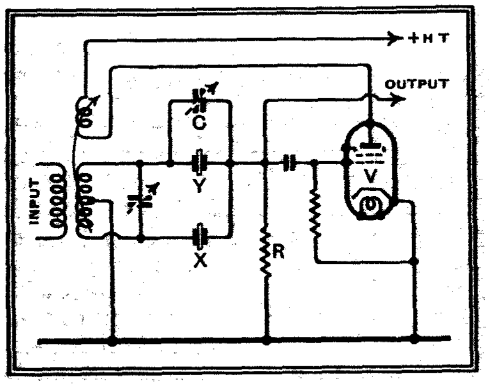


Fig. 10.—The pronounced trough in the resonance curve of Fig. 9 can be avoided by the use of reaction applied on the lines shown in the diagram.

The rather exceptional phase relationships which exist in a curve of the type shown in Fig. 9 can be utilised to give correction through the help of reaction. While it may not be the most convenient method for use in general radio reception, the effects of reaction are of great theoretical interest, and may be very useful in other applications of the filter.

The Use of Reaction

Consider the phase changes occurring throughout the curve of Fig. 9. It was explained in the initial article that over most of the pass band the phase of the output voltage from the filter (relative to the input voltage) is practically constant, and differs by 90 deg. from that at either peak. The phases at the two crystal frequencies will differ by 180 deg., since each crystal behaves as a resistance at resonance and causes no phase changes, whilst each is connected to opposite ends of the input coil (see Fig. 7).

Thus, if the phase of the central portion, near M, be taken as zero, the two peaks will be +90 deg. and −90 deg. respectively, while from a few hundred cycles outside the pass band the outer regions will be 180 deg. out of phase relative to M. Except for a narrow region near each peak, where phase is changing rapidly, there will be zero phase over the whole of the pass band and the opposite phase over the whole external region.

Suppose reaction be applied in any convenient way, such as by connecting the grid of a valve, V, to the output side of the filter as indicated in Fig. 10, and coupling the anode of this valve to the input of the filter, in such a sense that positive reaction occurs over the central region near M. It will now be possible to bring up the pass band response by a factor equal to the "feed-back factor" k, and if k be chosen so that it equals the original ratio between the response at M to that at the peaks of Fig. 9, then reaction will have raised the pass band towards a level response.

Near the peaks there will be a departure of phase from that taken as zero, which has been arranged to correspond to positive reaction coupling, and hence the reaction will fall off, but since the original response was greater as the peaks are approached, this falling off is just what is required to produce a level curve. At the peaks themselves reaction will be 90 deg. out of phase, or in quadrature. Under this condition the feedback will have little effect upon the peak response, and unless k be high it is nearly true to say that there will be no change due to reaction at the crystal frequencies.

Outside the pass band the phase quickly reaches 180 deg., and reaction therefore becomes negative, reducing the response over the whole outer region. Thus, to sum up, the effect of reaction is to increase the response between the peaks where reaction is positive, to vary the peak response but little, and to reduce response outside the peaks. The band pass as a whole has been improved and levelled, whilst the attenuation at other frequencies has been increased.

The effects produced are shown in Fig. 11. They are not merely theoretical, but have been produced and verified fully in the laboratory, when it was even found possible to raise the pass region considerably above the original peaks of Fig. 9, whilst maintaining stability.

Probably the only objection to the reactive method of flattening the band pass is the need for one or more additional valves, and a certain amount of circuit complication. When these are justified, there is much to be said for reaction, since it can improve the ratio of pass band response to rejection of other signals by several fold. Having noted this possibility, however, we will pass on to the simplest method of all, and that which has been found the most satisfactory for use in IF amplification.

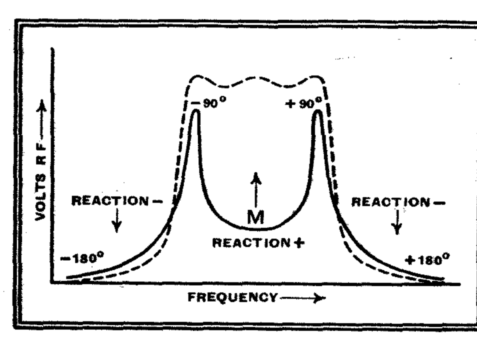


Fig. 11.—The effect of reaction is well illustrated by the dotted curve, the solid line showing a filter without reaction.

Television Programmes

An hour's special film transmission intended for demonstration purposes will be given from 10 to 11 a.m. each week day.

THURSDAY, NOVEMBER 24th.

3, Stanelli's Bachelor Party. **3.30,** Gaumont-British News. **3.40,** 193rd Edition of Picture Page.

7.45-8.20, "Under Your Hat." First Night scenes from the Palace Theatre, London. Viewers will meet Cicely Courtneidge and Jack Hulbert. **9,** Jack Hylton and his Band. **9.30,** British Movietonews. **9.40,** 194th Edition of Picture Page. **10.10,** News.

FRIDAY, NOVEMBER 25th.

3, "Divertissement," with the New English Ballet. **3.15,** Cartoon Film. **3.20,** Foundations of Cookery, No. 2, by Marcel Boulestin. **3.35,** British Movietonews, **3.45,** "Queens of France," a comedy by Thornton Wilder.

9, Marcel Boulestin (as at 3.20 p.m.) **9.15,** Cartoon Film. **9.20,** Demonstration of Ballroom Dancing. **9.35,** Gaumont-British News. **9.45,** Bridge Demonstration. **10,** Film. **10.10,** Marie Burke with the B.B.C. Television Orchestra. **10.20,** News.

SATURDAY, NOVEMBER 26th.

3, Cartoonist's Corner: Oscar Berger. **3.10,** Gaumont-British News. **3.20,** Cartoon Film. **3.25,** Jack Hylton and his Band.

9, Cabaret Cartoons. **9.35,** O.B. from Earls Court of Ice Hockey. **10.10,** British Movietonews. **10.20,** Music Makers. **10.30,** News.

SUNDAY, NOVEMBER 27th.

8.50, News. **9.5,** Cartoon Film. **9.10-10.30,** The Birmingham Repertory Company in Grace Carlton's play, "The Wooing of Anne Hathaway."

MONDAY, NOVEMBER 28th.

3-4.15, "An Elephant in Arcady," by Herbert and Eleanor Farjeon, with music adapted by Ernest Irving.

9, Starlight. **9.10,** Cartoon Film. **9.15,** Guest Night, No. 2. Another talk by A. G. Street, on planning the English House. **9.45,** British Movietonews. **9.55,** The Accompanist Speaks —Ivor Newton. **10.15,** News.

TUESDAY, NOVEMBER 29th.

3, Friends from the Zoo. **3.10,** British Movietonews. **3.20,** "Doctor, My Book."—a Dr. Abernethy play, by Rupert Cordova.

9, Friends from the Zoo. **9.10,** Gaumont-British News. **9.20,** "The Wind and the Rain," a play by Merton Hodge. **10.50,** News.

WEDNESDAY, NOVEMBER 30th.

3, Jack Jackson and his Band. **3.30,** Gaumont-British News. **3.40,** Cartoon Film. **3.45,** Forecast of Fashion.

9, Forecast of Fashion. **9.15,** Cartoon Film. **9.20,** Speaking Personally. **9.30,** British Movietonews. **9.40,** "The Padlock," a farce by Isaac Bickerstaff and Charles Dibdin.

The Trader Year Book, 1939. Pp. 123 + diary pages. The Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1. Price 7s. 6d. post free (issued to *Wireless and Electrical Trader* subscribers at a reduced rate).

THIS annual publication forms a handy reference book for both the wireless and electrical trades, for the use of which it is intended. Apart from the diary section it contains a complete classified directory of firms engaged in various branches of the industry, a mains voltage directory covering all districts in the British Isles and also certain towns overseas. Tabulated valve data and technical specifications of over 600 receivers and radio-grams marketed by nearly fifty manufacturers are given, together with details of 68 televisors. There is also a considerable amount of information concerning the new H.P. and Factories Acts.

NEWS OF THE WEEK

TELEVISION FROM THE THEATRE

First Transmission of Complete Play

WHILST technically (in the wireless sense) the recent televising of the complete show "When We Are Married," by J. B. Priestley, from the St. Martin's Theatre, was little different from any other O.B., it was certainly a milestone on the television road, for it is the first complete performance at a London theatre to be televised.

The producer of this excellent comedy, Basil Dean, is to be complimented for the scope thus afforded the B.B.C. television department. He was likewise in the forefront of those in the early days of broadcasting who realised the possibilities of the new medium of entertainment.

The television performance was indeed a credit to both producers and technicians alike.

It is probably not realised the difficulties which have to be overcome on all sides for the televising of such a show. In the first place the stringent rules of the London County Council regarding trailing cables and the blocking of exits have to be adhered to rigidly, which is by no means an easy matter when there are nearly a dozen cables and wires to be carried to the scanning van outside the theatre.

It was necessary to bring a three-phase AC supply into the theatre as only DC was available. This was a temporary arrangement, and was removed after the broadcast.

The normal stage lighting was, of course, inadequate for the purpose of television, and it was therefore augmented to 36 kW.

"When We Are Married" is an ideal stage show for television as there is very little vigorous movement, but players had to re-adjust their positions to a certain extent in order to keep themselves within the field of vision of the cameras.

THREE CAMERAS, two on platforms at the extreme ends of the orchestra stalls and one in the dress circle, were used for the televising of "When We Are Married."

STATEMENTS IN THE HOUSE

Television Service: Exclusive Overseas Broadcasts

IN a written Parliamentary reply to a question in the House of Commons last week, Major Tryon, Postmaster-General, said he was informed by the B.B.C. that the capital expenditure incurred on the television service up to September 30th this year, less depreciation written off, was approximately £126,000, and the income expenditure up to that date, including depreciation and programmes, engineering and staff costs, was approximately £660,000.

Sir W. Womersley, Assistant Postmaster-General, in reply to another question in the House, stated that the control normally exercised by the B.B.C. over speeches broadcast from their own stations did not apply in the case of speeches not broadcast here but sent by the public telephone service to the United States or other foreign countries to be broadcast there. In such a case the responsibility naturally rested with the foreign organisation concerned.

ABERDEEN'S BROADCASTING HOUSE

Studio Centre for Red Moss

FOLLOWING on the recent opening of the new transmitter at Red Moss, the B.B.C. has now transferred its Aberdeen studio centre from Belmont Street to Beechgrove House, hereafter to be known as Broadcasting House, Aberdeen. The premises, which consist of the original building and an extension of approximately the same size, will be opened on December 9th by the Marchioness of Aberdeen and Temair.

Studio's Pitched Roof

There are four studios, the largest of which (the Orchestral studio) has a capacity of 55,000 cubic feet and takes up the greater part of the north-east extension. The acoustic treatment is particularly interesting in that a pitched roof is utilised, although concealed by an open grille ceiling. The walls are treated with alternate panels of lath and plaster and rock wool above a seven-feet panel in oak. The other studios are respectively for Drama, Talks and Effects.

EUROPEAN WAVELENGTH PROBLEM

Project for a Plan

THE conference of the Union Internationale de la Radiodiffusion which is being held in Brussels and at which some thirty States are represented, has produced what is called a "Project for a Plan." This does not necessarily signify that any delegate agrees entirely with the projected rearrangement of channels. It is agreed, however, that a valuable basis for discussion has been evolved.

The main purpose of the conference is to examine the present distribution of wavelengths and revise the Lucerne plan, particularly in the light of the Cairo Telecommunications Conference. Some 100 new stations have to be accommodated in the new wavelength plan.

According to a correspondent at Brussels, a definite settlement of the long-wave muddle is foreshadowed; the suggestion is that Kaunas and Luxembourg be moved to the medium band. It is proposed that Holland loses her long-wave channel; Hilversum would then get an allocation at the upper end of the medium band.

On the medium waves there seems to be a general downward trend to make room for Kaunas, Hilversum and additional stations. It is recorded that Russia, which already has ten exclusive wavelengths, has applied for eighteen.

There are at present twenty-seven stations on the available twenty-two long-wave channels. The suggestion is that the number of channels is reduced to fourteen, with full 9 kc/s separation, and the number of stations reduced to seventeen. A further proposal is that Deutschlandsender should have a 10 kc/s separation on either side and that there should be 9.5 kc/s between Droitwich and Warsaw.

It will be interesting to have confirmation of these proposals which, it should be emphasised, are but a basis for discussion at the International Convention to be held in Switzerland next spring.

ANGLO-AMERICAN TRADE PACT

Effect on The Industry

THE position regarding import duties on wireless apparatus manufactured in the United States of America is unaltered by the Anglo-American Trade Agreement. In the Agreement, no specific reference is made to purely radio apparatus, the duty on which will therefore remain at 20 per cent.

Radio-gramophones, however, are specified, the duty having been reduced from 33⅓ to 25 per cent. Under the heading Sound Amplification Apparatus are amplifiers and loud speakers,

News of the Week—

which undoubtedly refers to public address and cinema apparatus, the duty on which has also been reduced from 33⅓ to 25 per cent.

It should be pointed out, however, that whilst the position regarding wireless receivers and components remains unchanged, the fact that they are not mentioned in the schedule does not preclude further consideration of the question of duty.

Whilst roughly 50 per cent. of the wireless industries imports into Great Britain come from the U.S.A., last year's exports (including re-exports) to America amounted to about £1,000, all of which was transmitting apparatus. It will be seen, therefore, that the reduction from 35 to 25 per cent. on all radio exports from this country to America can have little significance.

PORTABLE THEATRE ORGAN

Reginald Foort Takes to the Road

REGINALD FOORT demonstrated his twenty-ton portable theatre organ to a Press gathering at Drury Lane last week. He struck a happy note by giving Sandy MacPherson, his successor as B.B.C. Theatre Organist, the privilege of playing it for the first time to an audience.

The console has five manuals and provides for more than 5,000 tone combinations. The pipes, ranging in size from one large enough for three men to stand in to one smaller than a lead pencil, are operated by high pressure derived from two 15 h.p. blowers; two DC generators operate the electrical system. The relays, which contain many miles of wire, weigh two tons, and over 200 ounces of sterling silver are used for contacts.

Mr. Foort estimates that it will be possible to assemble and dismantle the organ in about one and a half hours. Completely built up on the stage, it measures 42 feet wide, 18 feet high, and 15 feet deep. It is to be transported from town to town by a fleet of appropriately labelled lorries, and will be heard regularly from Radio Normandie by means of electrical recordings.

SCIENCE IN THE ARMY

Exhibition at South Kensington

AN Exhibition designed to illustrate the British Army's working partnership with Science was opened last Friday at the Science Museum, South Kensington, by the Rt. Hon. Hore-Belisha; Lord Nuffield was in the Chair.

The latest developments in Army communications are to be seen there, and the 8-cwt. Morris Wireless Truck is of particular interest. It incorporates a portable short-wave transmitter-receiver for CW or telephony, providing for intercommunication between trucks, either stationary or on the move, or with fixed stations. The aerial is either a six-foot or nine-foot vertical rod, and power is derived from a 12-volt accumulator; frequency control is effected by a master oscillator or quartz crystal. The Exhibition is to remain open for three months.

DR. A. P. M. FLEMING (right), President of the I.E.E., and Mr. E. A. Gimingham, who joined Edison Swan in 1884, photographed after the informal inauguration last week of the Ediswan Exhibition of Historic Lamps in London.

B.B.C. HEADPHONE CONDUCTOR

ON more than one occasion during the broadcast of "Radio Pie" last week, Charles Shadwell, Conductor of the B.B.C. Variety Orchestra, slipped on a pair of headphones. He said afterwards that it had now become his practice to conduct the orchestra with the phones on when accompanying certain quiet singers or instrumentalists who he would otherwise experience difficulty in hearing from across the studio. The phones also make it possible for him to hear his work as the listener hears it—balanced and controlled.

CZECH STATIONS

THE Melnik 269.5-metre, 100-kW Czech station, which, until the occupation by Germany of the Sudetenland, broadcast entirely for the German minority, is now "international." Apart from the normal Czech transmissions, daily news bulletins will be given at quarter-of-an-hour intervals from 8.15 p.m. C.E.T. in Croat, Rumanian, German, French, Italian and English.

A temporary 1.5-kW transmitter was expected to be put into service in place of the ceded 100-kW Moravska-Ostrava station, on November 20th. The erection of a new 100-kW plant at Prostejov is being planned. The ceded transmitter, which has up to the present been announced as Schönbrunn, has now been officially re-named by the German broadcasting authorities "Sender Troppau."

FROM ALL QUARTERS

B.B.C. Glasgow Headquarters

BROADCASTING HOUSE, Glasgow, was officially opened on November 18th by Mr. Walter Elliot, Minister of Health, in the presence of Mr. Ogilvie.

News in English

IN accordance with the new, and what is claimed to be permanent, time-table for foreign language transmissions from French stations, news in English is broadcast from Lille on 247.3 metres and from Rennes on 288.5 metres every weekday at 5.30 p.m.

Broadcasting and the Royal Visit to Canada

THE "special events" branch of the Canadian Broadcasting Corporation is already planning a Dominion-wide series of broadcasts in connection with the visit of the King and Queen next summer.

B.B.C.'s Loneliest Station?

THE B.B.C. catering department is debating which is the B.B.C.'s loneliest and most forlorn transmitter, the intention being to regale the engineers there with the best Christmas dinner available. As in previous years, the dinner to staff on duty on Christmas Day will be free. At the moment the choice lies between Penmon and Burghead, both of which are desolate in winter.

South African Broadcasting Receives Listener Support

IT is the lot of broadcasting organisations to be attacked, and the South African Broadcasting Corporation is no exception. But, according to the Johannesburg *Star*, the criticisms by certain Opposition members of the House of Assembly do not reflect the opinions of the majority of listeners throughout the Union. A percentage of 97.75 of the letters recently received from listeners have shown approval of the programmes and the wireless licences are increasing at the rate of 2,500 every month.

College Radio Exhibition

THE Portsmouth Municipal College will be thrown open to the public on the occasion of an Exhibition which is being held there from 2 to 9 p.m. on December 8th and 9th. Readers will be specially interested in the wireless laboratory where, among other items, there will be transmitters, direction finders and television receivers constructed by the students.

Hive for "Queen Bees"

H.M.S. ARGUS, the only ship in the Navy to be set apart for use as a floating base for the wireless controlled *Queen Bee* target aircraft, is now being fitted out at Portsmouth; she will be ready for sea on November 30th.

Indian Radio Engineers' Guild

As a result of a meeting of radio engineers recently held in Madras, an association under the title of the Radio Engineers' Guild will be formed to create mutual understanding among radio engineers and servicemen and to encourage radio manufacturing in India.

O.B. Greetings

THE B.B.C. Outside Broadcasts Department has been accorded the honour of planning the New Year's Greeting programme, instead of the Drama Department, and the producer is to be Thomas Woodrooffe. Novel "O.B.s" are to be expected.

Negro Choirs by Record

A SERIES of programmes by Negro choirs has been arranged by Felix Greene, the B.B.C.'s representative in America. These will be recorded and sent to London for use in B.B.C. programmes at suitable opportunities. The first takes place on Christmas Day.

R.C.A. Income

NET profit for the first nine months of the year of the Radio Corporation of America and subsidiary companies, shows a drop of over a third compared with the same period last year. The figures for 1937 were $6,599,111, whilst this year's are $4,141,205.

New Rumanian Stations

RUMANIA is to have a new 50-kW short-wave broadcasting transmitter at Bucharest and a 60-100-kW medium-wave station at Baneasa.

Borough Polytechnic

As the result of recent developments in the Electrical Engineering Department of the Borough Polytechnic, the Governors have appointed Mr. S. N. Ray, M.Sc., A.M.I.E.E., A.Inst.P., to the full-time post of lecturer in Radio Engineering. He will assume this position in the New Year.

December Meetings

Monday, 5th, 7 p.m. I.E.E. South Midland Centre, at The James Watt Memoria Institute, Great Charles Street, Birmingham. "The London Television Service," T. C. Macnamara and D. C. Birkinshaw. "The Marconi—E.M.I. Television System," A. D. Blumlein, C. O. Browne, N. E. Davis and E. Green.

Wednesday, 7th, 6 p.m. I.E.E. Wireless Section, Savoy Place, London, W.C.2. "Long Feeders for Transmitting Wide Side-Bands, with reference to the Alexandra Palace Aerial-Feeder System," E. C. Cork and J. L. Pawsey. "E.M.I. Cathode-Ray Television Transmission Tubes," Dr. J. D. McGee and H. G. Lubszynski.

Tuesday, 13th, Institution of Electronics, 75, Gloucester Place, London, W.1. "Round About Five Metres," A. L. Beadle.

Friday, 30th, R.S.G.B. Annual General Meeting. "Superheterodyne Receivers," R. H. Hammans.

Fallacies

SOME POPULAR MISCONCEPTIONS

By "CATHODE RAY"

ONE usually thinks of fallacies as false arguments based on the ignorance of our remote ancestors. According to this, the only thing a fallacy can look forward to in these modern civilised days is to be exploded. Although exploding is notoriously one of the most characteristic expressions of modern civilisation, we find that it is still possible for fallacies to flourish even in such a recently developed field as wireless.

The term "wireless" itself is responsible for some of these curious twists of thought. One would have thought it would have dropped out just as quickly as "horseless carriage." But while we never think of asking the garage to service our horseless we still send for a man to service our wireless. And although the length of wire used every year for making "wireless" would stretch from the Earth to Venus (or is it Mars?) there is just a crumb of sense in the word because no wire is needed to link the transmitting and receiving aerials. But is that how the public understands "wireless"? Not a bit! Some years ago, before "Public Address" was on the map, I arranged a loud-speaker system in a certain church where the congregation habitually overflowed into the adjoining hall. The thing was fairly novel then, and attracted the attention of quite a number of newspapers, including one national daily. Though their accounts differed in detail, they all agreed in describing it in such headlines as "Wireless in —— Church," while one even went so far as to inform its readers that of course the church would have to take out a Post Office wireless licence! Even to-day, when the normal person sees any system depending exclusively on wire communication and making use of a loud speaker he unhesitatingly refers to it as "wireless." Any new dictionary that is brought out will have to take account of the growth of the English language by including the following definition: "*Wireless*—Sound distribution by means of loud speaker."

In almost every other part of the world "radio" has become accepted as the term denoting systems depending on radiation of waves through space, at any rate within certain limits of wavelength. But now comes another fallacy—that radio (or wireless) and television are two distinct things. How? Why? Can we of the twentieth century pride ourselves on our brains when we say a system with wires throughout is "wireless," and a system—television—which does not use wires to join transmitter to receiver is not "wireless"? Even a child thinks more clearly than this. "Daddy, isn't that a big radio?" "That's not radio, my child, that's television." "Why, Daddy?"

"Yes, Daddy, why?"

But confusion of thought seems to have touched its ultimate bottom in a newsbill I saw outside Olympia this year. It bore one word—"TELEOLYMPIA." What it meant was that as the exhibition at Olympia was given over largely to television instead of (!) radio it should not be called "Radiolympia" ("Why, Daddy?") but "Teleolympia." But of course the "tele" part of "television" merely expresses the idea of distance, which is equally applicable (or inapplicable) to telephony or telegraphy. Another paper, presumably with a classical scholar on its staff, came out with "Visiolympia," which does seem to have some connection with the idea it was intended to convey.

Cheaper Televisors ?

Talking about television, nearly every member of the public who discusses the subject with me seems to be firmly convinced that television sets must inevitably become as cheap as "ordinary radio." Instead of showing any trace of admiration for the gigantic technical problems that have been solved in order to allow television to be available on such favourable terms as at present, they ask in quite a resentful tone why the prices should be so high, and seem to be under the impression that the present period is being used by the manufacturers either for profiteering (if you want to see a television manufacturer go pop like a soap bubble on a stove, ask him why he is profiteering!) or as a sort of tedious ceremonial introduction to the sale of television receivers proper at about £9 19s. 11d. each. The argument is that "ordinary radio" has come down to the present prices from much higher ones, so television ought, on penalty of their sore displeasure, to do likewise. Yet they do not go to the Motor Show and take the exhibitors to task for failing to bring down their prices to the same level as those of push-bikes.

There is no limit to what the public expects, and even demands, of the technician. "Free Grid" has dwelt on this theme as a result of his encounters with persons who insisted on the smell as well as the sight and sound of a television cookery demonstration, and how they were not satisfied even when they unexpectedly got it as a result of a slight technical hitch in the power unit. And the products of the sensational fiction writers are not helpful in this respect. We have got past the descriptions of the wireless cabin on board ship where vivid blue sparks play around the gleaming brass as the fateful message is *received* (or have we not? I have lost touch with this class of literature recently). But the B.B.C. disseminated some curious ideas about the possibilities of radio in their "Gang-smasher" serial, in which the villain was able to work duplex telephony with any of his confederates, at any time, in any place, by means of his unobtrusive "short wave circuit," which, incidentally, had a nasty heterodyne whistle all the time. Perhaps that was a small price to pay for the unique advantages of the system, which included perfect secrecy.

The popular fallacy implied in the term "on the air" seems actually to be growing. As far as my memory serves me it was No. 2 of the *Radio Times*, somewhere around 1922, that introduced a weekly column under that title with an apology for its technical incorrectness. But at the present time announcers and others, and even engineers, use it freely without apology. So one can hardly expect the general public to realise that air has nothing to do with inter-aerial communication, which if anything would go on even better in a perfect vacuum.

Another fallacy concerning the propagation of radio waves is the idea of range. "The television transmitter has a range of only 25 miles, hasn't it?" people are always saying to me. And when I point out that this was an intentionally conservative estimate, they ask what the range is—50, 75 miles? I find it very difficult to convince them that it may be anything from 5 to 200 miles, according to circumstances.

And, of course, most of them think that broadcasting is radiated from Broadcasting House. The aerials on the roof are pointed out as clear proof. And I wonder how many times the Post Office aerials near Rugby have been pointed out as Daventry.

Big Aerials Are Best

Coming to receiving aerials, the opinion still lingers that large aerials are "less selective" than small ones—a fallacy promoted by the B.B.C. in the early days of the regional system by their instructions to cure inselectivity by shortening the aerial. While that advice served its purpose at the time, it does not affect the fact that when properly connected to the receiver in each case a large aerial gives the greater true selectivity.

I have already mentioned some of the wrong ideas that grow out of ill-selected technical terms. One of the most curious came to light as the result of a request that I should recommend a suitable make of speech transformer, as the inquirer had heard that such things were available, and although he was quite satisfied with his

Fallacies—
set's reproduction of music he did not get speech very clearly. So I had to explain to him as best I could that in scientific (?) language "speech" embraced music, jazz, singing, crooning, morse and, in fact, anything that might be received. His unanswerable retort was "Then why call it speech?"

Another misleading term is "noise suppression" applied to QAVC. The purchaser of a set advertised to include this feature may well be grieved when he finds it contains no protection whatever against noise of any sort, short of completely suppressing the programme too.

"Automatic Tuning" is a subject well to the fore just now, and is already assuming that indefinite and semi-wrong sort of meaning that seems fated to gather around most things in radio. Some people think it means the system that automatically ensures correct tuning so long as it has been brought somewhere near it. And others think it is the same thing as "push-button" tuning. The fact that both systems are often found in combination adds to the confusion.

But the most hopeless muddle of this sort is due to the term "valve." At first it looked as if we were one up on the Americans with their "tubes," for the original rectifying valve did work in a way that reminded one of a mechanical non-return valve, whereas a "tube" might signify a telescope or an underground railway or a drainpipe. But now that everybody is striving desperately to define for commercial purposes an *n*-valve (or -tube) receiver, the U.S.A. have walked away with it by their definition of a "tube" as "a device consisting of an evacuated enclosure containing a number of electrodes between two or more of which conduction of electricity through the vacuum or contained gas may take place." That rules out such things as barretters and even dial lamps (yes!) that were being included to inflate the rated number of tubes in a set, but leaves everything else—amplifiers, detectors, rectifiers, and tuning indicators, which can all cheerfully be referred to as "tubes" without offending any scruples. But *we* have to try to make sense out of a situation in which the only items that are generally left out of the count of valves happen to be about the only ones to which that term can correctly be applied! If anything in a set is a valve, it is the power rectifier. And if we include amplifiers and frequency changers as valves— as we have to—is there a leg to stand on in asking that tuning indicators or even barretters should be left out?

Random Radiations

By "DIALLIST"

Receiver Performance

THE suggestion put forward recently by a correspondent in *The Wireless World* for a straightforward sensitivity rating of wireless sets strikes me as a very good one indeed. Something of the kind has been wanted badly for a long time, for, as the writer of the letter said, a millivolts per metre conveys less than nothing to the man in the street. If only he could have some criterion as simple and as easy to comprehend as, say, the maximum top-gear speed of which a car is capable, he'd understand much more readily why the 1925 receiver to which he still pins his faith isn't quite so efficient as the 1938 model with which he ought to replace it.

Amazing

It's astonishing to me that wireless manufacturers as a body don't take steps to show the ordinary man just why it doesn't pay to go on using a receiver that has long been out of date and completely incapable of anything like the performance or the quality of a modern set. I suppose I could give at least a score of instances among my own acquaintances of well-off people who possess nothing but antediluvian receivers. It's astonishing, actually, to find how many of those who come to my house and see a press-button set had no idea whatever that there were such things. My prize example of the unguided listener is a wealthy man who has four separate receivers in his house, none of them less than six years old. And I wonder what proportion of those listeners who complain bitterly about man-made interference have ever heard of the anti-static aerial or the disturbance suppressor. A little missionary work amongst the unenlightened would work wonders if only the radio manufacturers would undertake it.

Fun with the Electric Meter

THE other day I wanted to check the current consumption of a receiving set and it occurred to me that a domestic electric supply meter might be made to do something else besides ticking up the units for my quarterly bill. A preliminary examination of its economy wasn't very encouraging, for it contained no dial giving a smaller reading than one-tenth of a kilowatt-hour. One could of course have connected up the set and have timed its consumption of one-tenth of a kilowatt-hour; but that would have been a slow process and I wanted something a good deal quicker and handier. I don't think that I have ever before bothered to examine the supply meter very carefully—one takes it for granted, much as one takes the gas meter. But the examination that I now made showed that it had distinct possibilities.

Checking-up

As you will discover, if you take a look at yours, there is a disk, set edge-wise, which revolves when current is flowing in the household circuits. On the meter there is a small plate which shows the number of revolutions made by the disk per kilowatt-hour. The disk itself is marked off into a number of divisions, which I'm afraid that I haven't yet counted, and it has a little indicator by means of which you can see when it has made a complete revolution. My meter makes 375 revolutions per kilowatt-hour, but this does not appear to be a standard figure, for I find that my next-door neighbour's makes 450. But once you know the number of revolutions per kilowatt-hour it's easy enough to work out the time per revolution for any given load. For example, a rate of 375 per kilowatt-hour means one revolution in 96 seconds under a 100-watt load, or in 960 seconds under a load of 10 watts. Hence 240 seconds per revolution indicates 40 watts, 192 seconds 50 watts, and so on. We can even evolve a formula:

$$\text{Watts} = \frac{3{,}600}{R \times T} \times 1{,}000,$$

where R is the revolutions per kilowatt-hour as shown on the meter and T the time in seconds for one revolution.

Most Useful

Before you can make use of your electricity meter for checking up this or that you must first satisfy yourself that it is reasonably accurate. This can be done by imposing a load whose value is exactly known and seeing what the meter has to say about it. Failing that, brand new electrical lamps of good make will answer pretty well, for they are guaranteed to be within a small percentage of their stated rating. Once you know that the meter isn't telling lies it is easy to discover whether or not a radio set is correctly rated at so many watts. Select a time when all electrical appliances in the house are out of use, plug in your set, switch on and, when it has warmed up, take the time for one revolution of the disk with a stop-watch. Apply the "Diallist" formula and there you are. You may, by the way, find that you obtain rather interesting results if you check some of the very cheap lamps in the same way.

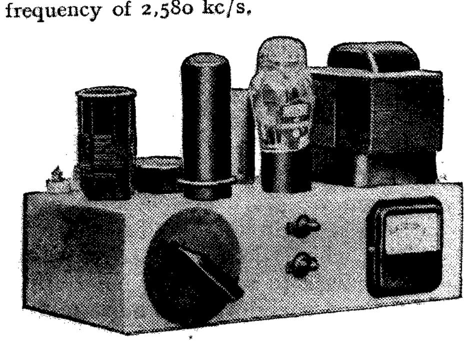
The Wireless Industry

THE annual Exide dance and cabaret took place last Friday at the Grand Spa Hotel, Clifton, Bristol.

Ward and Goldstone, Ltd., of Frederick Road (Pendleton), Manchester, 6, have issued their 1938-39 Radio and Electrical catalogue, and will send copies to readers who apply for them. As usual, this publication is a valuable source of information on components and accessories of various types, including many that are difficult to obtain through ordinary channels. An important section of the list is devoted to aerial equipment.

An Inexpensive Transmitter

A KIT of parts for a small CW transmitter capable of operating on any two harmonically related bands between 20 and 160 metres is announced by Radiomart, 44, Holloway Head, Birmingham, 1. The ready-assembled kit, which only requires wiring, includes a Bliley crystal, Raytheon valves, and, in fact, everything except the morse key. The kit, which costs £4 19s. 6d., can be supplied, if required, with a crystal and coil for the R.A.F. Civilian Wireless Reserve special frequency of 2,580 kc/s.



Stabilised Transformers

For Use Under "Constant Load" Conditions

By D. A. BELL, B.A., B.Sc.

REFERRING to the writer's recent articles on "Stabilising Power Supplies," a correspondent suggests that, in the section devoted to the constant voltage transformer, a description might have been included of the type of transformer operating with a saturated core and a series resistance. This device is apparently used in resistance thermometer work.

The device referred to is not strictly a "constant voltage transformer," but is better described as a "constant load system." The distinction is that a properly designed constant-voltage transformer of the compensated type is comparable with an ordinary transformer in regulation characteristics, i.e., constancy of secondary voltage with varying load current over the working range of secondary currents, and has reasonable efficiency; but this type, using a series resistance, can only be worked into a more or less constant load, and is of low efficiency. Resistance thermometry is obviously an ideal application for this special type, since both the variations of input impedance of the load circuit (i.e., the thermometer bridge), and the power required are small.

The principle of operation of a single saturated transformer with series resistance can be seen by plotting out a magnetising current/voltage characteristic for the particular core to be used; Fig. 1 shows such a characteristic for Stalloy up to a flux density of about 13,000 lines per sq. cm.; this is just about reaching saturation. Suppose now we take the limiting case:

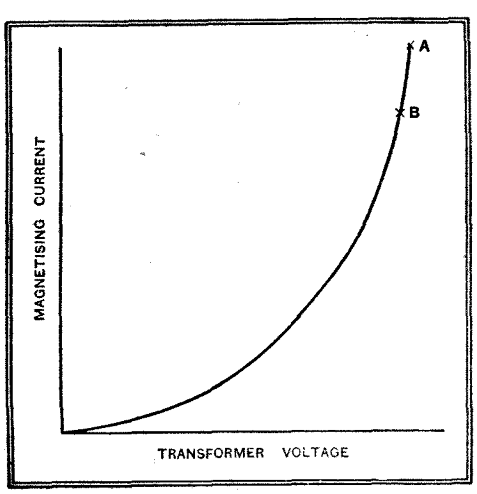


Fig. 1.—Illustrating the principle of operation. Magnetising current/voltage characteristics of a saturated transformer.

no load current and a very large series resistance. Then the only current will be the magnetising current, and that will be proportional to the supply voltage, since the series resistance is supposed to be so large that the transformer impedance has negligible effect on the current in the circuit. We may now read backwards from Fig. 1, regarding the scale of magnetising current as a scale of supply voltage, and for each value of this pick off the corresponding figure for transformer voltage. We thus find that a change of supply voltage of such a magnitude as to change the current from the point A to the point B in Fig. 1, i.e., a change in the ratio of 1.225:1, varies the transformer voltage in the ratio of 1.03:1; in other words, 22.5 per cent. change of supply voltage is reduced to 3 per cent. change of transformer voltage.

This, however, is for the limiting case, with zero efficiency. While efficiency may not be important from the point of view of power consumption in instrument applications, too low an efficiency is an embarrassment owing to the amount of heat, arising from the waste energy, which must

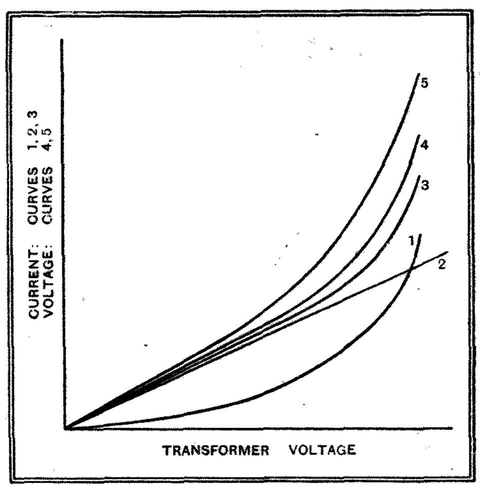


Fig. 2.—Curves for various currents and voltages in terms of transformer voltage.

be dissipated. Any particular practical case can be calculated approximately if we assume values for the ratio of magnetising current to load current and the ratio of voltage drop across the series resistor to voltage across the transformer.

As an example, take load current equal to magnetising current at point B of Fig. 1, and volt-drop across the resistor three times transformer voltage at this point. We can then construct in succession all the curves of Fig. 2 for the various currents and voltages in terms of transformer voltage. Curve 1 is magnetising current, as in Fig. 1. Curve 2 is load current, which for a constant load is simply proportional to transformer voltage. Curve 3 is the resultant of 1 and 2, but since the two currents are in quadrature, this is not obtained by simple addition but according to the expression $I^2_3 = I^2_1 + I^2_2$. Curve 4 is the volt-drop across the resistance, due to the total current; finally, curve 5 is the required input, i.e., the resultant of transformer voltage V_t and curve 4, once again not simple addition but allowing for phase

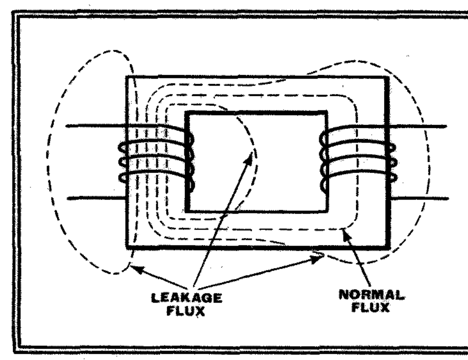


Fig. 3.—At high flux densities there is considerable leakage.

difference. (Phase angle ϕ given by $\tan \phi = I_1/I_2$; and $V^2_5 = V^2_t + V^2_4 + 2V_t V_4 \cos \phi$). We can then read back from curve 5 of Fig. 2, obtaining for any input voltage the corresponding transformer voltage; it will be found that corresponding to the points A, B in Fig. 1, giving 3 per cent. change in transformer voltage, the input voltage change is about 9 per cent. The efficiency in this example will be somewhere of the order of 20 per cent. Increasing either the degree of saturation of the core, or the ratios of magnetising current to load current, or volt-drop in resistance to transformer voltage, will improve constancy of output at the expense of efficiency.

Magnetic Leakage

But actually considerably better performance than indicated by the figures above can be obtained by taking advantage of the effects of magnetic leakage. In the ordinary way magnetic leakage is highly undesirable, since the leakage reactance makes regulation bad; but since the system under consideration is limited to practically constant load, because regulation is in any case hopeless owing to the series resistance, a large amount of leakage can be tolerated. The effect is as shown diagrammatically in Fig. 3; the normal flux remains within the iron core, and thus links both primary and secondary, but at high flux densities some of the flux generated in the primary tends to take paths through the air rather than through the already saturated iron, and since it does not link with the secondary windings this does not contribute to the secondary voltage. There will also be some leakage between the primary winding, particularly the turns farthest from the core, and the core. This effect naturally becomes proportionately greater with increasing flux

Stabilised Transformers—
density, so that as a result the secondary voltage increases more slowly even than appears from the calculations above where no allowance was made for leakage.

This type of transformer can, therefore, give a good performance provided one remembers that it is strictly limited to (a) approximately constant load and (b) low power, owing to its low efficiency and consequent need of generous provision for heat dissipation.

Letters to the Editor

The Editor does not necessarily endorse the opinions of his correspondents

Television in Disrepute

IN view of the immense amount of money and publicity which has been devoted to the popularising of television, the following incident may be of interest.

Passing by the radio department of a large departmental store in one of London's south-western suburbs this afternoon, I was attracted inside as it was evident that a television demonstration was in progress. Horror of horrors! There was a poor, innocent little 25-guinea table model (*sans* attendant) showing *three* delightful images all at once and suffering from "Bay of Biscay Blues," for the tossing waves and slashing rain were only too plain to see. But none of this, I might remark by way of anticlimax, marred the enjoyment of the twenty-odd schoolchildren aged four to twelve, who composed the entire audience!

G. W. BARBER.

Improving Amateur Operating Technique

THE First-Class Operators' Club exists to encourage genuine experimental work and first-class operating technique among transmitting amateurs. Membership of the Club is necessarily very limited, as the standard of qualification is so high that comparatively few are eligible for election to it. But I have received letters, expressing keen interest in the aims of the club, from many amateurs whose qualifications at present fall just short of the required standard.

It is obvious that if these could be brought within the scope of the F.O.C., without lowering the present standard for full members, the club's influence would be greatly strengthened and widened. One of your readers, Mr. W. Oliver (2DRM), has written to me suggesting a way in which this might be done.

Briefly, his proposal is that we should inaugurate an associate membership scheme, under which we could enrol those who are approaching first-class operating standards and are fully in sympathy with the objects of the F.O.C.

Associate members would be elected for a probationary period, during which full members of the club could help and encourage them to become first-class operators. The annual subscription for associates would be a nominal one (1s. per annum), and the code speed required would be fifteen words per minute.

In joining the F.O.C., associate members would agree to do all they could to promote first-class operating and to reduce QRM on the amateur bands, in addition to helping newcomers who wished for advice or technical assistance. If, therefore, a large number of associates could be enrolled, their influence would be a potent factor in raising the general standard of operating and furthering the best interests of amateur radio.

We should welcome your readers' comments (which may be sent direct to me: Radio G5BW, Willingdon, Eastbourne, Sussex), as we are anxious to ascertain, before launching a scheme on the lines suggested, what response is likely to be forthcoming.

R. B. WEBSTER
Eastbourne. (G5BW).

"Radio Laboratory Handbook"

SOME readers who have followed the circuit diagram of an audio-frequency source, Fig. 102 in my *Radio Laboratory Handbook*, have reported difficulty with motor-boating due to the action of the amplitude-control valve. I must apologise for having departed for a moment from my usual principle and made a slight change in the values of certain components (with the object of reducing any remains of distortion due to the control valve) without having checked them thoroughly for possible drawbacks in practice. The values marked for the control valve load resistance and for the filter between it and the dynatron oscillator are 4 megohms, 4 megohms and 0.1 mfd. respectively. The original ones, which definitely worked, were 1 megohm, 1 megohm and 0.5 mfd. A reader who has made up the apparatus and investigated it carefully slightly prefers 1 megohm, 2 megohms and 0.15 mfd. There is no doubt that the optimum values depend to some extent on individual valves, etc.

Where it is particularly desired to obtain a high standard of freedom from AC mains components of voltage in the output it is advised that the smoothing should be supplemented, say, by inserting a 20H choke in series with the 1,250-ohm smoothing resistor; also care should be taken to join heater centre-tap to −HT.

Taking into account the above notes, it appears that the specification can be recommended with confidence.

Bromley. M. G. SCROGGIE.

News from the Clubs

Goldsmith's Radio Society

Headquarters: The Goldsmith's College, London, S.E.14.
Hon. Sec.: Mr. A. L. Beedle, 67, Hillcross Avenue, Morden.

The Society has now a new SW receiver and a new transmitter. The latter is in operation on a frequency of 14,116 kc/s, between 8 and 10 in the evening. The call sign is G6OW. The Society would welcome reports on their transmissions.

Edgware Short-wave Society

Headquarters: Constitutional Club, Edgware.
Meetings: Wednesdays at 8 p.m.
Hon. Sec.: Mr. F. Bell, 118, Colin Crescent, London, N.W.9.

On October 26th G2QY explained his 5-metre transmitter and receiver and also described the different aerials used in the recent tests. During November 5-metre tests across the Atlantic will be held, and on November 30th a discussion on members' sets and the results of the tests has been arranged. At recent meetings lectures have been given by a representative of Cossor, Ltd., and by Dr. Stephans, of the T.C.C. Co. At the last meeting Mr. Youthed described his service equipment. Lectures by the G.E.C. and Rothermel have been arranged for the near future.

All tickets have now been sold for the Club's first annual dinner. The Club's membership is now 40.

Radio, Physical and Television Society

Headquarters: 72a, North End Road, London, W.14.
Meetings: Fridays at 8.15 p.m.
Hon. Sec.: Mr. C. W. Edmans, 72a, North End Road, London, W.14.

On November 11th, a lantern lecture was given by Mr. H. N. J. Riddle, of the Siemens and General Electric Railway Signal Co., Ltd.; several police officers attended the lecture, which dealt with the electrical arrangement of road traffic control systems. The Society is shortly paying a visit to the main telegraph office of Cable and Wireless, Ltd.

Dollis Hill Radio Communication Society

Headquarters: Braintcroft Schools, Warren Road, London, N.W.2.
Meetings: Alternate Tuesdays at 8.15 p.m.
Hon. Sec.: Mr. E. Eldridge, 79, Oxgate Gardens, London, N.W.2.

Mr. D. N. Corfield dealt with the subject of the alignment of the superhet receiver in great detail in his lecture on November 1st. Visitors will receive a hearty welcome at the junk sale to be held on November 29th.

Ashton and District Amateur Radio Society

Headquarters: Commercial Hotel, 86, Old Street, Ashton-under-Lyne.
Meetings: Alternate Wednesdays.
Hon. Sec.: Mr. K. Gooding, 7, Broadbent Avenue, Ashton-under-Lyne.

A lecture on electrical calculations was given by Mr. S. Wilde on November 9th. Mr. Wilde has agreed to give a series of lectures on this subject. A crystal frequency register has been compiled for the benefit of members, and is also available for the use of other societies. Several members have joined the Civilian Wireless Reserve of the R.A.F. and are now awaiting their training.

Exeter and District Wireless Society

Headquarters: Y.W.C.A., 3, Dix's Field, Southernhay, Exeter.
Meetings: Mondays at 8 p.m.
Hon. Sec.: Mr. W. J. Ching, 9, Sivell Place, Heavitree, Exeter.

The Wireless World Quality Amplifier and Receiver were demonstrated by Mr. F. W. Saunders on November 7th. On November 21st a demonstration was given by Voigt Patents, Ltd.

Surrey Radio Contact Club

Headquarters: The Alhambra, Wellesley Road, Croydon.
Meetings: First Tuesday in the month at 8 p.m.
Hon. Sec.: Mr. A. B. Willsher, 14, Lytton Gardens, Wallington.

At the meeting on November 1st Mr. J. Clarricoats, Secretary of the R.S.G.B., gave a talk on the history and growth of amateur radio.

The Club's annual dinner will be held in the Café Royal, Croydon, at 7.30 p.m. on December 8th. Full particulars concerning the price of tickets can be obtained from the Hon. Secretary.

Croydon Radio Society

Headquarters: St. Peter's Hall, Ledbury Road, South Croydon.
Meetings: Tuesdays at 8 p.m.
Hon. Sec.: Mr. E. L. Cumbers, 14, Campden Road, South Croydon.

On November 8th Mr. Stuart Davis gave a very interesting lecture in which he dealt with his high-quality apparatus. After describing the output stages Mr. Davis dealt with the gramophone pick-up. His receiver was the familiar *Wireless World* Pre-tuned Quality instrument to which he had made several alterations. He then gave a demonstration of recording and finally reproduced the television sound transmission.

UNBIASED

By Free Grid

Well known in the musical world.

Radiolympia Vindicated

I HAVE from time to time felt constrained, in the interests of my readers, to utter a few criticisms concerning certain undesirable features of the Radio Show. The paid mercenaries of the radio manufacturers have usually replied to my just accusations by putting forward the somewhat futile excuse that exhibitions associated with other pursuits have far less desirable features associated with them; just as if two wrongs made one right. In particular, I have always been assured that technical enquirers have always been given exceptionally generous treatment at the Wireless Show, and that it is far different at other exhibitions.

I long ago decided to test these statements by a personal visit to one of these "other" shows and finding myself wandering through Russell Square at a loose end the other evening, I drifted into an exhibition held under the auspices of the Royal Photographic Society. My chief reason for going in was that there was nothing to pay, such generosity being very rare nowadays in this highly commercialised world.

My first impression was that the quarters were rather cramped, and it was a bit of a struggle to get into a sub-standard ciné show that was being held, but by vigorous application of umbrella and elbows I succeeded at last. I don't know much about art, having been brought up very strictly in my youth, and one glance at my fellow visitors made me realise that I was rather out of my element. In the darkness of the

An "art" ful change.

projection room, however, I managed somehow to knot my tie into a bow and bash my bowler into some semblance of a sombrero, as if there is one thing I hate more than another, it is being conspicuous.

Emerging from the ciné show I determined to ask a few technical questions, but I realised that it behoved me to walk rather delicately as I might get taken out of my depth. I decided, therefore, to confine my questions to matters appertaining to the sharp focusing of television images, since this is, after all, a common link between photography and wireless. With this idea in view I approached a representative of a very well-known firm and asked a question about the polarisation of light.

Instead of a flood of sales talk which I had expected I was surprised and delighted to receive a reply which was both courteous and technically informative, and I spent a very interesting and instructive couple of hours discussing various other technical matters. Even then it was only the ill-mannered impatience of the queue behind me which caused me to pass on reluctantly to the next exhibit. My personal impression of the replies I received to my questions was that here was something that many of the exhibitors at the Radio Show might well try to emulate, although I could scarcely say the same of certain other features of the exhibition, and as a result the organisation of Radiolympia has gone up considerably in my estimation. Perhaps, however, I do not possess the artistic temperament.

Realistic Reproduction

THE other week I was complaining that there was never any very startling and thrilling improvement in wireless technique, more especially in the matter of quality reproduction such as was the case years ago when, for instance, resistance coupling was first introduced. I little thought that I was so soon to be pleasantly disillusioned. As the result of my note I had a letter from a man of my acquaintance who is very well known in the musical world and has for some time past been devoting himself to the study of radio and acoustic engineering in order to try and get the last ounce of distortion removed from radio reproduction. Unfortunately, he is, like myself, very short of funds, although not for the same reason, as he is unmarried.

What he lacks in cash, however, he makes up for in enthusiasm, but I cannot say that I was very excited when he invited me round to his place to receive what is vulgarly called an eye-opener—or, as I should say, in this case, an ear-opener—in the matter of quality of reproduction. Let me say here and now that I was very impressed indeed by what I heard, my feelings being akin to the old excitement which we used to get in the early days of the moving-coil loud speaker. The results obtained can only be described by the word "realistic," since it seemed as though the orchestra were in the actual room.

I was rather disappointed, however, when he told me that I had been listening to a gramophone recording via a modification of *The Wireless World* Quality Amplifier and that he could not get the same realism out of radio without the co-operation of the B.B.C., but I was amazed when he told me I had been listening to a home-made recording of the musical efforts of an amateur quartette. At first, I quite failed to grasp how he managed to obtain such realistic results, even when he pointed to the fact that he was using two loud speakers. I was, as I told him, perfectly well aware that some semblance of spatial or three-dimensional effect could be obtained by using two loud speakers, but this would not be sufficient to account for the exceptional results I had heard.

It was, he told me, all due to the fact that when making the recording, two separate microphones had been used, each being coupled by an entirely separate amplifier to its own recording apparatus. Actually, of course, two records were made and these were being played by two separate pick-ups, each with its own amplifier and loud speaker, the two turntables being synchronised by being driven from the same motor through a common gearing.

This idea of stereophonic reproduction is by no means new, of course, but I must confess that I had never actually heard it in use before, and I have become a very enthusiastic protagonist of the system. It is surely a golden opportunity for the recording companies to sell two records instead of one and for the radiogram makers to sell a double instrument having two of everything inside it. The system would, of course, lend itself more than anything to that type of radiogram in which the recording is on a narrow strip of film as there would be no difficulty in putting the double recording on parallel sound tracks on the same film strip.

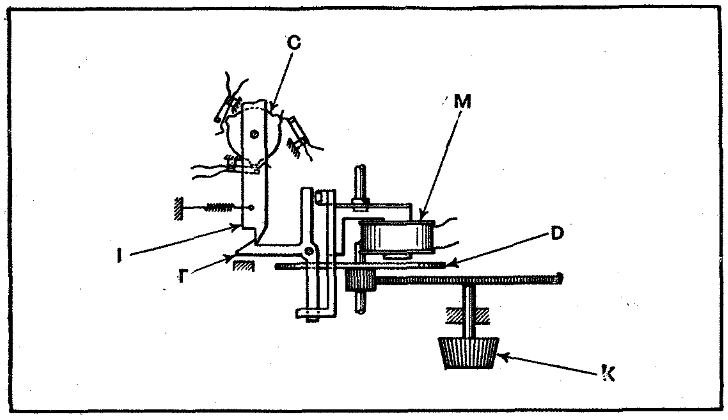
If only the B.B.C. could be persuaded to try the experiment of using the two Alexandra Palace transmitters, in non-television hours, for stereophonic broadcasting, the combination of this and of the extended frequency band available on ultra-short-waves would almost certainly result in reproduction better than the original.

Recent Inventions

Brief descriptions of the more interesting radio devices and improvements issued as patents will be included in this section.

"BRAKE" TUNING

RELATES to the type of tuning control in which a definite check is felt by the user of the set when the circuits are correctly adjusted. According to the invention the braking control is simultaneously applied to release the loud speaker from the muted state into which it has previously been placed in order to ensure quiet inter-station tuning.



Brake tuning device with inter-station noise suppression by loud-speaker muting.

As shown in the figure a braking-magnet M is automatically energised by the incoming signals, as the circuits are brought into resonance by the control knob K; the magnet then moves slightly downwards into contact with a magnet disc D, which is geared to the control knob. As it comes into contact with the disc D, the magnet is driven forward through a small angle, which is sufficient to cause it to release a detent T. This allows a spring-loaded lever L to rotate a cam C, which switches off the energising current for the magnet M, and simultaneously brings the loud speaker into operation.

N. V. Philips Gloeilampenfabrieken. Convention date (Holland), December 11th, 1936. No. 489914.

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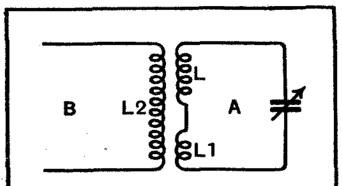
AUTOMATIC INDUCTANCE STABILISERS

IF the coupling between two tuned circuits is varied in order to change, say, the selectivity of a wireless set, the resulting change in mutual inductance causes a certain amount of de-tuning, which must, of course, be corrected. The object of the invention is to make the correction automatically, as and when the coupling is altered, particularly when the selectivity of the set is adjusted independently of the main tuning-control.



Avoiding changes in tuning due to variations in inter-circuit coupling.

As shown in the figure, the inductance of the circuit A is made up of a coil L in series with a smaller coil L1, the two coils being mounted on separate spindles to form a variometer. The spindle of the coil L1 is geared to the knob used to control the coupling between the circuits A. B. In operation, as the coil L2 is moved away from the coil L, the coupling between the two coils L and L1 is simultaneously altered, so as to keep the overall inductance of the circuit A (and, therefore, its tuning) constant.

C. Lorenz Akt. Convention date (Germany), September 5th, 1936. No. 490104.

o o o o

RADIO "GUIDEWAYS"

TO direct an aeroplane towards the aerodrome, and to assist it to land in foggy weather, use is commonly made of a short-wave transmitter which sends out two overlapping beams of energy. The beams are so orientated that the correct course lies along the centre-line of the overlapping parts. In order to indicate this track, one beam is modulated, say, by dots, and the other with dashes, the two signals merging into a single continuous note along the centre zone. Outside this zone the pilot hears one or other of the notes separately, and so knows that he is off the direct course.

The "guideway" is usually formed by alternately keying two reflectors, one located on each side of the main transmitting aerial. In this way the main beam is swung first to one side and then the other, thereby giving the effect of two overlapping beams. If any "keying clicks" are transmitted during the switching operation, they may tend to mislead a pilot who is actually on the centre line (where a continuous note should be heard) into thinking that he is picking up separate dot or dash signals, and so lead him to think he is "off course." The invention describes means for adjusting the feed-lines and the aerial excitation to prevent any such false indication.

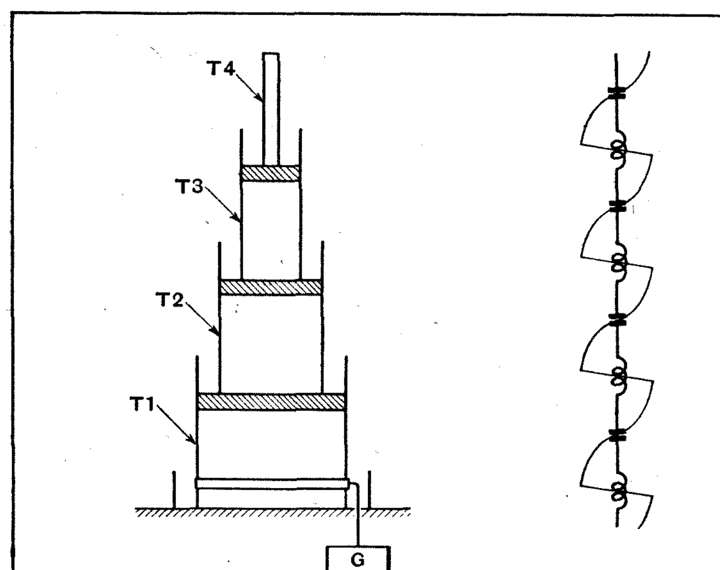
Telefunken Ges fur drahtlose Telegraphie m.b.h. Convention date (Germany), November 23rd, 1936. No. 488827.

o o o o

SHORT-WAVE AERIALS

A SHORT-WAVE transmitting aerial is built up of a number of tubes T1—T4 which decrease in diameter towards the "free" end of the system. They are fitted one within the other so that the "nested" or screened part is somewhat less than a quarter-wave long, and the exposed or radiating part rather more than half a wave long, the exact proportions being found by trial and error. The lowest tube is coupled directly to the high-frequency generator G.

The equivalent electrical circuit is shown on the right-hand side of the Figure. It represents a number of dipoles in series, carrying in-phase current, with intermediate sections which are practically non-radiating. The adjacent sections are coupled together by the mutual inductance of the overlapping parts of each tube.



Tubular short-wave aerial radiating a field uniformly distributed horizontally. The equivalent circuit is shown.

The result is a mechanically simple structure which can easily be erected on the top of a high building or tower. It radiates a field which is uniformly distributed horizontally, and has little vertical spread, so that it is particularly suitable for broadcasting television programmes.

Marconi's Wireless Telegraph Co., Ltd. (assignees of C. W. Hansell and N. E. Lindenblad). Convention date (U.S.A.) February 3rd, 1936. No. 489774.

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LOUD SPEAKERS

THE air in the immediate neighbourhood of a loud speaker diaphragm is set into vibrations of considerable amplitude at the rear as well as in front of the diaphragm. When the loud speaker is housed in a cabinet this tends to produce undesirable resonance, as well as the so-called "Larsen" or feed-back effect between the loud speaker and the valve amplifier which feeds it, or between the microphone and loud speaker in a public-address system.

In order to avoid such forms of distortion, the cabinet or casing of the speaker is fitted with a number of hollow tubes which more or less confine the adjacent air and allow its movements to be controlled. The tubes are so shaped that they can be neatly fitted into whatever vacant spaces are available, and are provided with adjustable discs which act as "acoustic resistances" and modify the air-movements inside the cabinet or casing in the desired manner.

Standard Telephones and Cables, Ltd. (assignees of Le Materiel Telephonique Soc. Anon.). Convention date (France) September 2nd, 1936. No. 489588.

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PRINCIPAL BROADCASTING STATIONS OF EUROPE

Arranged in Order of Frequency and Wavelength (Stations with an Aerial Power of 50 kW and above in heavy type)

Station.	kc/s.	Tuning Positions.	Metres.	kW.
Istanbul (Turkey)	152		1973.5	5
Kaunas (Lithuania)	153		1961	7
Hilversum (No. 1) (Holland)	160		1875	10-150
Radio Romania (Romania)	160		1875	150
Lahti (Finland)	166		1807	150
Moscow (No. 1) (U.S.S.R.)	172		1744	500
Paris (Radio Paris) (France)	182		1648	80
Ankara (Turkey)	183		1639	5
Irkutsk (U.S.S.R.(	187.5		1600	20
Deutschlandsender (Germany)	191		1571	60
National (Droitwich)	200		1500	150
Minsk (U.S.S.R.)	208		1442	35
Reykjavik (Iceland)	208		1442	100
Motala (Sweden)	216		1389	150
Novosibirsk (U.S.S.R.)	217.5		1379	100
Warsaw (No. 1) (Poland)	224		1339	120
Luxembourg	232		1293	150
Moscow (No. 2) (U.S.S.R.)	232		1293	100
Kalundborg (Denmark)	240		1250	60
Kiev (No. 1) (U.S.S.R.)	248		1209.6	100
Tashkent (U.S.S.R.)	256.4		1170	25
Bergen (Norway)	260		1153.8	20
Oslo (Norway)	260		1153.8	60
Vigra (Aalesund) (Norway)	260		1153.8	10
Leningrad (No. 1) (U.S.S.R.)	271		1107	100
Tromsö (Norway)	282		1065	10
Tiflis (U.S.S.R.)	283		1060	35
Moscow (No. 3) (U.S.S.R.)	300		1000	100
Saratov (U.S.S.R.)	340		882.3	20
Finmark (Norway)	347		864	10
Archangel (U.S.S.R.)	350		857.1	10
Rostov-on-Don (U.S.S.R.)	355		845.1	20
Budapest (No. 2) (Hungary)	359.5		834.5	18
Sverdlovsk (U.S.S.R.)	375		800	40
Banská-Bystrica (Czechoslovakia)	392		765	15-30
Boden (Sweden)	392		765	2.5
Voronezh (U.S.S.R.)	413.5		726	10
Oulu (Uleaborg) (Finland)	431		696	10
Baranowicze (Poland)	520		576	50
Ljubljana (Yugoslavia)	527		569.3	6.3
Viipuri (Finland)	527		569.3	10
Bolzano (Italy)	536		559.7	10
Wilno (Poland)	536		559.7	50
Budapest (No. 1) (Hungary)	546		549.5	120
Beromünster (Switzerland)	556		539.6	100
Klaipeda (Lithuania)	565		531	10
Catania (Italy)	565		531	3
Palermo (Italy)	565		531	3
Radio Eireann (Ireland)	565		531	100
Stuttgart (Germany)	574		522.6	100
Alpes-Grenoble, (P.T.T.) (France)	583		514.6	20
Madona (Latvia)	583		514.6	50
Vienna (Germany)	592		506.8	100
Athens (Greece)	601		499.2	15
Rabat (Morocco)	601		499.2	20
Sundsvall (Sweden)	601		499.2	10
Florence (No. 1) (Italy)	610		491.8	20
Brussels (No. 1) (Belgium)	620		483.9	15
Cairo (No. 1) (Egypt)	620		483.9	20
Kouibyshev (U.S.S.R.)	625		480	10
Christiansand (Norway)	629		476.9	20
Lisbon (Emissora Nacional) (Portugal)	629		476.9	20
Tröndelag (Norway)	629		476.9	20
Prague (No. 1) (Czechoslovakia)	638		470.2	120
Lyons (P.T.T.) (France)	648		463	100
Petrozavodsk (U.S.S.R.)	648		463	10
Cologne (Germany)	658		455.9	100
Jerusalem (Palestine)	668		449.1	20
North Regional (Slaithwaite)	668		449.1	70
Sottens (Switzerland)	677		443.1	100
Belgrade (Yugoslavia)	686		437.3	20
Paris (P.T.T.) (France)	695		431.7	120
Stockholm (Sweden)	704		426.1	55
Rome (No. 1) (Italy)	713		420.8	120
Hilversum (Jaarsveld) (Holland)	722		415.4	17
Kharkov, (No. 1) (U.S.S.R.)	722		415.4	10
Madrid (EAJ2) (Spain)	731		410.4	3
Seville (EAJ5) (Spain)	731		410.4	5
Turi (Estonia)	731		410.4	38
Munich (Germany)	740		405.4	100
Marseilles (P.T.T.) (France)	749		400.5	100
Katowice (Poland)	758		395.8	12
Scottish Regional (Burghead)	767		391.1	60
Scottish Regional (Westerglen)	767		391.1	70
Stalino (U.S.S.R.)	776		386.6	10
Toulouse (P.T.T.) (France)	776		386.6	120
Leipzig (Germany)	785		382.2	120
Barcelona (EAJ1) (Spain)	795		377.4	7.5
Lwów (Poland)	795		377.4	50
Welsh Regional (Penmon) (Anglesey)	804		373.1	5
Welsh Regional (Washford)	804		373.1	70
Milan (No. 1) (Italy)	814		368.6	50
Bucharest (Romania)	823		364.5	12
Bodö (Norway)	823		364.5	10
Kiev (No. 2) (U.S.S.R.)	832		360.6	35
Stavanger (Norway)	832		360.6	10
Berlin (Germany)	841		356.7	100
Sofia (Bulgaria)	850		352.9	100
Valencia (Spain)	850		352.9	3
Simferopol (U.S.S.R.)	859		349.2	10
Strasbourg (France)	859		349.2	100
Poznań (Poland)	868		345.6	50
London Regional (Brookmans Park)	877		342.1	70
Graz (Germany)	886		338.6	15
Linz (Germany)	886		338.6	15
Helsinki (Finland)	895		335.2	10
Hamburg (Germany)	904		331.9	100
Dniepropetrovsk (U.S.S.R.)	913		328.6	10
Toulouse (Radio Toulouse) (France)	913		328.6	60
Brno (Czechoslovakia)	922		325.4	32
Brussels (No. 2) (Belgium)	932		321.9	15
Algiers (Algeria)	941		318.8	12
Göteborg (Sweden)	941		318.8	10
Breslau (Germany)	950		315.8	100
Paris (Poste Parisien) (France)	959		312.8	60
Odessa (U.S.S.R.)	968		309.9	10
Northern Ireland Regional (Lisnagarvey)	977		307.1	100
Bologna (Radio Marconi) (Italy)	986		304.3	50
Toruń (Poland)	986		304.3	60
Hilversum (No. 2) (Holland)	995		301.5	10-60
Bratislava (Czechoslovakia)	1004		298.8	13.5
Chernigov (U.S.S.R.)	1013		296.2	4
Midland Regional (Droitwich)	1013		296.2	70
Barcelona (EAJ15) (Spain)	1022		293.5	3
Cracow (Poland)	1022		293.5	10
Königsberg (No. 1) (Germany)	1031		291	100
Parede (Portugal)	1031		291	5
Leningrad (No. 2) (U.S.S.R.)	1040		288.5	10
Rennes-Bretagne (France)	1040		288.5	120
West of England Regional (Washford)	1050		285.7	50
Bari (No. 1) (Italy)	1059		283.3	20
Tiraspol (U.S.S.R.)	1068		280.9	10
Bordeaux-Lafayette (France)	1077		278.6	60
Madrid (EAJ7) (Spain)	1095		274	5
Vinnitsa (U.S.S.R.)	1095		274	10
Kuldiga (Latvia)	1104		271.7	25
Melnik (Czechoslovakia)	1113		269.5	100
Nyiregyhaza (Hungary)	1122		267.4	6.25
North-East Regional (Stagshaw)	1122		267.4	60
Hörby (Sweden)	1131		265.3	60-100
Genoa (No. 1) (Italy)	1140		263.2	10
Trieste (Italy)	1140		263.2	10
Turin (No. 1) (Italy)	1140		263.2	7
London National (Brookmans Park)	1149		261.1	40
North National (Slaithwaite)	1149		261.1	40
Scottish National (Westerglen)	1149		261.1	50
Košice (Czechoslovakia)	1158		259.1	10
Monte Ceneri (Switzerland)	1167		257.1	15
Copenhagen (Denmark)	1176		255.1	10
Nice-Côte d'Azur (France)	1185		253.2	60
Frankfurt (Germany)	1195		251	25
Freiburg-im-Breisgau (Germany)	1195		251	5
Schönbrunn (Germany)	1204		249.2	5
Lille (Radio P.T.T. Nord) (France)	1213		247.3	60
Rome (No. 2) (Italy)	1222		245.5	60
Gleiwitz (Germany)	1231		243.7	5
Görlitz (Germany)	1231		243.7	5
Cork (Ireland)	1235		242.9	1
Saarbrücken (Germany)	1249		240.2	17
Riga (Latvia)	1258		238.5	15
Salamanca (Spain)	1258		238.5	20
Aberdeen	1285		233.5	5
Klagenfurt (Germany)	1294		231.8	5
Vorarlberg (Germany)	1294		231.8	5
Radio Mediterranée (France)	1303		230.2	27
Naples (Italy)	1303		230.2	10
Malmö (Sweden)	1312		228.7	2.5
Bremen (Germany)	1330		225.6	2
Flensburg (Germany)	1330		225.6	2
Hanover (Germany)	1330		225.6	2
Stettin (Germany)	1330		225.6	2
Dublin (Ireland)	1348		222.6	0.5
Genoa (No. 2) (Italy)	1357		221.1	5
Milan (No. 2) (Italy)	1357		221.1	4
Bordeaux-Sud-Ouest (France)	1366		219.6	25
Warsaw (No. 2) (Poland)	1384		216.8	7
Lyons (Radio Lyons) (France)	1393		215.4	25
Radio Normandie (Fécamp) (France)	1411		212.6	15
Vaasa (Finland)	1420		211.3	10
Kaiserlautern (Germany)	1429		209.9	2.5
Burgos (Spain)	1447		207.3	6
Paris (Eiffel Tower) (France)	1456		206	7
Bournemouth	1474		203.5	1
Plymouth	1474		203.5	0.3

SHORT-WAVE STATIONS OF THE WORLD

Arranged in Order of Frequency and Wavelength (Stations with an Aerial Power of 20 kW and above in heavy type)

Station.	Call Sign.	mc/s.	Tuning Positions.	Metres.	kW.
Amateurs		1.71		174.43	—
		to		to	
		2.00		150.00	
Amateurs		3.50		85.71	—
		to		to	
		4.00		75.00	
Calcutta (India)	VUC2	4.88		61.48	10
Bombay (India)	VUB2	4.90		61.00	10
Madras (India)	VUM2	4.95		60.61	10
Delhi (No. 2) (India)	VUD2	4.99		60.06	10
Bandoeng (Java)	PMY	5.15		58.30	1
Pretoria (South Africa)	ZRH	6.00		50.00	7
Montevideo (Uruguay)	CXA2	6.00		49.96	5
Poděbrady (Prague) (Czechoslovakia)	**OLR2A**	6.01		49.92	30
Sydney (Canada)	CJCX	6.01		49.92	1
Zeesen (Germany)	**DJC**	6.02		49.83	5-40
Poděbrady (Prague) (Czechoslovakia)	**OLR2B**	6.03		49.75	30
Vatican City (Vatican State)	**HVJ**	6.03		49.75	25
Boston (U.S.A.)	**W1XAL**	6.04		49.67	20
Miami (U.S.A.)	W4XB	6.04		49.67	5
Daventry (Gt. Britain)	**GSA**	6.05		49.59	10-50
Cincinnati (U.S.A.)	W8XAL	6.06		49.50	10
Philadelphia (U.S.A.)	W3XAU	6.06		49.50	10
Motala (Sweden)	SBO	6.06		49.46	0.7-12
Hong Kong (China)	ZBW2	6.09		49.26	2.5
Lima (Peru)	OAX4Z	6.09		49.24	15
Capetown (South Africa)	ZRK	6.10		49.20	5
Bound Brook (U.S.A.)	**W3XAL**	6.10		49.18	15-35
Chicago (U.S.A.)	W9XF	6.10		49.18	10
Belgrade (Yugoslavia)	YUA	6.10		49.18	1
Daventry (Gt. Britain)	**GSL**	6.11		49.10	10-50
Wayne (U.S.A.)	W2XE	6.12		49.02	10
Montevideo (Uruguay)	CXA4	6.12		48.98	10
Jelöy (Norway)	LKJ	6.13		48.94	1
Pittsburgh (U.S.A.)	**W8XK**	6.14		48.83	28
Winnipeg (Canada)	CJRO	6.15		48.78	2
Riobamba (Ecuador)	PRADO	6.61		45.31	2
Radio-Nations (Switzerland)	**HBQ**	6.67		44.94	20
Amateurs		7.00		42.85	—
		to		to	
		7.30		41.09	
Radio-Nations (Switzerland)	**HBP**	7.80		38.48	20
Sofia (Bulgaria)	LZA	8.46		35.44	1.5
Budapest (Hungary)	HAT4	9.12		32.88	6
Ankara (Turkey)	**TAP**	9.46		31.70	20
Madrid (Spain)	EAR	9.49		31.62	10
Rio de Janeiro (Brazil)	PRF5	9.50		31.58	12
Melbourne (Australia)	VK3ME	9.50		31.58	5
Bangkok (Siam)	HS8PJ	9.50		31.58	5
Mexico City (Mexico)	XEWW	9.50		31.58	10
Lahti (Finland)	OFD	9.50		31.58	1
Daventry (Gt. Britain)	**GSB**	9.51		31.55	10-50
Montevideo (Uruguay)	CXA8	9.51		31.55	2.5
Skamlebaek (Denmark)	OZF	9.52		31.51	6
Pretoria (South Africa)	ZRH	9.52		31.50	7
Hong Kong (China)	ZBW3	9.52		31.49	2.5
Calcutta (India)	VUC2	9.53		31.48	10
Jelöy (Norway)	LKC	9.53		31.48	1
Schenectady (U.S.A.)	**W2XAF**	9.53		31.48	25
Tokio (Japan)	**JZI**	9.54		31.46	50
Zeesen (Germany)	**DJN**	9.54		31.45	5-40
Poděbrady (Prague) (Czechoslovakia)	**OLR3A**	9.55		31.41	30
Paris (Radio-Mondial) (France)	**TPB11**	9.55		31.41	25
Vatican City (Vatican State)	**HVJ**	9.55		31.41	25
Bombay (India)	VUB2	9.55		31.40	10
Schenectady (U.S.A.)	W2XAD	9.55		31.40	18
Sourabaya (Java)	YDB	9.55		31.40	1
Zeesen (Germany)	**DJA**	9.56		31.38	5-40
Lima (Peru)	OAX4T	9.56		31.37	10
Millis (U.S.A.)	W1XK	9.57		31.35	10
Manila (Philippine Isles)	KZRM	9.57		31.35	1
Daventry (Gt. Britain)	**GSC**	9.58		31.32	10-50
Melbourne (Australia)	VLR	9.58		31.32	1
Delhi No. 2 (India)	VUD2	9.59		31.28	10
Philadelphia (U.S.A.)	W3XAU	9.59		31.28	10
Sydney (Australia)	**VK2ME**	9.59		31.28	20
Perth (Australia)	VK6ME	9.59		31.28	2
Huizen (Holland)	**PCJ**	9.59		31.28	60
Moscow (U.S.S.R.)	**RW96**	9.60		31.25	20
Capetown (South Africa)	ZRK	9.60		31.25	7
Sourabaya (Java)	YDB	9.61		31.20	1
Rome (Italy)	**12RO3**	9.63		31.13	25
Lisbon (Portugal)	CS2WA	9.65		31.09	2
Buenos Aires (Argentine Republic)	LRX	9.66		31.06	7
Guatemala City (Guatemala)	TGWA	9.68		30.98	10
Havana (Cuba)	COCM	9.83		30.51	1
Madrid (Spain)	**EAQ**	9.86		30.43	20
Lisbon (Portugal)	CSW3	9.94		30.18	5
Marapicú (Brazil)	PSH	10.22		29.35	12
Ruysselede (Belgium)	ORK	10.33		29.04	9
Buenos Aires (Argentine Republic)	LSX	10.35		28.99	12
Taiboku (Japan)	JIB	10.53		28.48	10

Station.	Call Sign.	mc/s.	Tuning Positions.	Metres.	kW.
Lisbon (Portugal)	CSW2	11.04		27.17	5
Radio-Nations (Switzerland)	**HBO**	11.40		26.31	20
Warsaw (Poland)	**SPD**	11.53		26.01	20
Motala (Sweden)	SBP	11.70		25.63	0.7-12
Moscow (U.S.S.R.)	RIA	11.71		25.62	15
Winnipeg (Canada)	CJRX	11.72		25.60	2
Paris (Radio-Mondial) (France)	TPA4	11.72		25.60	12
Paris (Radio-Mondial) (France)	**TPA6**	11.72		25.60	25
Huizen (Holland)	**PHI**	11.73		25.57	25
Boston (U.S.A.)	**W1XAL**	11.73		25.57	20
Daventry (Gt. Britain)	**GSD**	11.75		25.53	10-50
Poděbrady (Prague) (Czechoslovakia)	**OLR4B**	11.76		25.51	30
Zeesen (Germany)	**DJD**	11.77		25.49	5-40
Lahti (Finland)	—	11.78		25.47	1
Boston (U.S.A.)	**W1XAL**	11.79		25.45	20
Tokio (Japan)	**JZJ**	11.80		25.42	50
Zeesen (Germany)	**DJO**	11.80		25.42	5-40
Vienna (Germany)	OER3	11.80		25.42	1.5
Rome (Italy)	**12RO4**	11.81		25.40	25
Daventry (Gt. Britain)	**GSN**	11.82		25.38	10-50
Wayne (U.S.A.)	W2XE	11.83		25.36	10
Lisbon (Portugal)	CWS4	11.84		25.34	5
Poděbrady (Prague) (Czechoslovakia)	**OLR4A**	11.84		25.34	30
Zeesen (Germany)	**DJP**	11.85		25.31	5-40
Daventry (Gt. Britain)	**GSE**	11.86		25.29	10-50
Pittsburgh (U.S.A.)	**W8XK**	11.87		25.26	24
Paris (Radio-Mondial) (France)	**TPB7**	11.88		25.24	25
Paris (Radio-Mondial) (France)	TPA3	11.90		25.21	12
Moscow (U.S.S.R.)	**RNE**	12.00		25.00	20
Reykjavik (Iceland)	TFJ	12.23		24.52	7.5
Warsaw (Poland)	SPW	13.63		22.00	2
Amateurs		14.00		21.42	—
		to		to	
		14.40		20.83	
Radio-Nations (Switzerland)	**HBJ**	14.53		20.64	20
Moscow (U.S.S.R.)	**RKI**	15.08		19.89	25
Zeesen (Germany)	**DJL**	15.11		19.85	5-40
Vatican City (Vatican State)	**HVJ**	15.12		19.84	25
Paris (Radio-Mondial) (France)	**TPB11**	15.13		19.83	25
Boston (U.S.A.)	**W1XAL**	15.13		19.83	20
Daventry (Gt. Britain)	**GSF**	15.14		19.82	10-50
Bandoeng (Java)	YDC	15.15		19.80	1.5
Delhi (India)	VUD3	15.15		19.80	10
Guatemala City (Guatemala)		15.17		19.78	10
Skamleback (Denmark)	OZH	15.17		19.78	6
Daventry (Gt. Britain)	**GSO**	15.18		19.76	10-50
Moscow (U.S.S.R.)	**RW96**	15.18		19.76	100
Hong Kong (China)	ZBW4	15.19		19.75	2.5
Ankara (Turkey)	—	15.20		19.74	20
Zeesen (Germany)	**DJB**	15.20		19.74	5-40
Pittsburgh (U.S.A.)	W8XK	15.21		19.72	18
Huizen (Holland)	**PCJ2**	15.22		19.71	60
Poděbrady (Prague) (Czechoslovakia)	**OLR5A**	15.23		19.70	30
Paris (Radio-Mondial) (France)	TPA2	15.24		19.68	12
Boston (U.S.A.)	**W1XAL**	15.25		19.67	20
Daventry (Gt. Britain)	**GSI**	15.26		19.66	10-50
Wayne (U.S.A.)	W2XE	15.27		19.65	10
Zeesen (Germany)	**DJQ**	15.28		19.63	5-40
Buenos Aires (Argentine Republic)	LRU	15.29		19.62	7
Daventry (Gt. Britain)	**GSP**	15.31		19.60	10-50
Schenectady (U.S.A.)	W2XAD	15.33		19.57	18
Zeesen (Germany)	**DJR**	15.34		19.56	5-40
Budapest (Szekesfehervar) (Hungary)	HAS3	15.37		19.52	6
Hicksville (U.S.A.)	W2XGB	17.31		17.33	10
Hong Kong (China)	ZBW5	17.75		16.90	2.5
Zeesen (Germany)	**DJE**	17.76		16.89	5-40
Wayne (U.S.A.)	W2XE	17.76		16.89	10
Huizen (Holland)	**PHI2**	17.77		16.88	25
Bound Brook (U.S.A.)	**W3XL**	17.78		16.87	15-35
Daventry (Gt. Britain)	**GSG**	17.79		16.86	10-50
Paris (Radio-Mondial) (France)	**TPB3**	17.81		16.84	25
Buenos Aires (Argentine Republic)	LSY3	18.11		16.56	5
Radio-Nations (Switzerland)	**HBH**	18.48		16.23	20
Bangkok (Siam)	HS8PJ	19.02		15.77	5
Zeesen (Germany)	**DJS**	21.45		13.99	5-40
Daventry (Gt. Britain)	**GSH**	21.47		13.97	10-50
Schenectady (U.S.A.)	W2XAD	21.50		13.95	18
Wayne (U.S.A.)	W2XE	21.52		13.94	10
Daventry (Gt. Britain)	**GSJ**	21.53		13.93	10-50
Pittsburgh (U.S.A.)	W8XK	21.54		13.93	6
Daventry (Gt. Britain)	**GST**	21.55		13.92	10-50
Amateurs		28.00		10.71	—
		to		to	
		30.00		10.00	
London Television (Sound)		41.50		7.22	3
London Television (Vision)		45.00		6.66	17
Amateurs		56.00		5.35	—
		to		to	
		60.00		5.00	
Amateurs		112.00		2.67	—
		to		to	
		120.00		2.50	