Wireless World

Radio • Electronics • Electro-Acoustics

34th YEAR OF PUBLICATION

JUNE 1944

Proprietors :
ILIFFE & SONS LTD.

Managing Editor :
HUGH S. POCOCK, M.I.E.E.

Editor :
H. F. SMITH.

Editorial, Advertising and Publishing Offices :

DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.

Telephone : Waterloo 3333 (35 lines).
Telegrams : "Ethaworld,Sedist,London."

Δ

PUBLISHED MONTHLY

Price : 1/6

(Publication date 25th of preceding month)

Subscription Rate : Home and Abroad 20/- per annum.

Branch Offices :

COVENTRY : 8-10, Corporation Street,
Telephone : Coventry 5210.
Telegrams : "Autocar, Coventry."

BIRMINGHAM : Guildhall Buildings, Navigation Street, 2.
Telephone : Midland 2971 (5 lines).
Telegrams : "Autopress, Birmingham."

MANCHESTER : 260, Deansgate, 3.
Telephone : Blackfriars 4412 (4 lines).
Telegrams : "Iliffe, Manchester."

GLASGOW : 26B, Renfield Street, C.2.
Telephone : Central 4857.
Telegrams : "Iliffe, Glasgow."

Δ

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.

MULLARD
THE MASTER VALVE

A Valve for Every Purpose

DOMESTIC · COMMERCIAL · INDUSTRIAL · SCIENTIFIC · MEDICAL · EXPERIMENTAL

THE MULLARD WIRELESS SERVICE CO. LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2. (77 rev.)

Wireless World

Radio · Electronics · Electro-Acoustics

Vol. L. No. 6 JUNE 1944 Price 1s. 6d.

Monthly Commentary

Anti-Interference Legislation

CONTRIBUTORS to this journal have stressed the fact that, when the war ends, a unique opportunity will arise for reducing machine-generated interference with wireless reception. When that time comes, many of the existing interfering appliances, both industrial and domestic, will be due for replacement. It behoves everyone concerned with any aspect of wireless to do what he can to ensure that these worn-out appliances are replaced by new ones embodying reasonable precautions against the generation and radiation of interference.

It is generally accepted that legislation is essential to achieving this end. That principle was supported as long ago as 1936, when a representative Committee, by no means devoted only to wireless interests, decided in favour of it. Legislation should be ready before the mass-production of electrical equipment is resumed after the war. We do not suggest that it would be practicable now to introduce a comprehensive Bill laying down precise limits for permissible interference; that might come later. What is needed is a stop-gap measure, establishing the simple principle that after the war it will be illegal to sell, install or operate electrical equipment without taking reasonable precautions against radiating interference.

We are glad to see that the urgency of anti-interference legislation is being recognised. The house journal of Murphy Radio is appealing to the firm's dealers to use their opportunities to spread the idea among users of broadcast receivers, while Dr. R. L. Smith-Rose, in a Commemoration Meeting address before the I.E.E., recently pointed out that, if we are to gain the maximum benefit from wartime advances in short-wave technique, anti-interference legislation will be necessary.

In common justice it seems inescapable that users of wireless equipment are entitled to legal protection against avoidable interference in just the same way as the public is protected by law against other nuisances.

Combined Sound-Vision Broadcasting.—Much has been said and written during recent months on the technical aspects of our post-war television system, and many valuable suggestions have been made for re-establishing the service on the best possible lines. The other side of television—the "programme side"—is surveyed on another page, and our contributor makes the suggestion that the sharp line of demarcation hitherto drawn between sound and vision broadcasting should be removed; in a word, we should have one kind of broadcasting, using sound or vision, or both together, as appropriate for the subject to be presented. That proposal will arouse some controversy. But it must be admitted that hardly anything could do more to hasten the spread of television than the constant reminders of its existence that would thus be given to those not equipped with a "combined" receiver.

Variable-mu or Variable-μ?—Our associated journal, *Wireless Engineer*, in an Editorial in the May issue draws attention to yet another example of the confusing and indiscriminate use of two terms to describe one quality, namely, the special characteristics of RF and IF amplifying valves designed for control of volume by variation of grid bias.

There seems little doubt that "variable-mu" was originally intended to be an abbreviation for "variable mutual conductance," and in any further contraction "variable-*g*" should logically have preference over "variable-μ," which, although phonetically the same as "variable-mu," implies quite another thing, namely, variable amplification factor. As our companion journal points out, "the amplification factor is also variable to some extent, but that this is merely incidental is shown by such textbooks as the 'Admiralty Handbook of Wireless Telegraphy,' which uses '*m*' for amplification factor, and not 'μ.'"

For our part we advocate the continuance of "variable-mu," not only because it is the more firmly established but because when we draw valve curves to show variable-mu characteristics they are invariably curves of anode current against grid volts, the slope of which is an index of mutual conductance.

SEE WW SEPT /44 FOR ADDITIONS + MODIFICATIONS

PENTODE-DIODE VALVE VOLTMETER

Linear Calibration Down to Less Than 0.1 Volt

By
T. A. LEDWARD,
A.M.I.E.E.

THE ideal valve voltmeter would have infinite impedance at all frequencies; it would have an evenly divided instrument scale, and would be adaptable for reading either peak, mean, or RMS values. Also, the scale range would be changeable at will and supply voltage variations would not affect the accuracy. As it is not possible to obtain all these features together, it is necessary to decide which are of most importance for any particular work, and to choose the most practical and convenient instrument for the purpose in view.

The instrument to be described was designed in the first instance for experimental work with audio frequencies, and a low scale range was needed. In order, however, to extend its usefulness, provision was made for a number of voltage ranges and also for DC tests. An external RF diode may be connected, if desired, for radio frequency work, but separate calibration will then be needed.

In order that the apparatus should be fairly robust and not usually expensive, it was decided to use a type of indicator that a great many experimenters possess, namely, a 0-1 milliammeter. Further, in order that the milliammeter should not

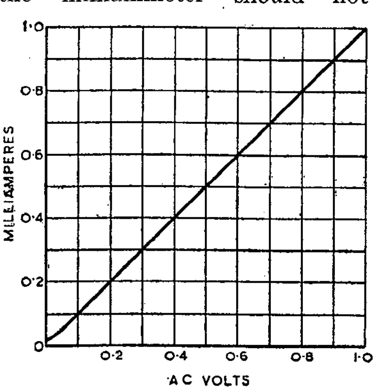


Fig. 1. The linear calibration curve gives useful readings below 0.1 volt.

require a special scale, and to obtain good readings at the lower end of the scale, a straight line calibration was desirable with a full-scale reading of 1 volt. The advantage of straight line calibration is very great at low readings, as it is possible with a 0-1-volt range to obtain clear readings well below 0.1 volt, which would

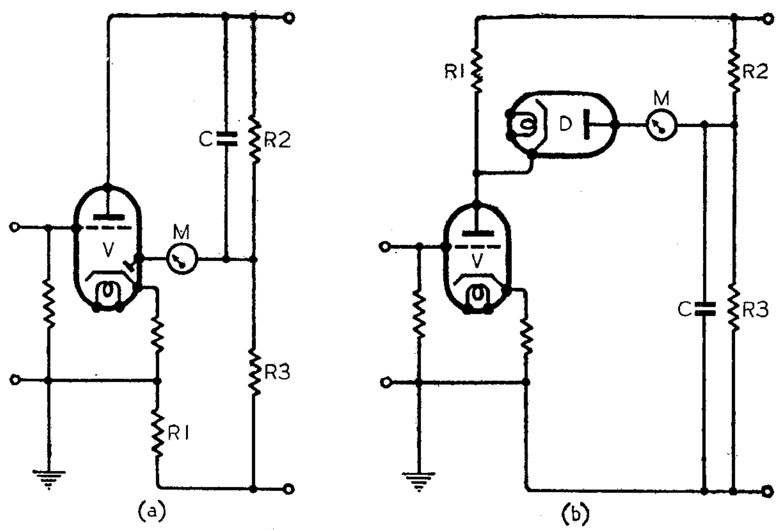


Fig. 2. (a) Basic circuit and (b) modified form with earthed negative HT.

not be possible with a "square law" scale. Although it is not possible to maintain true straight line calibration right down to zero (except for DC tests), it will be seen from the curve of Fig. 1 that it is linear from full scale down to less than 0.1 volt, and is direct reading on the mA scale over this range. Even below 0.05 volt the curve is steep enough to obtain clear readings by reference to the calibration curve, or by specially marking the scale at this end.

The original circuit in its simplest form is shown in Fig. 2 (a), but the basic arrangement was subsequently altered to that of Fig. 2 (b). This modified circuit is to be preferred because it allows the negative HT and the cathode end of the valve input to be at earth potential, which is of some importance at the very high audio frequencies.

The principle will be most readily understood by reference to the equivalent circuit of Fig. 3. This is a bridge circuit which is balanced for DC, so that no current normally flows through the instrument M, the resistances R_a, R1, R2, and R3 being equal. R_a is the internal resistance of the valve. The valve, when AC is applied to the grid, acts as a generator V, which injects AC into one arm of the bridge and thus produces an AC voltage across the points Y and Z, to which the instrument M is connected in series with the rectifier D. The condenser C, connected across R3, is made large enough to offer a negligible impedance to the lowest frequency used, and thus increases the AC voltage across YZ, while not affecting the DC balance. The valve V is biased to work on the straight part of its characteristic, so that no DC component exists in the voltage across YZ except by virtue of subsequent rectification by the diode D. The AC voltage across YZ is thus proportional to the valve input voltage, and rectification gives a reading on M that is proportional to the mean value of the input voltage.

In the basic circuit of Fig. 2 (b) a triode valve is shown, but a pentode is to be preferred on account of the lower effective input capacitance.

An important consideration with mains-operated measuring apparatus is the effect of variations of mains voltage. Where a stabilised source is not available it is essential that supply voltage variations should affect the apparatus as little as possible. The simple form of bridge circuit can, by suitable choice of component values and by adding a series HT resistor, be made insensitive to reasonable changes in HT voltage, but cathode temperature needs to be correct for maintenance of a DC balance. Variation of the cathode temperature, and consequently of R_a, will unbalance the bridge, and the need for continual re-balancing can be quite troublesome. If, however, either R1 or R3 is automatically varied by the same amount as R_a, the balance will remain undisturbed.

The most satisfactory way to make either R1 or R3 vary in the same manner as R_a when the supply voltage varies is to use, in place of one of these resistors, a similar valve to V. This has been done in the final circuit as shown in Fig. 4, in which V2 replaces R1, and includes the diode D. Each of the valves V1 and V2 is a Mullard PEN4DD, this being the most suitable standard valve available at the time the instrument was made. The diode section of V1 is not required, but it was necessary that the cathode and heater should be the same as in V2, hence the same type of valve was used.

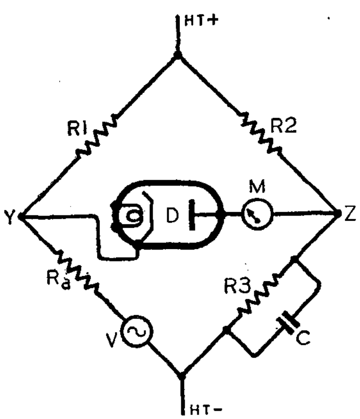
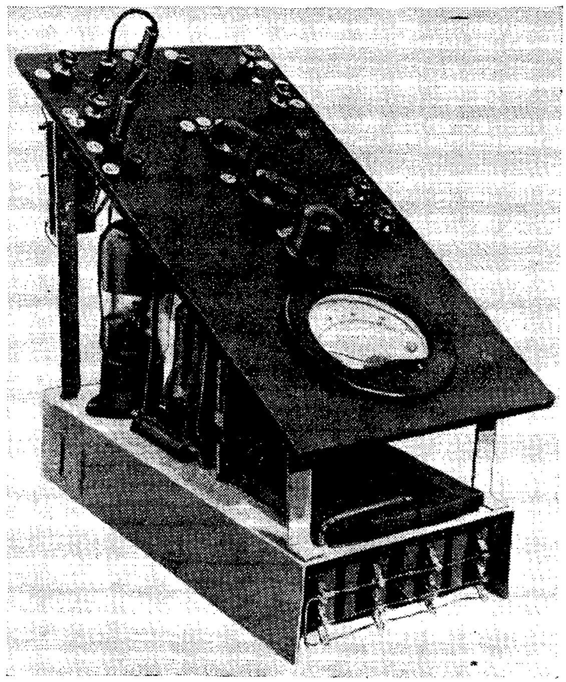


Fig. 3. Equivalent bridge circuit of Fig. 2 (b)

Two series resistors R15 and R16 are provided for the instrument M and are adjusted to give a 1-volt full-scale reading for AC and DC respectively. A switch S1 is used to select the appropriate resistor, and in the case of DC tests the diode is cut out, as it is not required. This allows straight line calibration for DC tests right down to zero. It may be mentioned that the AC resistor may be dispensed with, if desired, and the grid bias resistor in the cathode circuit adjusted until full-scale deflection is obtained for exactly 1-volt AC. If the deflection is found to be less than full scale for 1 volt with the bias resistor value as given in Fig. 4—and this may possibly happen with a different valve—then the bias resistor must be reduced until full-scale deflection is obtained. This is because the bias resistor also gives negative feedback.



View of pentode-diode valve voltmeter removed from its case.

The correct values for the instrument series resistors will have to be determined by trial, but, as a guide, the following values were required in the writer's case, where the instrument M had an internal resistance of 75 ohms: R15, 135 ohms; R16, ~~24,030~~ ohms.

Although power valves are used, they are only lightly loaded and HT volts and current are quite low, approximately 90 volts across each valve with an anode current of 8 mA, so that the valves should have a long life.

The pentode screen resistor is connected directly to the anode, and although this is not usual the arrangement gives a much higher impedance—provided the correct value of resistance is used—than if the valve were used as a triode. In fact, the input impedance is the same as if the screen resistor were connected to HT positive, but raised in value to give the correct screen voltage, as in the normal pentode circuit. The sensitivity would be increased by this latter arrangement, but the extra sensitivity is not required in the present instance and the arrangement shown in Fig. 4 is preferred. The effective input capacitance of the valve is 31 $\mu\mu$F, measured at 18,000 c/s. This is increased by a further 8 $\mu\mu$F by switching arrangements on the input side.

If the input to V1 is derived from a source which gives continuity across the input terminals, the grid resistor R10 may be disconnected by opening switch S2—for which a plug and socket may be used—in order to give the highest possible input impedance. If the input circuit includes a series condenser, or whenever the higher voltage ranges are in use, then S2 must be closed.

The higher voltage ranges are provided by a sectionalised grid resistor as shown; a switch S3 selects the appropriate grid resistor tappings. A further 10/1 multiplier is provided by means of a separate 9 megohm resistor. A plug and socket switch S4 is used for this multiplier.

Pentode-Diode Valve Voltmeter—

Apart from the 1 volt range available with no shunting resistance across the input, ranges of 1, 10 and 100 volts are available with an input resistance of 1 megohm, while ranges of 10, 100 and 1,000 volts are available with an input resistance of 10 megohms. The input impedance on AC must, of course, take into account the effective grid capacitance of V1 and will depend upon the frequency.

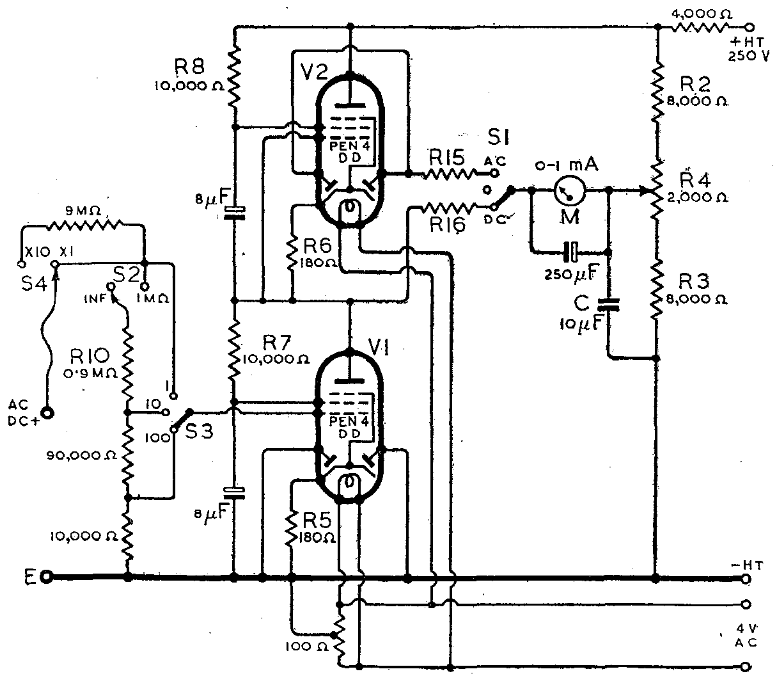


Fig. 4. Circuit diagram of final instrument. R15 and R16 are adjusted to give 1 volt full-scale reading for AC and DC respectively.

The 100 and 1,000 volt ranges are only intended for DC and low frequencies—such as 50 c/s supply mains. Any attempt to measure high voltage AC of high audio frequency by direct connection to the instrument would probably result in considerable error due to stray fields, and due to valve capacitance altering the voltage divider ratio.

It is obvious that on any range other than 0-1, the accuracy will depend upon the correct ratio of the grid resistor sections, so that resistors must be carefully chosen. Wire-wound resistors of such high values are rather a luxury, and it should be remembered that it is the resistance *ratios* that matter and not the absolute values. A further consideration is that as regards bulk, self-capacitance and inductance, carbon resistors are better than wire-wound. Good carbon resistors will vary slightly in value with temperature change and change of applied voltage, but the *ratios* are not likely to alter appreciably. The ratios and accuracy of indication can be checked quickly at any time by applying known values of DC voltage. This is a great convenience. It must be admitted that some patience is required in the initial construction of these voltage dividers if reasonably good accuracy is required, and it would help considerably if satisfactory variable potentiometer type resistors were available, especially as these could be readjusted from time to time if it were found necessary. The ordinary carbon volume control is too bulky for this particular purpose. The writer has made some special straight carbon potentiometers with sliders and these are no larger than fixed 1-watt resistors. They are undergoing a test in the present voltmeter and appear to be satisfactory, but it will necessarily be some months before it is possible to say whether they can be relied upon.

Wire-wound resistors should be used for the bridge arms R2, R3; cathode resistors R5, R6; screen resistors R7, R8 and instrument series resistors R15, R16. The balance adjusting potentiometer R4 should also be wire-wound.

A suitable panel layout is shown in Fig. 5. The mains supply unit is separate and is of standard form. A metal case for screening the instrument should be provided. It is an advantage to separately screen V1, and sufficient screening can be most readily provided by coating the glass bulb with "Aquadag," unless a metallised valve is available. The coating should be connected to the cathode pin. The switches, where provided, should be of a good low capacitance type, such as the "Yaxley," and the metal frames of the switches should be earthed.

The DC calibration is, of course, a simple matter, and the AC calibration may be carried out just as simply with a 50-cycle mains supply.

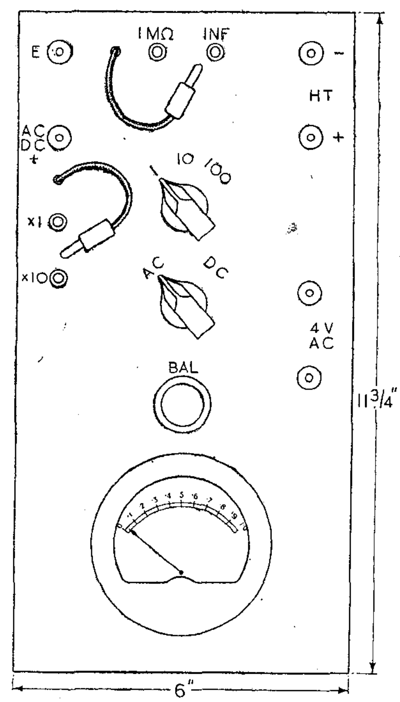


Fig. 5. Panel layout adopted in the writer's instrument.

The satisfactory operation up to 18,000 c/s was checked by the writer by means of the oscillator described in an earlier article (*W.W.*, Sept., 1943), and an Elliott 10 mA thermocouple. The latter was connected in series with a non-inductive resistor across the input terminals of the valve voltmeter. The reading of a micro-ammeter connected to the thermocouple was kept constant at different frequencies, while the reading of the valve voltmeter was noted. The test circuit is shown in Fig. 6. A constant reading was obtained on the valve voltmeter from 25 to 18,000 cycles. The thermocouple output is, of course, proportional to the RMS value of the current, which in turn is proportional to RMS voltage, but the waveform was good enough to give a constant mean value of current, and thus of resistor volts, when the RMS value was maintained constant. The valve voltmeter reading is, as previously stated, proportional to the mean value of the voltage. At 25 c/s there is noticeable vibration of the milliammeter pointer, although the instrument is shunted by a 250 μF electrolytic condenser, but the vibration disappears completely as 50 c/s is reached.

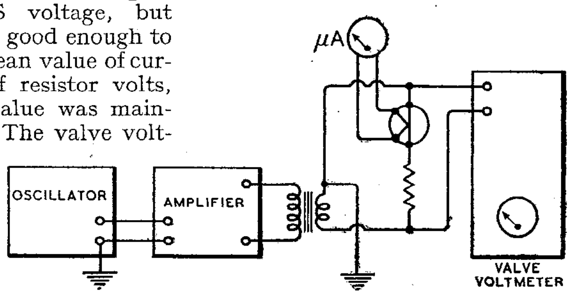


Fig. 6. Schematic test circuit for checking calibration at high audio frequencies.

There is one point about calibration that should be carefully noted: Reference to the curve of Fig. 1 will show that the electrical zero does not coincide with the mechanical zero. *This applies to AC only.* The volts zero corresponds to 0.02 mA scale indication. This means that the DC balance of the bridge is deliberately upset by means of the balance adjustment R4 to give a reading of 0.02 mA with zero input. The reason for this is that the linear volts scale from under 0.1 volt to full scale then coincides with the mA scale. Another advantage is that it is much easier to set the volts zero to 0.02 mA than to set it to zero mA, because if the latter course were adopted it would be possible to carry the adjustment too far without knowing it, as the current cannot reverse. (When the diode is cut out for DC tests a true zero adjustment is, of course, possible.) The balance adjuster takes the form of a potentiometer R4.

If it is desired to obtain a full-scale reading for very much less than 1 volt, an external amplifier will be necessary. The description of a suitable amplifier is beyond the scope of the present article and will depend largely upon the frequency range desired. If, say, a full-scale reading for 100 mV or less is required at one frequency only, such as 50 c/s, then a single valve with either resistance or transformer coupling may be used before the AC input to V1. If, however, a wide frequency band is to be covered with such a low voltage range, it is suggested that the better procedure would be to use an external diode to feed V1 and a single RF pentode to feed the diode.

Low DC ranges are, of course, slightly more difficult. In conclusion it may be stated that for the general requirements mentioned in this article the arrangement described has been found to be very satisfactory and was adopted after much consideration and experimental work with different circuits.

POLICING THE ETHER

U.S. Monitoring Service

MORE than one hundred fixed stations are employed by the Radio Intelligence Division of the U.S. Federal Communications Commission for the maintenance of "law and order" in American radio traffic.

The R.I.D. maintains twelve main monitoring stations, 90 secondary stations (one or more of which are located in each of the 48 States and in the territories and possessions) and three radio intelligence centres at Honolulu, San Francisco and Washington.

In addition to these fixed stations, which are usually located in isolated places far from the nearest town in order to secure ideal listening conditions, thirty mobile units now maintain a continuous patrol of the entire 5,000-mile coast line of the Continental United States. These coastal units are particularly on the watch for any radio transmitters on shore which might be communicating with an enemy ship at sea relative to the departure, location or cargoes of departing vessels. It is claimed the system is so organised that a clandestine signal originating anywhere in American territory can be traced down.

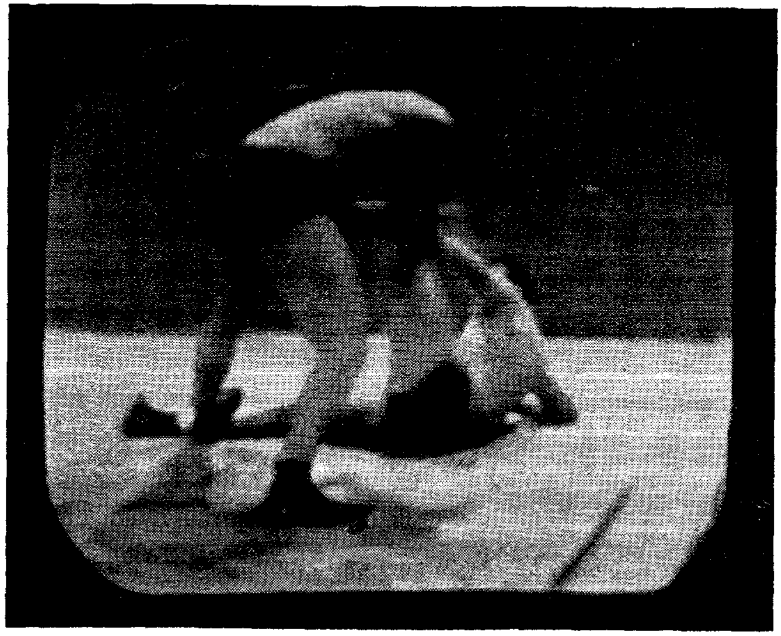
When an introducer is detected three or more monitoring stations collaborate in getting a bearing on the signal. The final task of running down the offender is performed by monitoring officers using cars fitted with the latest type of detection equipment.

THE FIRST of the much-talked-of German radio-controlled "tanks" to fall into our hands. Having driven the vehicle, carrying an 800 lb. explosive charge, towards its objective the driver dismounts and directs it by radio for the final few hundred yards. It then drops its charge, which is fitted with a time fuse, and is backed to the driver by radio control. The vehicle, 12 ft. long, 6 ft. wide and 4 ft. high, is slightly smaller than a Bren carrier.

TELEVISION SURVEY

Plea for an "All-in" Sound Vision Service

By R. W. HALLOWS, M.A., A.M.I.E.E.



The growth of television is closely linked with abatement of the interference nuisance. This "un-retouched photograph hardly gives an adequate idea of the " annoyance value " of motor ignition interference (note the white spots).

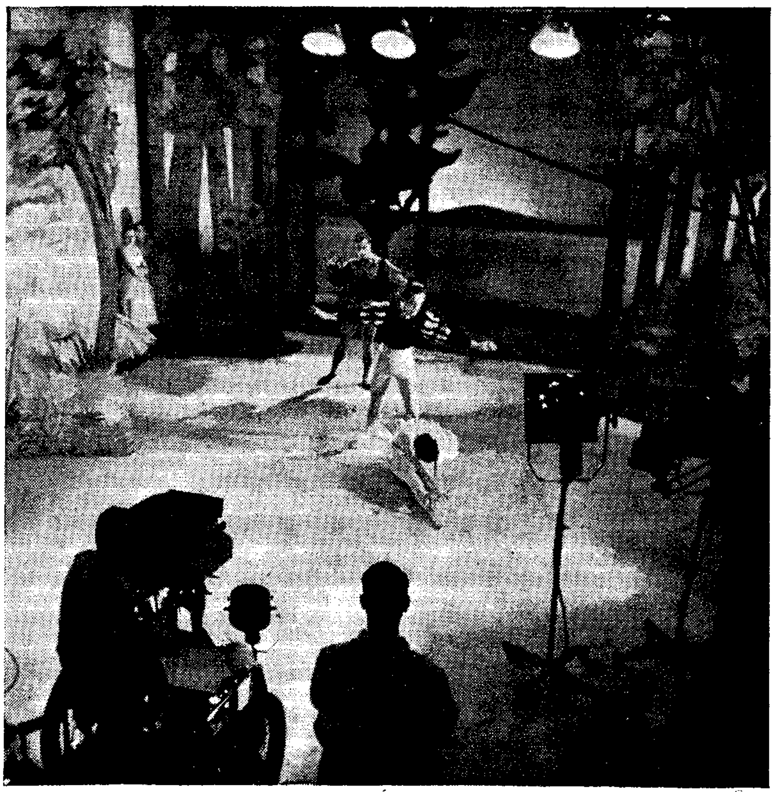
BEFORE we come to consider the future of television when peace has once more come to the world it may be well to see just what it had achieved when, on September 1st, 1939, the threat of war closed down for the time being the activities of the B.B.C.'s Television Department and hid technical progress and developments behind a veil of secrecy. We may well ask whether, at that fateful moment, television had in fact reached a point at which what it had to offer was acceptable to the public, which had for so long been clamouring for the reception of vision as well as sound broadcasts in its own homes. Was the position in the autumn of 1939 such that we could feel that television had at last found its feet? Were we working on the right lines? If, in a word, there had been no war and development had continued to follow the path that it was taking in 1939, would the television receiver be found today in the homes of the great majority of moderately well-to-do folk? Or would some radical change in technique, or in the matter broadcast, or in both, have been required to enable it to achieve the popularity which it seemed for so long to be on the point of gaining, yet never actually managed to gain?

Of one thing there can be " no possible, probable shadow of doubt ": the public wanted television and was prepared to receive with open arms the kind of television that answered its requirements. The television of pre-war days cannot fully have met those requirements, or its history during the two years of broadcasting from the Alexandra Palace would have been very different. Something was amiss. If we can find what it was—what it was that deterred the man in the street from accepting the gift which he had been demanding so long and so loudly—we may be able when the war is over to give television the impetus that it lacked in the past to ensure its wide and rapid popularity. That television can and will become popular I am convinced. I am equally sure that this could not have been brought about by the methods in vogue up to 1939.

Television has a curious history in this country—and it must never be forgotten that ours was the first to develop it. And its history here has been repeated to a great extent in the United States. Sometime before the war (in 1937, I think it was) a big American firm wrote to me. They were thinking, the letter said, of taking up the manufacture on a large scale of components for television receivers. Knowing what I did of the progress of television in this country, would I advise them on the wisdom or otherwise of this course? In my reply I said that I had followed closely the infancy of television in America and, so far as I could see, its story there would be exactly parallel to its story here. It had already been boosted, boomed and balleyhooed by the American lay press. Great expectations had been aroused in the bosom of the man in the street, who was already saying in the United States, as he had said here, that he wouldn't be happy till he got it. It would be found, I predicted, that the public would eat every word that the lay press gave them on television and would ask for more; would fill the correspondence columns with letters yearning for the newest boom to mankind; would pack demonstration theatres to suffocation, loudly applauding what they were shown there. They would in fact show every sign of being ready to absorb television receivers as fast as they could be placed on the market; but when those receivers were available would be very coy indeed about buying them.

That, I foretold, would be the early history of television in the United States and I advised the firm against the line of action that they had in mind. "Unless," I added, "people in your country can put their finger on what is lacking here in television and can discover how we have so far failed to give the would-be viewer what he really wants." The history of television in the United States from the first broadcasts until that country came into the war was very much as I had forecast. And there is a good deal to be learned from the fact that what happened in our country happened also in the United States of America.

There were those who ascribed the slowness of our folk to acquire television receivers to the natural caution of the Briton: before buying something new he likes to make sure that this apparatus will not quickly be rendered obsolete by some new discovery. But in America, the land of constantly recurring new things, there is no such natural reluctance to take the plunge. Others, again, held that the cost of television sets put them beyond the reach of the mass of our people. But in 1938 television receivers were being offered at prices less than those of the wireless sets that sold as fast as they could be turned out in the early days of sound broadcasting. Nor would prices have deterred the American public with its higher wage-levels and its vast use of deferred payment systems. No, the peoples of both countries were of the opinion that something was lacking, and so long as that "something" remains lacking television is not going to make the strides it should make. It must be a very important "something" if the already eager public would not respond to the terrific free publicity that television received both here and in America.



The high cost and complexity of dramatic presentation by television is suggested by this photograph, taken in the Alexandra Palace studios shortly before the war.

Innumerable opportunities have come my way of discussing television both with owners of receiving apparatus and with people who might have become owners but didn't. Thinking over and sifting out what they have said convinces me that two cardinal mistakes, which must not be repeated when a fresh start is made, were responsible for the fact that television as a source of home entertainment has hitherto been a partial failure instead of a resounding success. The first of these was that when the technical development of television had reached a stage at which it was completely fit to provide entertainment in the homes of the people, we did not know what to do with it, and we forced it to take on rôles for which it was entirely unsuited. The second vital mistake was that television broadcasting was divorced from normal sound broadcasting instead of being made part and parcel of it, a point on which more will be said in a moment. Meantime, let us consider the suggestion that we didn't know what to do with television when we had it.

"Terribly Artificial"

Just what did we do with it? Well, the B.B.C. put on special television programmes, quite separate and distinct from those of the normal sound schedule, lasting two or three hours a day. The programmes included plays, cabaret and films, the plays and the cabaret being mostly specially written and produced to suit the technical requirements of television broadcasting. There were also, if I remember rightly, attempts at some kind of newsreel, illustrated talks on such feminine matters as cooking and dressmaking, visits to the Zoo in the children's hour and illustrated hints and tips on how to do this and that. There was something terribly artificial about the bulk of such televised programmes: one felt that they had been devised, produced and transmitted not because they were worth transmitting, but simply because television was in being and *something* had to be scratched together to show off its paces. As entertainment they had not sufficient value to induce more than a few thousand people of the ten to twelve millions living in the area served to buy television receivers; and those who did buy made less and less use of their sets for bringing in the regular programmes—once the novelty had worn off after the first fortnight or so. What they did use their sets for was the reception of television broadcasts

Television Survey—

of big sporting and other events as these occurred. Had there been Derbys and Boat Races, Cup Tie Finals and Lord Mayor's Shows every day the entertainment value of television would never have been in doubt. But there weren't and there won't be. Also, television must surely have a wider task to perform than that. So what is to be done about it?

Vision + Sound = Broadcasting

That brings me to the second great mistake that was made—the gulf that was fixed between sound broadcasting and vision broadcasting. I do not mean that the vision broadcasts were not accompanied by sound, for of course they were. What I am driving at is that the main programmes continued to be devised with a view to their effects on the ears of listeners, and that special programmes were drawn up for television that appealed to both eye and ear. It was a major error to foster the idea that there were two kinds of broadcasting. From the very first they should have been merged into one complete whole. Broadcasting with no qualifying epithets. The sound programmes, which had amply proved their entertainment value by bringing about the annual sale in Great Britain of some nine million ten-shilling receiving licences, should have been modified gradually so as to enable them to absorb and make part of themselves the new feature, vision.

Please do not imagine that I am advocating that vision should accompany all items of all programmes. When the war is ended we shall presumably return to regional and national programmes. I would make the latter, to begin with, at any rate, the complete programme, and would have it transmitted from start to finish on very short, medium and long wavelengths. Any item that lent itself to vision as well as sound—and, as I have already suggested, programmes would be so modified from their present form as to include a considerable number of these—would be illustrated by means of television transmission and reception. Those who had not means of receiving vision, or who were receiving on the medium or long waves, would still obtain genuine entertainment from their loud speakers; but the broadcast in its entirety would be received only by those who had both loud-speakers and viewing screens in use during the illustrated items. Careful planning and production would be needed to ensure that the illustrated items were sufficiently numerous and of the right kind. Above all, it would be essential that they should be neither incomprehensible nor just plain dull to those without vision receiving facilities. There is nothing impossible, or even very difficult in these requirements. Programmes produced on the lines indicated would make sound reception alone the "penny plain" and sound-cum-vision reception the "twopence coloured" of broadcast entertainment.

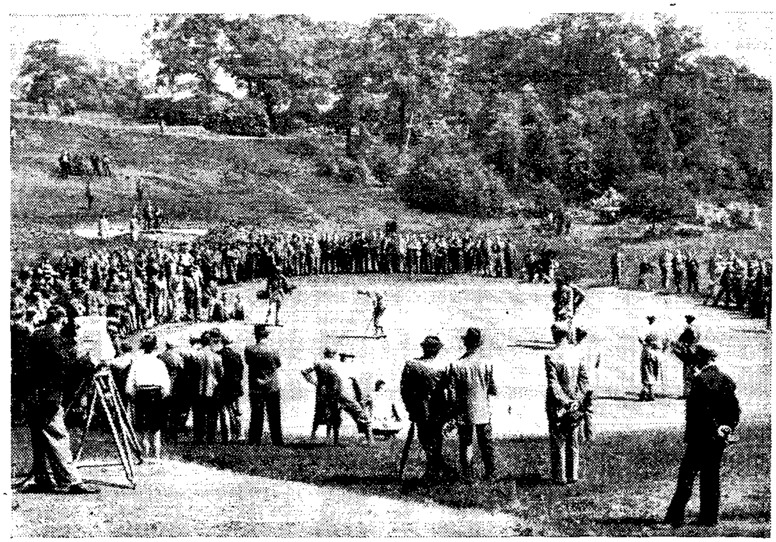
It will be asked what kind of modified programmes I have in view. How, again, can we be sure of a supply of items free from the artificiality of so large a proportion of the pre-war television broadcasts? Certain items, such as the daily dozen, practical hints on gardening, cooking, dress-making, household jobs and the like lend themselves readily to illustration, the verbal descriptions being always such that those receiving with loudspeaker only can follow easily what is being done. The film critic and the theatre critic can show samples from the plays or films under review, again making sure that their descriptions are adequate. Cabaret, music hall shows, plays and so on are probably accompanied throughout by vision transmissions. Soloists, orchestras and bands are most likely confined to sound only.

Hot News

That is a beginning: there is much more to be done. Of one thing there is no doubt, and that is that the public likes descriptions and illustrations of events of the day. It is to that liking that the daily and weekly papers owe their present enormous circulations. Hitherto the branch of broadcasting confined to sound has rather tended to limit its activities in these directions to what may be called major events, whether sporting or otherwise. But there is always plenty going on that is of general interest. Sound film recording units of the mobile type could bring in a rich harvest every day of illustrations and running commentary.

Space does not allow me to go more into detail about the make-up of programmes; but the reader will see for himself that the field is immense and the possibilities almost unlimited. And he will, I believe, be disposed to agree that with programmes of the kind suggested there would be a real inducement to everyone who could afford to become the owner (*and* user) of a sound and vision receiver.

I have said little about the



Undoubtedly the most popular features of our pre-war television service were "actuality" broadcasts, such as this transmission of an International professional golf match.

technical side of the matter because I do not think that shortcomings there were to any great degree responsible for the failure of television in pre-war days to achieve popularity. Enormous strides have been made during the war in both VHF and CRT techniques, so that I do not feel that we need worry unduly about the technical aspect. I do, though, very much hope that the radio manufacturers will take to heart the need to put an end to the separation of television broadcasting from what we used to regard as "normal" sound broadcasting. It is the combination of sound and vision that should be normal. To sell as "television receivers" sets capable of bringing in vision as well as sound on all the broadcasting wavelengths would be ridiculous. These should be known simply as "broadcast receivers," sets able to deal with sound alone being termed "broadcast receivers (sound only)."

VHF High Fidelity

As I see it, the rapid development of a network of VHF stations over the country is to be expected as soon as peace returns. At first these stations may relay the sound and vision components of a single programme. Later we may hope for alternative programmes: it should be but a matter of time for a selection of VHF illustrated programmes to be available in all but the most isolated places. This will mean that genuine high-fidelity reproduction of sound is possible everywhere, and it is to be hoped that the radio industry will not fling away this priceless gift, as it tried to do in the years before the war came upon us by two acts of folly. First, many television receivers were made whose AF sides were incapable of doing justice to the available high-fidelity transmissions of the sound accompaniment to television. Secondly, though the B.B.C. was willing to transmit the complete national sound programme on VHF with high fidelity, the industry would have none of it, holding that if the man in the street once heard what sound reproduction by wireless *could* be like, he would plague the life out of them by demanding the impossible —high-fidelity on all wavelengths and from sets at all prices. The sensible attitude would have been to welcome high-fidelity transmissions, to explain to the public that they were receivable to perfection only on the very short waves by sets that could not be sold at low prices, and to spur on the B.B.C. to establish more and more VHF transmitters.

Anti-interference Legislation

Apart from what has been said so far, there is one factor on the technical side which does not concern the VHF receiver (sound or vision) itself, but may yet be a decisive factor in the success or otherwise of VHF broadcasting —and vision can be broadcast only on the very high frequencies. This is interference, particularly that radiated by motor car ignition systems. Various kinds of anti-interference aerial systems were designed and used before the war; but they were palliatives at best and not always very effective. It is scarcely going too far to say that that VHF reception of sound-cum-vision or of sound only was too unsatisfactory to have much if any entertainment value in most houses near which there was any considerable volume of motor traffic. A particularly knowledgeable wireless dealer with much pre-war experience of television said to me recently: "If the authorities tackle the problem of motor car interference firmly, television will be a success; if they don't, it hasn't a hope."

There is a great deal in this. No matter how attractive programmes on the lines already suggested might be, nor what degree of perfection of reproduction of transmission was achieved, no one could take much pleasure in sound continually accompanied by machine-gun effects or in images marred by the "snowstorms" with which many of us were all too familiar. There is no doubt that this kind of interference can be dealt with successfully if the necessary legislation is introduced. If VHF radio is possible between plane and ground or between plane and plane, the suppression methods that have been developed must be effective and they cannot have serious effects on the all-important liveliness of aero engines. Though it employs coil and battery ignition as a rule, the car engine should be equally susceptible to effective suppression.

To sum up: television is bound, sooner or later, to come into its own. Whether it does so rapidly or only after the lapse of some considerable time will depend mainly upon the action taken as soon as the war is over. The man in the street is as eager for it as ever he was; but he will not buy it simply as a novelty. Television has long passed the stage when any kind of image on the viewing screen was enough. What the public wants from it is genuine entertainment, and that can be given only if its transmissions are merged with those of sound to form the parts of a complete whole —the broadcast programme. The public is satisfied that television is technically capable of providing what it wants, and it will be still more satisfied on that score when it knows of the improvements that are now waiting to see the light of day. On two vitally important points it has still to be satisfied: that television and sound mean better entertainment than sound alone, and that the programmes sent out can be received without frequent and disturbing interference. Once it becomes confident about these things television will not just march forward: it will gallop.

THE WIRELESS INDUSTRY

WE have received an illustrated booklet giving technical details of the domestic standard fuse plug and socket made by Dorman and Smith, Ltd., Ordsal Electrical Works, Salford, Manchester, 5. The fuse takes the place of one of the pins of the plug and is easily replaceable.

A substitute for the ordinary split battery plug is now available in the Titen spring battery plug which is being distributed by London and Provincial Factors, Ltd., "Wanie House," Aylmer Parade, E. Finchley, London, N.2. The retail price is 2d. each.

W. F. Newell, B.Sc., who has been associated with Weston Instruments for more than ten years, has resigned from Sangamo Weston, Ltd., and is taking up the position of Technical Contracts Manager with the Automatic Coil Winder and Electrical Equipment Co.

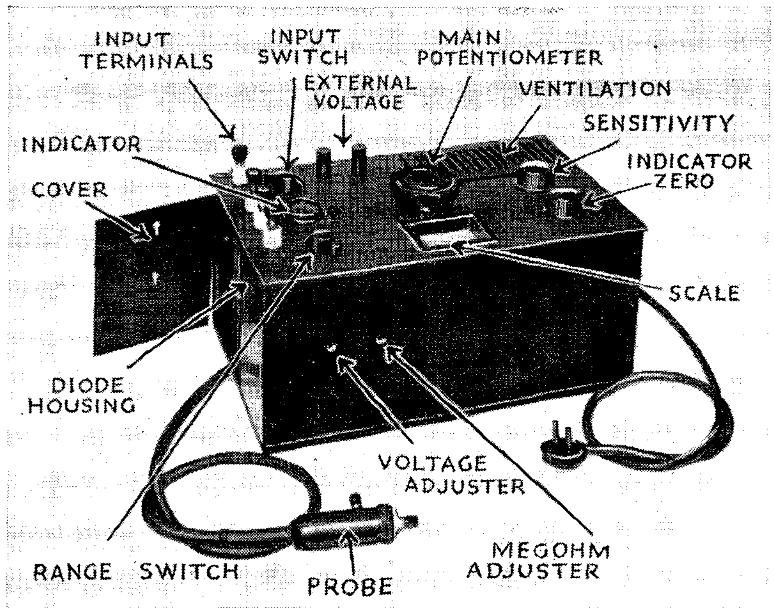
COVER ILLUSTRATION

OUR cover shows a group of T.C.C. small transmitting condensers, made from thimble-shaped ceramic mouldings with silvered electrodes fired on to inner and outer surfaces. Capacities of the largest size illustrated (overall length about 3¼in.) range from 0.0006 to 0.00175 μF. Working voltages of this type of condenser are up to 10,000 V DC.

UNIVERSAL MEASURING INSTRUMENT

2—Practical Details

By G. A. HAY, B.Sc.



Ranges :

(1) Alternating peak voltages from 0.1 to 100V at 20 c/s to 60 Mc/s. Input resistance 5 MΩ. Accuracy ± 5 per cent. below 1V ; ± 2 per cent. up to 10V ; ± 1 per cent. above 10V.

(2) DC voltages from 5 mV to 100V. Input resistance practically infinite. Accuracy ± 0.5 per cent. above 1V.

(3) Resistance from zero to 1 MΩ, or insulation from 1 MΩ to 1,000 MΩ.

(4) Bridge indicator, AC or DC or both, with sensitivity of about 2 mV.

THE basic principles involved in the design were described in the first part of this article, which now concludes with details of a practical instrument.

Fig. 1 shows the complete circuit. It is arranged round a Mullard EM1 CR tuning indicator with cathode feed-back, arranged as a DC null indicator, to which can be connected by switching various filters, standard resistances, a diode rectifier, etc.

Power for the instrument is supplied from an internal power unit. The advantages of this scheme are numerous, as the power is always available so long as a 250V AC supply is at hand ; the habit of batteries of being run down just when they are wanted is well known. A half-wave rectifier is used, as the current drain is only about 20 mA. Smoothing is conventional, and a supply of about 320V at 20 mA is obtained.

Since the instrument was completed, the writer's attention has been drawn to the desirability of screening the power transformer in measuring instruments.* While the absence of this has so far caused no trouble, its inclusion would no doubt be advisable.

The output from the unit is applied to a potential divider, which splits the output broadly into two parts, 200V for operation of the " magic eye," and 120V for the potentiometer giving the comparison voltage. The latter is developed across an S.130 neon stabiliser which ensures a constant reference voltage. In addition, there is a semi-variable tapping to give 100V positive to " earth " for operation of the megohmmeter.

Although a completely stabilised HT supply would be an advantage, it was felt that the extra complication was not justified, as it is unnecessary for rough measurements. When using the instrument for exact work one must also stabilise the heater supplies, and this is best done by using a 250V stabilised AC source.

The EM1 is connected between earth and + 200V, with an adjustable cathode resistor, 2000 Ω fixed in series with 5000 Ω variable. This gives variable sensitivity which is useful when rough measurements are to be made, ensuring that the settings are not too critical. The cathode return is made to a 400 Ω potentiometer in the main potential divider, which acts as a zero adjuster and enables one to set the shadow to the most convenient reference position. This zero setting is constant for all DC and resistance measurements, and also constant at a different setting for all AC ranges. The exact reference setting to be used depends on a number of factors. Maximum sensitivity is obtained at a shadow angle of about 45 deg., and if there is a mark on the target here, this is best used. Sometimes pieces of dust, grit, etc., can be shaken from the base of the valve on to the target by inverting and tapping sharply. Failing that, it is quite satisfactory to adjust the shadow to zero angle. Other CR indicators than the EM1 can be used, but to the writer's knowledge all have a much larger target current. This makes the initial cathode bias larger, and the backing-off bias must be greater, with a greater risk of zero shift. It seems that the type with a single shadow in place of the maltese cross pattern always suffers from this disadvantage—which, of course, does not affect the normal use of the tube.

In an earlier model the standard voltage was measured by an internal voltmeter of B.S.1 accu-

* "Transformer Screening." T. A. Ledward, *Wireless World*, Jan. 1944.

racy. Subsequently a Cossor S.130 neon stabiliser was used to give an output of about 115V at a tube current of 15mA. This is used as the comparison voltage, the 5000 Ω voltage adjustment dropping it to 100V across the potentiometer network, which consumes 5 mA. The potentiometer track, R5, consists of a 20 watt, type P.I.W. Reliance potentiometer arranged with a 6in. diameter rotating scale, viewed through a window fitted with a hair-line: for the 100V range this is connected across the whole supply, in switch position 3. In the other two switch positions, 1 and 2, resistance networks are brought into circuit which reduce the voltage across R5 to 1V and 10V respectively. The total resistance of the whole network remains constant and equal to R5 at any switch position. The calculation of resistance values is straightforward but tedious, and only the results are given here; they are expressed as functions of R5:

$R6 = 0.9.R5 \qquad R7 = 0.09.R5$

$R8 = \frac{10.R5}{99} \qquad R9 = \frac{R5.}{99}$

It is suggested that these resistors be wire-wound (of the same wire as used in R5), and adjusted by comparison with R5 as standard in a conventional bridge circuit. In fact it is best for all the resistances except the megohm values to be wire-wound, as this reduces the risk of zero shift due to temperature changes. If it is desired to measure a voltage greater than 100—either AC or DC—an external source of voltage can be connected to the terminals marked, which are normally short-circuited by a link.

The switching arrangements in the grid circuit of the EM1 are necessary to connect the various filter circuits to the grid. Although it was originally thought that switches would be unsatisfactory because of low insulation resistance it has been found in practice that Yaxley wafers are satisfactory provided that points between which low leakage is desired are kept on different wafers. It is also necessary to keep the wafers clean and dry and use resin flux only in soldering.

In switch position 1 the instrument is set for use as a bridge indicator. The input is connected across terminals "High" and "Low" and the slide-back control set at zero. This use of the meter is effective throughout the audio range. In using it one must remember the extreme sensitivity of the indicator, and the difficulties which may be experienced due to external electrostatic fields. If the alternating voltage under investigation is superimposed on a DC component, the latter can either be balanced out by the slide-back voltage, or removed by a condenser-resistance filter, which can be built up as a separate unit (see Fig. 1). If the bridge does not present a complete path to DC looking from the detector terminals, a resistance must be connected across these. This can conveniently be R18 in the filter unit just mentioned.

In switch position 3, DC voltages can be measured, again using terminals "High" and "Low," the former being positive. AC components are removed by an internal filter consisting of a 5MΩ

TABLE

R1	10Ω	R15	3750 Ω
R2	10 MΩ	R16	400 Ω tapped 150 Ω
R3	5 MΩ	R17	1 MΩ "standard" ±1 per cent.
R4	1 MΩ	R18	1 MΩ
R5	20,000 Ω	C1	100 μμF silvered mica
R6	See text	C2	0.01 μF mica
R7	See text	C3	0.01 μF mica
R8	See text	C4	4 μF electrolytic
R9	See text	C5	4 μF electrolytic
R10	5000 Ω	C6	0.01 μF mica
R11	3000 Ω		
R12	5000 Ω		
R13	4000 Ω		
R14	2000 Ω		

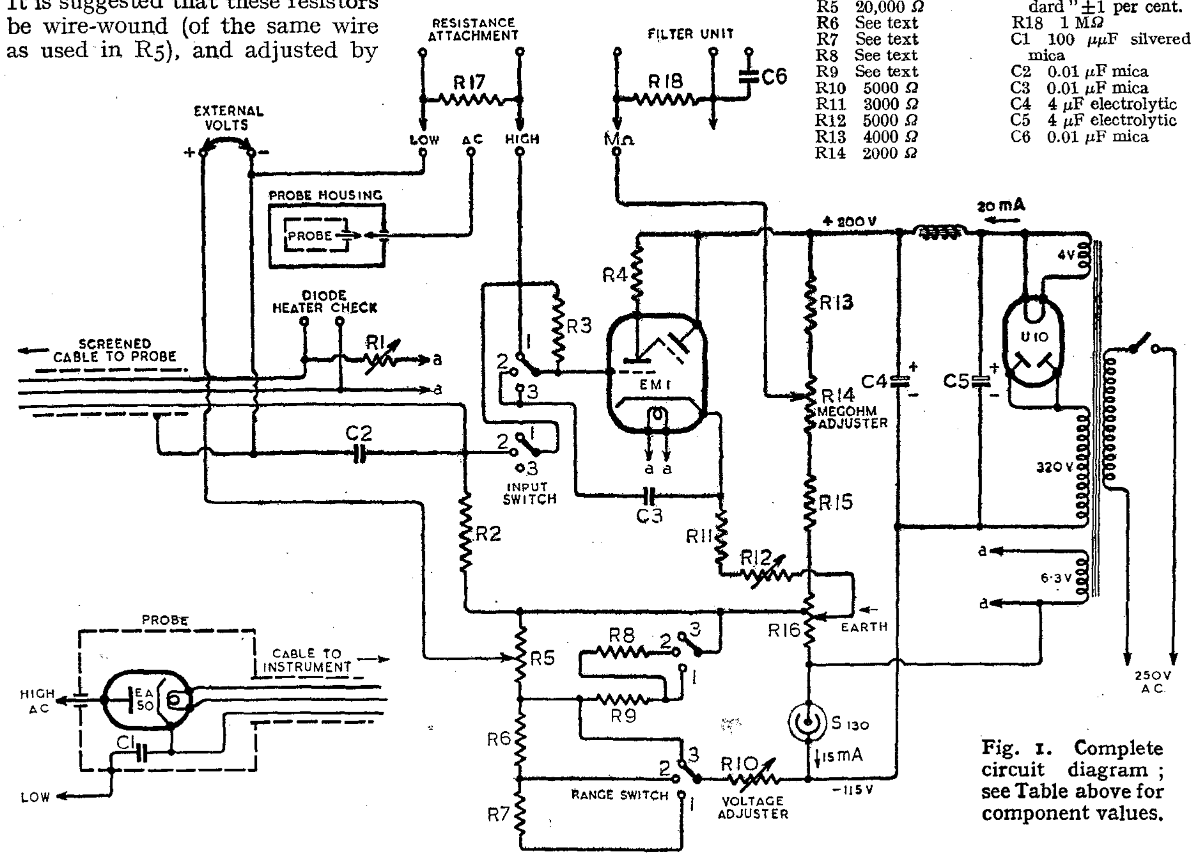


Fig. 1. Complete circuit diagram; see Table above for component values.

SEE W W ~~FEB~~ APRIL 1947 for mod to new circuit

Universal Measuring Instrument

resistance and 0.01 μF condenser. A DC path across the input is again necessary. Readings are taken on the main scale A (see Fig. 3), graduated from 0 to 100 in 1V steps, the appropriate multiplying factors 0.1 and 0.01 being used on the 10V and 1V ranges respectively. Resistance and insulation are also measured in this position, and this is done by connecting an external 1 MΩ standard to the appropriate terminals. For resistances below 1 MΩ, the standard, which is fitted with rigid spade connectors, is placed between terminals "MΩ" and "High," the unknown between "High" and "Low," and scale A used with a multiplying factor of 10,000. The range switch then operates in the same way as for DC voltage. For resistances above 1 MΩ, the standard is connected between "High" and "Low," the unknown between "High" and "MΩ," and scale D used. This scale is calibrated by calculation from the expressions given in the first part of this article. The multiplying factors on the range switch are now the reciprocal of those shown, e.g. on range 1 the scale reading is multiplied by 100.

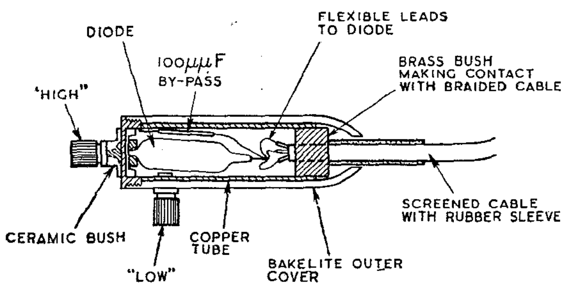


Fig. 2. Construction of probe. The diode anode is fixed to the hollow terminal with Wood's metal.

The megohm adjuster is best set as follows. Having set the EM1 zero and the voltage adjuster to give correct DC voltage readings, the standard megohm is connected across "High" and "Low," the scale set to 1 MΩ, and another external standard megohm connected across "MΩ" and "High." The megohm adjuster is then set until the EM1 zero is again reached. This procedure is only necessary when precise readings are wanted. If approximate results will suffice, the megohm adjuster can be set until there is a PD between the "MΩ" terminal and earth of 100V, measured by a low-consumption voltmeter. Once set, the megohm adjuster need rarely be altered except for exact measurements.

In switch position 2, the diode rectifier is connected for AC voltage measurements. In all cases the peak voltage is indicated, and if RMS values are desired the form factor of the voltage waveform must be taken into consideration. The diode is made in the form of a probe, connected by a three-way screened cable. A Mullard EA50 is used, the 6.3V heater being run at 5V to reduce heater-cathode leakage and PD's due to initial electron velocity. This voltage is adjustable by a pre-set variable resistance, and for most accurate low voltage measurements it is necessary to check this periodically. For audio- and low radio-frequency work the probe can be pushed into a housing in the body of the instrument, where the diode anode terminal makes contact with a tag connected to the terminal "AC." The probe is thus protected from unnecessary mechanical damage. This housing can be seen on the left of the photograph with its cover alongside.

The probe is shown in section in Fig. 2. Only a 100μμ F silvered mica bypass condenser is included in the probe, and as this is inadequate below 100 kc/s, it is supplemented by a 0.01 μF mica condenser in the main instrument. Essential points to watch in construction are: (1) a short path from the diode anode to its terminal and from the cathode through the condenser to the earthy terminal, (2) screening as complete as possible to minimise stray induced voltages, (3) screening and good insulation of the cable to the main instrument, (4) ceramic insulation wherever possible in the RF circuits to reduce losses at ultra-high frequencies.

The permanence of calibration of the diode voltmeter is mainly dependent on the heater current as described above; if this is adjusted when a new diode is brought into use to give the same contact potential as the old one then the calibration will alter by only a negligible amount—this being due to differing AC resistance. The meter is thus truly independent of changing valve characteristics. The theoretical value for the input resistance is of the order of 5 MΩ, while approximate measurements show

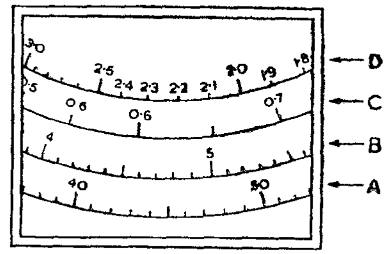


Fig. 3. Part of the scale showing the method of graduation.

a value somewhat lower than this at 50 c/s and about 10V input.

Calibration of the potentiometer is done against a sub-standard voltmeter and external potentiometer. When the 100V DC range A is calibrated it serves also for the 10V and 1V DC and 100V AC ranges and also the 1 MΩ resistance range. The 10V and 1V AC ranges must be calibrated separately, however, with a known heater voltage on the diode. It is probably sufficient to use the equations given in the first part of the article to graduate the D scale by comparison with the DC voltage ranges. A section of the scale, as seen through the escutcheon, is shown in Fig. 3.

A general idea of the appearance can be gathered from the photograph: of course, considerable latitude exists in design details. On account of compensation for errors and independence of valve characteristics the meter can be relied on as an accurate standard or as a DC to AC transfer instrument against which other AC meters can be checked or calibrated.

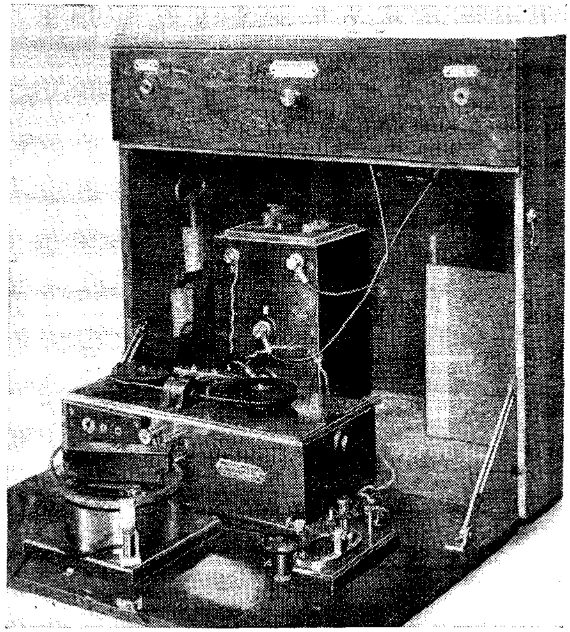
GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

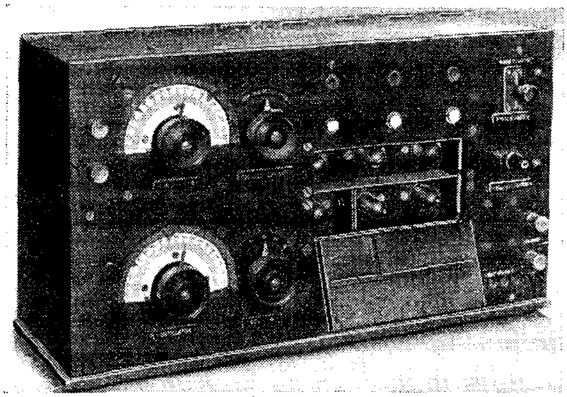
RADIO JUBILEE

25th Birthday of I.E.E. Wireless Section

OF late we have had many reminders that wireless has not merely grown up, but has attained a riper maturity. The basic idea of using electromagnetic waves as a means of communication is now just over half a century old, while even relative newcomers to the art, such as the B.B.C. and several firms manufacturing broadcasting equipment have recently celebrated their coming-of-age. The Silver Jubilee of the Wireless Section of the Institution of Electrical Engineers comes as another reminder. In the words of the President of the I.E.E., the Section was formed in 1919 "to provide a forum to present and discuss papers dealing with wireless and to recognise and provide for, within the framework of this Institution, the specialised requirements of engineers interested in wireless." Membership, which is now over 1,900, represents all branches—industrial, academical, Armed Forces and Government departments.



A " transceiver " of 1912 ; combined Marconi spark transmitter and receiver, including magnetic detector.



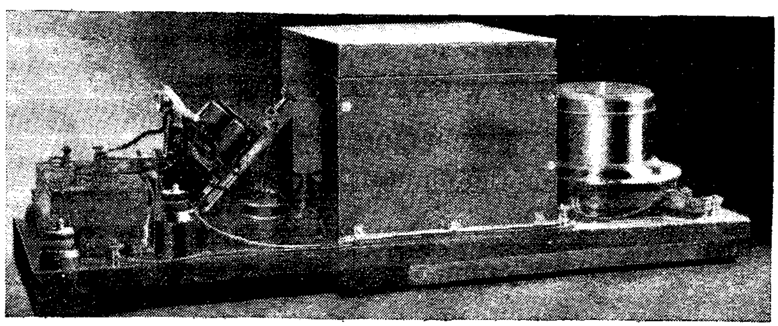
One of the first superheterodyne receivers to be built n Europe ; a Standard Telephones and Cables production of 1924. This and other apparatus illustrated on this page were among the historical exhibits on show at the I.E.E. Wireless Section Commemoration Meeting.

At a Commemoration Meeting, held on May 3rd, six past chairmen of the Section delivered addresses to a large and distinguished audience, which included representatives of all the wireless industrial associations and the Radio Society of Great Britain. Delegates of the Commonwealth Communications Council representing the Dominions and India were present.

Dr. W. H. Eccles surveyed the technical events that led up to the founding of the Section 25 years ago. Professor G. W. O. Howe maintained that the outstanding achievements of the early days of wireless telegraphy were accomplished in spite of principles and theories as then enunciated. Theory was revised after each successive practical step. In particular, ideas about the ionosphere and long-distance propagation were vague until well after long-distance communication had actually been achieved.

The history of wireless in the Navy was dealt with by Admiral Sir Charles Kennedy-Purvis. He recalled that the first tuned-circuit Naval apparatus, installed in about 1900, worked on wavelengths rated as 395 and 1,150 *feet*.

The difficult task of forecasting future developments was most capably undertaken by Dr. R. L. Smith-Rose, who stressed the possibilities of using recent developments in VHF (over 100 Mc/s) for services with ranges up to 100 miles. That would relieve congestion on bands with world-wide ranges. Increasing knowledge of ionosphere conditions will make for more economical distribution of frequencies.



A Marconi coherer unit of about 1900, comprising coherer, tapper, relay (for actuating morse inker), RF transformer and battery.

SIMPLE MODULATION MEASUREMENTS

Change of RMS Value as an Indication of Modulation Depth

By G. S. LIGHT, B.A.Sc.

IT is the purpose of this article to discuss the possibilities of one of the simplest methods of modulation measurement, namely the increase in RF current when modulation is applied.

When a sine wave carrier, the instantaneous value of whose current is $i_1 = I_1 \sin 2\pi f_1 t$, is amplitude modulated by another sine wave whose instantaneous value is $i_2 = I_2 \sin 2\pi f_2 t$, it can be shown that the equation of the resulting wave is

$$i = I_1 \sin 2\pi f_1 t + \tfrac{1}{2} I_2 \cos 2\pi (f_1 - f_2) t - \tfrac{1}{2} I_2 \cos 2\pi (f_1 + f_2) t$$

The three terms on the right-hand side are respectively carrier, lower side band and upper side band. For complete modulation $I_1 = I_2$, thus each side band has half the amplitude of the carrier, and therefore a quarter as much power, since all these currents are necessarily flowing through the same circuit resistance. For a modulation factor of "m" the amplitude of each side band is $\tfrac{1}{2}m$ times that of the carrier. Thus the RMS value of the modulated carrier is $\sqrt{1 + (\tfrac{1}{2}m)^2 + (\tfrac{1}{2}m)^2} = \sqrt{1 + \tfrac{1}{2}m^2}$ times that of the unmodulated carrier, and the relationship is worked out for typical values in the table.

A thermocouple or hot-wire meter reads RMS current values, and if one of these be connected in the tuned circuit of a modulated oscillator or amplifier or into a coupled circuit its reading will give an indication of the depth of modulation. Some standard signal generators employ this device; in one well-known make the internal modulation is set at 80 per cent., and the "Set Mod." mark on the meter is calibrated to represent 14.9 per cent. more current than at the "Set Carrier" mark.

The aerial current of a transmitter can thus be used to indicate depth of modulation by speech or tone. In one mass production factory the percentage modulation of transmitters is rapidly determined from aerial ammeter readings. A special slide rule (see sketch) is used to save a separate calculation for each set. The "Carrier" mark is set to the unmodulated aerial current and the percentage modulation read off direct from the modulated current reading.

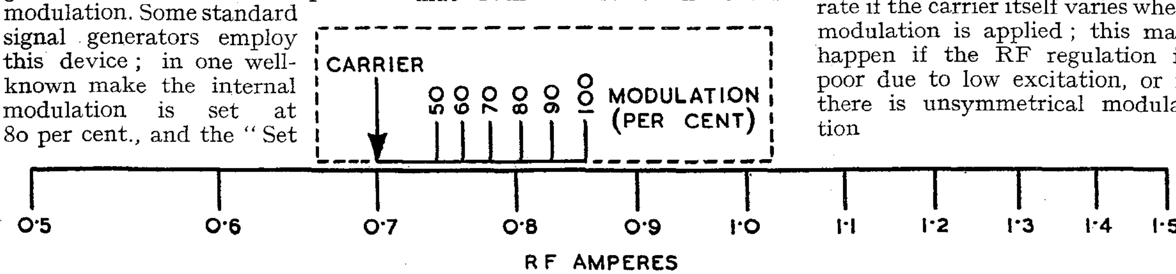
Modulation (per cent.)	m	Current Increase (per cent.)
10	0·1	0·25
20	0·2	1·0
30	0·3	2·25
40	0·4	4·0
50	0·5	6·0
60	0·6	8·6
70	0·7	11·5
80	0·8	14·9
90	0·9	18·5
100	1·0	22·5

In order that the percentage relationship shall hold good at any part of the scale it is necessary that both RF scale and slider should be divided on a logarithmic basis. Typical figures for a scale approximately 10in. in length are given in the caption to the illustration. It happens that convenient values are obtained by multiplying the common logarithm of the RF ampere readings by 2, so that readers requiring intermediate values may obtain them in this way. In the case of the percentage modulatior scale an example will make the working clear. From the table 50 per cent. modulation is equivalent to an increase of RF current of 6 per cent., i.e., multiplying by a factor of 1.06. The log. of this is 0.0253, and multiplying by 2 gives 0.506in. or 0.51in. to the accuracy with which the scale can be drawn.

The above calculations hold only for a sinusoidal waveform of modulating voltage, but in practice slight departures do not make a noticeable difference and agreement to within 5 per cent. can always be obtained with oscilloscope methods.

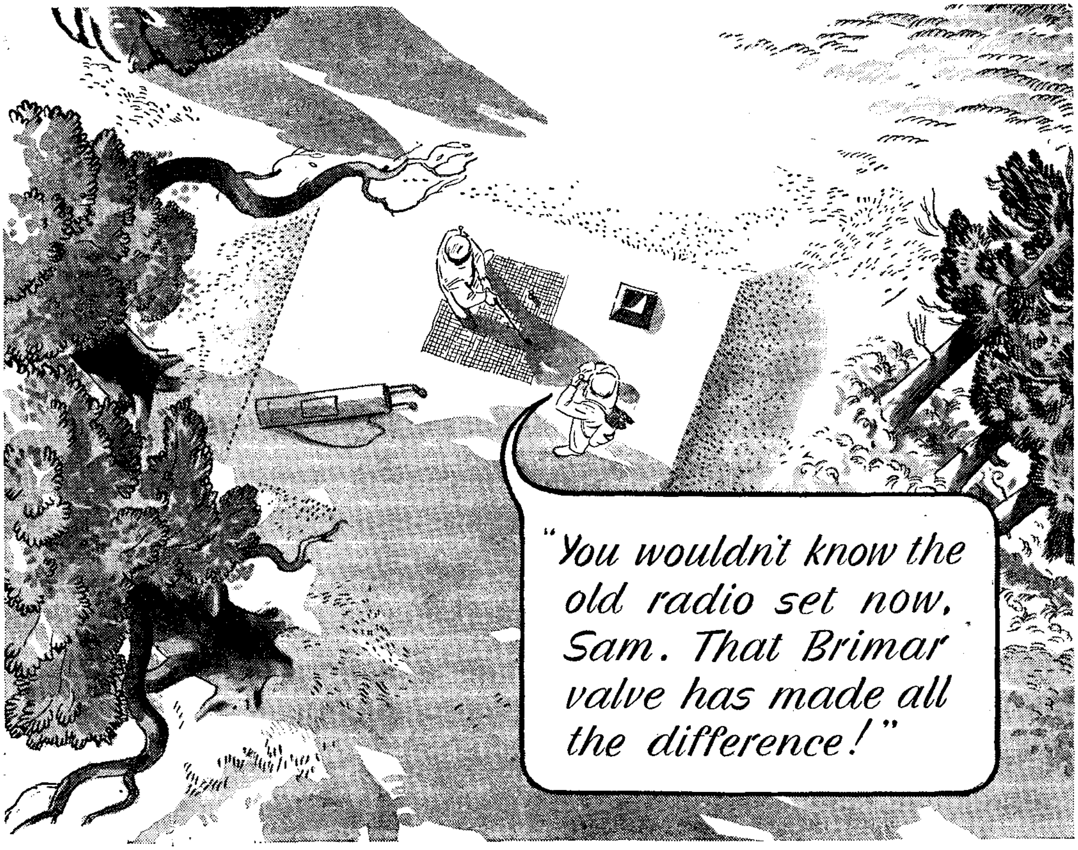
Low modulation depths are hard to estimate, and the method should only be used for modulation factors exceeding 0.5. The upper part of the RF ammeter square-law scale is best for observing small changes. Further, ove[r]modulation is *not* shown, and mu[st] be guarded against, since for this condition the needle falls *back* from the 22.5 per cent. point.

Finally, results will be inaccurate if the carrier itself varies when modulation is applied; this may happen if the RF regulation is poor due to low excitation, or if there is unsymmetrical modulation



Slide rule for calculating percentage modulation from change of aerial ammeter reading. Essential dimensions for a "10-inch" rule are as follows. Distance of RF ampere readings from left-hand end of scale: 0.6, 1.58in.; 0.7, 2.94in.; 0.8, 4.10in.; 0.9, 5.10in.; 1.0, 6.06in.; 1.1, 6.90in.; 1.2, 7.68in.; 1.3, 8.39in.; 1.4, 9.02in.; 1.5, 9.64in. Distance of modulation percentages from "Carrier" mark: 50, 0.5in.; 60, 0.72in; 70, 0.95in.; 80, 1.20in.; 90, 1.48in.; 100, 1.76in.

Angles on BRIMAR PRESTIGE



Every radio set gives its peak performance when the correct Brimar Valves are used. Engineers know how closely and unfailingly they conform to specification.

BRIMAR

BVA

VALVES

STANDARD TELEPHONES AND CABLES LIMITED, FOOTSCRAY, SIDCUP, KENT.

HIGH SELECTIVITY

at Audio and Intermediate Frequencies

A Stable Negative Resistance Circuit with Applications in Wave Analysers, Etc.

By

E. LLOYD THOMAS,
B.Sc., A.C.G.I.

IT is often an object in the design of communications equipment to construct a circuit having a very selective characteristic which responds to a narrow band of frequencies while greatly attenuating all other frequencies outside this pass-band.

At radio frequencies it is customary to use filter circuits

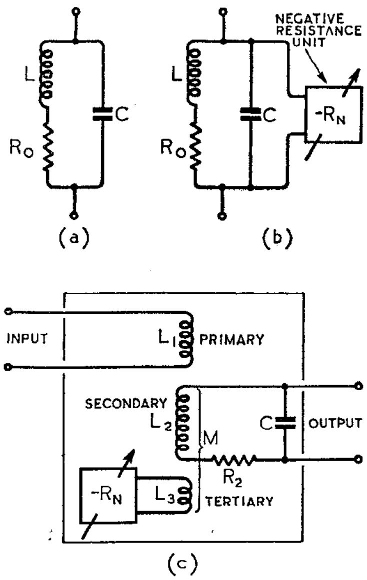


Fig. 1. Showing the successive stages in the development of the selective circuit described in the text. Formulæ for the effective "Q" of circuits (b) and (c) are worked out in the Appendix.

incorporating crystal resonators for this purpose, but at low and intermediate frequencies this method is not available and in the past it has been necessary to resort to more or less elaborate chains of tuned circuits. Such networks, for even a moderate degree of selectivity, are bulky and troublesome to adjust. Moreover, it is not usually practicable to vary either the width of the pass-band or its position in the frequency spectrum.

It is the purpose of this article to describe a method of obtaining high and variable selectivity at relatively low frequencies which avoids these difficulties. The resulting circuit, based on the application of controlled negative resistance to a single tuned coil, may also be used as an inter-stage coupling in a filter-amplifier to realise a very high stage gain.

Consider, to begin with, the factors which determine the selectivity of an isolated tuned circuit, Fig. 1 (a). The losses in such a circuit are mostly due to the resistance of the inductive element; and the "Q" factor, which is usually taken as a measure of the selectivity, may be written as the ratio of the reactance of the coil to its resistance.

Now, the "Q" of a coil for use at any given frequency is governed by its size, shape, and construction, and by the material of the core on which it is wound. Although some improvement can be effected by using stranded wire and a core of appropriate magnetic material, it is not possible at these frequencies to obtain a natural "Q" of more than a few hundred with a coil of reasonable size.

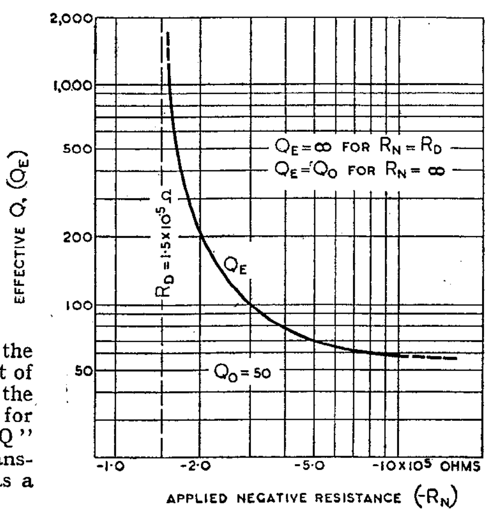


Fig. 2. Relation between the effective "Q" of the circuit of Fig. 1 (b), and the value of the applied negative resistance for a coil having a natural "Q" of 50. The curve for the transformer-coupled system has a similar shape.

For many purposes such a value is inadequate. Moreover, a coil having a magnetic core tends to overload, owing to saturation of the core material, when the potential across it exceeds a few volts. This causes undesirable distortion which can only be avoided completely by reverting to an air-cored coil.

Even if it were possible to construct a very low loss coil, the damping imposed on it by the associated circuit and valves would limit the effective selectivity. Indeed, the higher the natural "Q" of the coil the more serious would be the damping.

In the present system these difficulties are overcome by taking a coil of normal construction and raising its "Q" by artificial means. The successive stages in the development of the circuit are set out in Fig. 1, and a short mathematical analysis of the design will be found in the Appendix.

The simplest practical arrangement consists of a negative resistance device of the voltage-controlled type connected directly across a parallel-tuned circuit, Fig. 1 (b). The relation between the effective "Q" of the combination, which is higher than that of the tuned circuit alone, and the value of the applied negative resistance is derived in Appendix 2, and shown graphically in Fig. 2. As the negative resistance is decreased, the effective "Q" increases; slowly at first, and then more rapidly, until

High Selectivity—
when the value of the negative resistance equals the natural dynamic resistance of the tuned

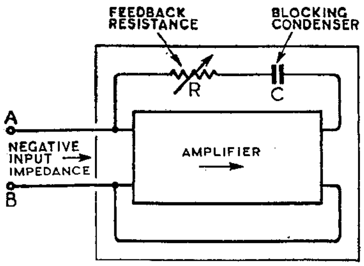


Fig. 3. The basis of the negative resistance unit is an amplifier having its output coupled regeneratively to its input.

circuit the " Q " is infinite. If the negative resistance is decreased still further, the circuit becomes unstable and will tend to go into oscillation.

Before any use can be made of this selective element, some means must be provided for coupling it in a circuit. For this purpose it is convenient to convert the tuned coil into a transformer by adding a coupling winding. The tuned winding then becomes the secondary and the coupling winding the primary.

The usefulness of this system depends entirely on the characteristics of the negative resistance unit. Unless the value of negative resistance applied to the tuned circuit can be varied easily and yet remain constant over a fairly wide range of applied voltage, then the method will have only a very limited field of application. Most of the simple negative resistance devices, such as the dynatron, are unsuitable because they are not very stable or flexible, and usually suffer from non-linearity. Fortunately, a negative resistance circuit that has been developed fairly recently satisfies these requirements. It is based on the fact that if the output of an amplifier is coupled regeneratively to its input, then the system may behave as a negative resistance to any circuit connected across its input terminals (Appendix 1 and Fig. 3). The value of negative resistance developed is determined by the gain of the amplifier and the amount of feedback. If the gain is stabilised by the application of negative feedback, the negative resistance may be made almost independent of valve and supply voltage variations.

Since a two-stage resistance-capacitance coupled unit of this type is only linear for inputs up to a few volts, it is unsuitable for direct connection when the voltage across the tuned winding may exceed this value. However, the difficulty may be overcome by adopting transformer coupling if a third winding, of comparatively few turns tightly coupled to the secondary, is added to the transformer and the negative resistance unit connected across this coil. The optimum number of turns for this tertiary is closely linked with the design of the negative resistance unit, and should be determined experimentally to give the best results (Appendix 3).

The final arrangement, Fig. 1 (c), will function satisfactorily at any frequency at which a suitable amplifier, free from appreciable phase shift, can be constructed for the negative resistance unit. With a little care it should be possible to cover the range from 50 c/s. to at least 500 kc/s.

The circuit diagram of a practical circuit is shown in Fig. 4, the component values given being suitable for the frequency range 5—50 kc/s. It will be seen that three valves are used; two of them in the negative resistance unit.

Component Values (Fig. 4)

R1	1 megohm	C1	5,000 $\mu\mu$F
R2	1,200 ohms.	C2	8 μF
R3	4,700 ,,	C3	8 ,,
R4	390,000 ,,	C4	8 ,,
R5	100,000 ,,	C5	0.1 ,,
R6	33,000 ,,	C6	0.1 ,,
R7	2,700 ,,	C7	10—100 $\mu\mu$F
R8	470,000 ,,	C8	40 μF
R9	2,200 ,,	C9	0.5 ,,
R10	100,000 ,, (max.)	C10	0.5 ,,
R11	270 ,,	C11	8 ,,
R12	1,000 ,,	V1	6J7 or SP. 41
R13	10,000 ,,	V2	6J7 or SP. 41
		V3	6V6 or PEN. 45

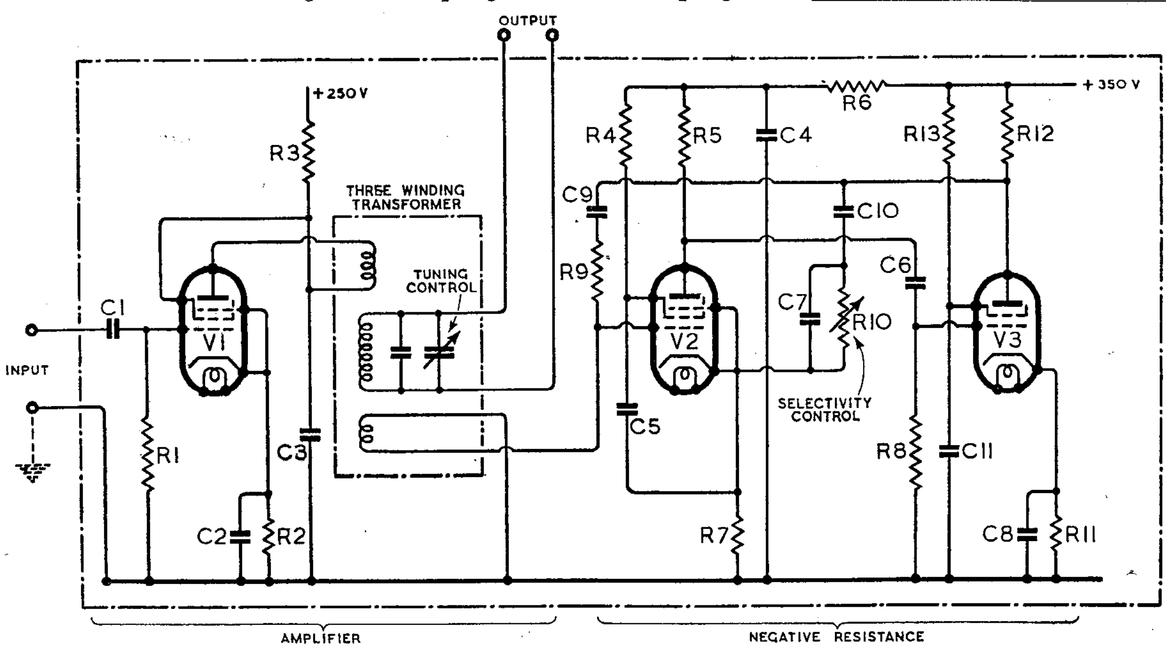


Fig. 4. Circuit diagram of a practical filter-amplifier based on the system of Fig. 1 (c).

The signal is fed to the circuit via the amplifier valve V1, in whose anode circuit is connected the primary of the transformer, and the output is taken from the tuned secondary. Owing to the high effective "Q" of the secondary the primary impedance may

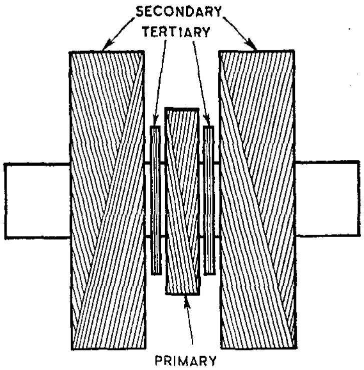


Fig. 5. Suitable construction for three-winding transformer.

be very high. Consequently a small low-slope pentode, such as the 6J7, is sufficient in this position to develop almost any output that may be required.

The negative resistance unit comprises a two-stage resistance-capacitance coupled amplifier with positive and negative feedback applied according to the principles already discussed. The first valve (V2) is a pentode of the same type as V1, connected as a voltage amplifier. The second valve (V3) supplies most of the power dissipated in the tuned circuit, and must be chosen according to the output voltage required. For outputs up to about 100 volts peak across the tuned circuit a pentode or tetrode of the medium-power output type is satisfactory. The anode of V3 is coupled back to both the grid and cathode of V2, each feedback path consisting of a resistance in series with a blocking capacitor of negligible reactance.

It is convenient to control the selectivity of the stage by choosing a suitable fixed value for the positive feedback resistance (R9) and making the negative feedback resistance (R10) variable. The latter is in effect a selectivity control, a decrease in resistance reducing the gain of the negative resistance unit and therefore the selectivity. The purpose of the small capacitor (C7) connected in parallel with R10 is to suppress parasitic oscillation by causing heavy degeneration at high frequencies.

It is advisable to use separate anode supplies for the amplifier and negative resistance valves in order to reduce the possibility of instability when working with very high selectivity.

The exact mechanical form adopted for the circuit will be determined by individual requirements. It will be sufficient here to indicate some of the more important factors governing this aspect of the design.

Owing to the high selectivity small mechanical and electrical changes are liable to have a considerable effect on the performance of the stage and every precaution should be taken to make the structure rigid and stable.

Particular care must be taken with the screening of the transformer in order not to spoil the high "Q" of the tuned winding. For th.s reason electromagnetic screening[1] is preferable to magnetic, and the screening box should not be too small. Copper is the most suitable material for this box, and it should be remembered that a considerable thickness, at least 0.1in. at 10 kc/s is necessary for effective screening at these comparatively low frequencies. If aluminium is used, this thickness must be increased by about 50 per cent.

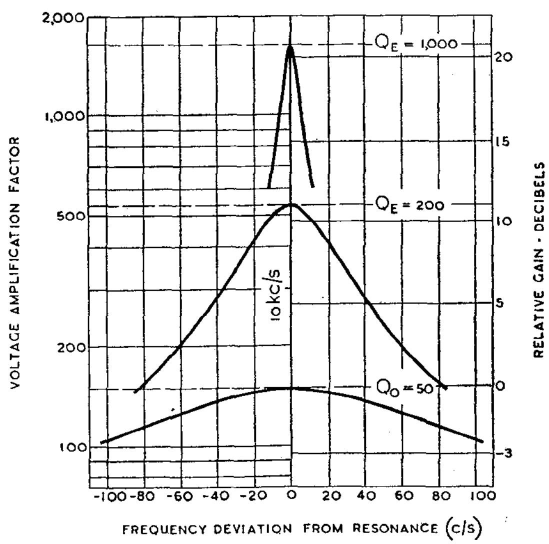


Fig. 6. Selectivity curves obtained with the circuit of Fig. 4 at a frequency of 10 kc/s, for various settings of the selectivity control. The curve Q_0=50 shows the performance of the stage before applying negative resistance.

A suitable construction for the three-winding transformer is shown in Fig. 5. Since there is no great advantage to be obtained by using stranded wire at low frequencies, the windings consist of five coils of plain copper wire wave-wound on a bakelised paper former. The secondary is wound in two halves, in opposite directions on either side of the primary, so that a balanced output may be obtained if desired. The tertiary, also in two sections, is wound by hand into the gaps between the primary and secondary.

Experiments carried out with this circuit at a frequency of 10 kc/s showed that, with a transformer secondary having a natural "Q" of only 50, an effective "Q" of 1,500 could be realised before the system became unstable. Owing to the small frequency differences involved, the selectivity of the stage was estimated by feeding a steady signal to it, and then measuring the change in capacitance required to detune the output circuit by a given amount. It may be shown (Appendix 4) that with a "Q" of 1,000 at this frequency the bandwidth for 3 db. loss is only 10 c/s.

Since the amplification of the stage depends on the dynamic resistance of the tuned circuit, which is in turn proportional to the "Q," the enhanced selectivity due to the application of negative resistance is accompanied by a corresponding rise in sensitivity. With a "Q" of 800, for example, a voltage amplification factor of 1,000 can be achieved quite easily. This is illustrated by the curves of Fig. 6.

It should be noted that the

High Selectivity—
tuning of the transformer secondary is not entirely independent of the selectivity control. The effect is quite small, however, for it can be shown that if the "Q" is raised from 500 to 1,000, the resonant frequency changes by only 1 c/s. in 10 kc/s.

Apart from the more obvious applications, such as to variable selectivity IF amplification and to AF filtering, it is suggested that this circuit might form the basis of a practical wave analyser. It would also prove useful for demodulation, in separating the carrier from an amplitude modulated signal, as the following experiment will show.

A 10 kc/s. carrier, amplitude modulated to 80 per cent. at 400 c/s, was fed to the grid of the amplifier valve while the modulation depth of the output from the transformer was observed on an oscilloscope. As the selectivity control was advanced the sidebands became more and more attenuated until, when the bandwidth had been reduced to about 12 c/s., the modulation depth was too small to detect and the output consisted of the amplified carrier alone. In fact, with a selectivity of this order the circuit will convert square pulses of carrier into a steady unmodulated signal.

APPENDIX

1. *The Negative Resistance Unit.*

If the amplifier in Fig. 3 has an infinite input impedance, a voltage amplification factor N and negligible phase shift, then the current that will flow if a voltage $v = V \sin \omega t$ is impressed on the terminals AB is

$$i = \frac{V \sin \omega t - N \, . \, V \sin \omega t}{Z} = \frac{(I - N)}{Z} \, . \, V \sin \omega t$$

where Z is the impedance of R and C in series. The input impedance of the device is therefore

$$Z_i = \frac{v}{i} = \frac{Z}{(I - N)}$$

which is negative if N > I. If the reactance of the blocking capacitor is negligible compared with R (which includes the output resistance of the amplifier) then Z_i is a pure negative resistance of magnitude $\frac{R}{(N - I)}$

The output resistance of the amplifier and the reactance of C impose a lower limit on the value of input resistance that can be obtained.

2. *Direct Coupled Negative Resistance.*

The natural "Q" of the tuned circuit of Fig. 1 (b) is $Q_0 = \frac{\omega L}{R_0}$ where $\omega = 2\pi \times$ frequency.
The natural dynamic resistance of the circuit is

$$R_D = \omega L \, . \, Q_0 = \frac{\omega^2 L^2}{R_0}$$

and the effective dynamic resistance when a resistance $-R_N$ is connected in parallel with the circuit is

$$R_D' = \frac{R_N \, R_D}{(R_N - R_D)} = \frac{\omega^2 L^2}{\left(R_0 - \frac{\omega^2 L^2}{R_N}\right)} = \omega L \, . \, Q_E$$

The effective "Q" of the combination is therefore

$$Q_E = \frac{R_D'}{\omega L} = \frac{\omega L}{\left(R_0 - \frac{\omega^2 L^2}{R_N}\right)}$$

which is infinite when $R_N = R_D$.

3. *Transformer Coupled Negative Resistance.*

The complete solution of the three-winding transformer circuit (Fig. 1 (c)) is somewhat involved and unnecessary when, as is usually the case, all that is needed is a rough idea of the value of negative resistance required to realise a given "Q". However, an approximate solution can be obtained if the system is reduced to a two-winding transformer, either by neglecting the primary (only possible if the anode resistance of the amplifier valve is very high compared with the primary impedance) or by modifying the resistance of the secondary to allow for the damping effect of the amplifier valve.

If R_N is the magnitude of the negative resistance connected across the tertiary, and M is the mutual inductance between the secondary and tertiary, it may be shown that the effective series resistance of the secondary is approximately

$$R_E = \left(R_2 - \frac{\omega^2 M^2}{R_N}\right)$$

The effective "Q" of the tuned winding is therefore

$$Q_E = \frac{\omega L_2}{R_E} \doteqdot \frac{\omega L_2}{\left(R_2 - \frac{\omega^2 M^2}{R_N}\right)}$$

(Compare this with the expression obtained for the direct-coupled system.)

4. *Measurement of Selectivity.*

If the difference in capacitance between the two settings of the tuning capacitor for which the voltage across the tuned winding is $\frac{I}{\sqrt{2}}$ times that at resonance is δC, and the total tuning capacitance is C, then it may be shown that

$$Q_E \doteqdot \frac{2C}{\delta C}$$

and the bandwidth for 3 db loss is

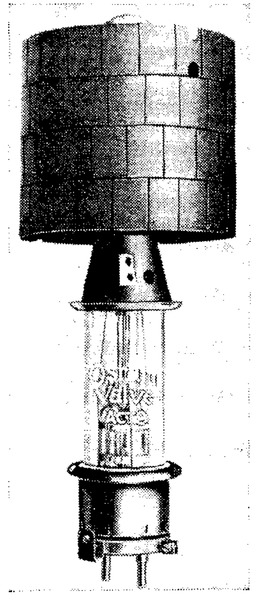
$$\delta f \doteqdot \frac{f_0}{Q_E} = \frac{\delta C}{2C} \cdot f_0$$

where f_0 is the resonant frequency.

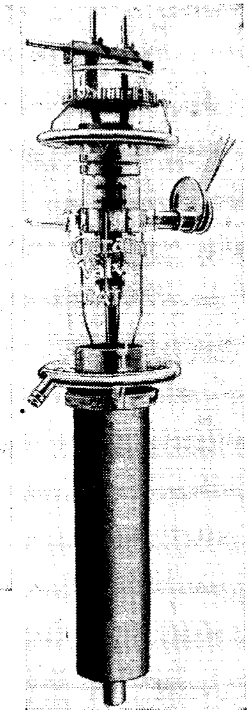
RADIO HEATING EQUIPMENT

III. High-powered Valves: Automatic Control Devices

By L. L. LANGTON, A.M.I.E.E.



The anode of the Osram Type ACT9 is fitted with external cooling fins and is rated for a power dissipation of 800 watts in free air or 1100 watts with forced air cooling. It is suitable for use up to at least 15 Mc/s.



(Right) Water cooling in the Osram Type CAT9 enables the valve to dissipate 18kW at the anode. The maximum operating frequency is 20 Mc/s. In this photograph the water jacket has been removed to show the cylindrical anode.

IT has been indicated that it is advisable that the power capabilities of a radio heater should be sufficient to compensate for losses, which will be unavoidably large in some applications. In general use the equipment may rarely be operated at maximum efficiency, for, in seeking always to satisfy the factors governing efficiency, the industrial application will be somewhat restricted.

Valves employed for generating radio power in larger equipments are designed to facilitate dissipation of heat generated at the anode. When power of the order of kilowatts is to be dissipated the temperature rise of the anode would be very great were no measures adopted to restrict it.

The first group of larger valves is that having glass envelopes and more or less conventional internal construction. The anodes in these valves become very hot, and the envelopes are of considerable size, so that the dissipating area may be large. Their power handling capabilities are limited by the temperature at which glass softens, about 450 deg. C., and valves of this type are obtainable for powers up to about 2.5 kW. Another type of valve has an envelope of silica, which softens at a temperature of about 1,500 deg. C., the power capabilities of such valves being correspondingly greater.

For powers exceeding 2.5 kW, copper anode valves are normally employed. Fins may be fitted to the copper anode to increase the heat-dissipating area when air cooling is employed and, with forced air circulation, valves up to 5 kW are obtainable. Larger valves are normally water-cooled and are manufactured up to powers exceeding 100 kW. Even higher powers are possible with the demountable type of valve, which requires pumping equipment to maintain the vacuum.

Two precautions should be particularly observed when operating large valves. It is often necessary to arrange a circulating system of soft water for cooling valves, as ordinary mains water in many districts is unsuitable. The LT voltage must be applied gradually, as the cold resistance of a tungsten filament is only about one-tenth of the resistance when up to full emission temperature. If full LT voltage is applied when starting, the reaction between the magnetic fields due to the current in each tungsten wire of the filament may bow the wires out on to the grid.

There are many factors governing the upper frequency at which a valve may be operated successfully. The electron transit time and inter-electrode capacitance are controlled by the physical dimensions and disposition of the electrodes, the position in which connections are brought out and the potentials applied to the electrodes. The leads from the electrodes have to be brought out through pinches made of glass or similar material and, in the case of copper anode valves, such material forms the seal of the anode. The loss factor of the pinch or seal material imposes a further limitation on the frequency at which power may be generated. Manufacturers usually indicate the maximum anode voltage which may be safely applied when working at given frequencies.

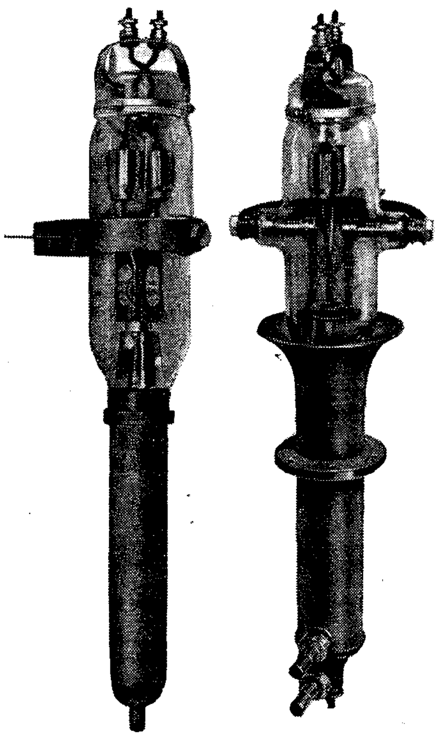
The normal run of transmitting valve is not designed to operate efficiently above 30 Mc/s, and at this frequency the power capability is reduced according to the type of valve to about 50 to 70 per cent. of that at 10 Mc/s. The highest frequencies commercially used in dielectric heating are around 100 Mc/s and special valves are required for their generation. High frequencies of this order must be employed when the voltage gradient through the dielectric heated is required to be low, and also when an attempt is being made to heat materials having very low loss factors. The valves needed for UHF generation are much more expensive than normal valves of equivalent power, and comprehensive precautions against loss must be taken in the whole equipment.

Radio Heating Equipment—

The capital cost of such a generator would, of course, greatly exceed that of one which operates below 30 Mc/s. The satisfactory heating of most thermosetting plastics does not, however, require frequencies in excess of 30 Mc/s.

For HT supply, the hot cathode mercury vapour valve is usually employed, and rectifies AC transformed up to the required voltage. It should be noted that it is essential, particularly in large generators, to isolate the HT transformer from RF currents. These will heat and may sometimes even burn the insulation at the ends of the transformer winding. Efficient RF chokes and by-pass condensers should be included in the HT circuit to shunt RF current from the transformer.

Apart from safeguarding the transformer against breakdown, this precaution is vital to reduce interference injected into the mains. Even with efficient RF filters preceding the transformer primary, it is better to minimise RF in the HT circuit. In larger equipments, the transformer and rectifier are usually housed separately from the oscillator and although the screening of the oscillator compartment may be adequate the fact that HT leads and end turns of the transformer will radiate may be overlooked. The necessity for the adequate screening of the entire equipment is increased by the fact that the mercury vapour rectifiers may themselves burst into violet parasitic oscillation, unless steps are taken, such as the fitting of stopper resistances or RF chokes, to obviate this risk. A recent editorial sounded a note of warning regarding the interference propensities of radio heating, and mentioned the crippling legislation which will probably follow if the users of radio heating do not exercise care in reducing interference. The author intends later to discuss the question of radiation and interference, and the above points are mentioned at this stage to emphasise the gravity of the matter.



Two views of the Mullard Type TX12-20 valve with and without water-cooling jacket. The maximum anode dissipation is 18 kW, and the maximum operating frequency 20 Mc/s.

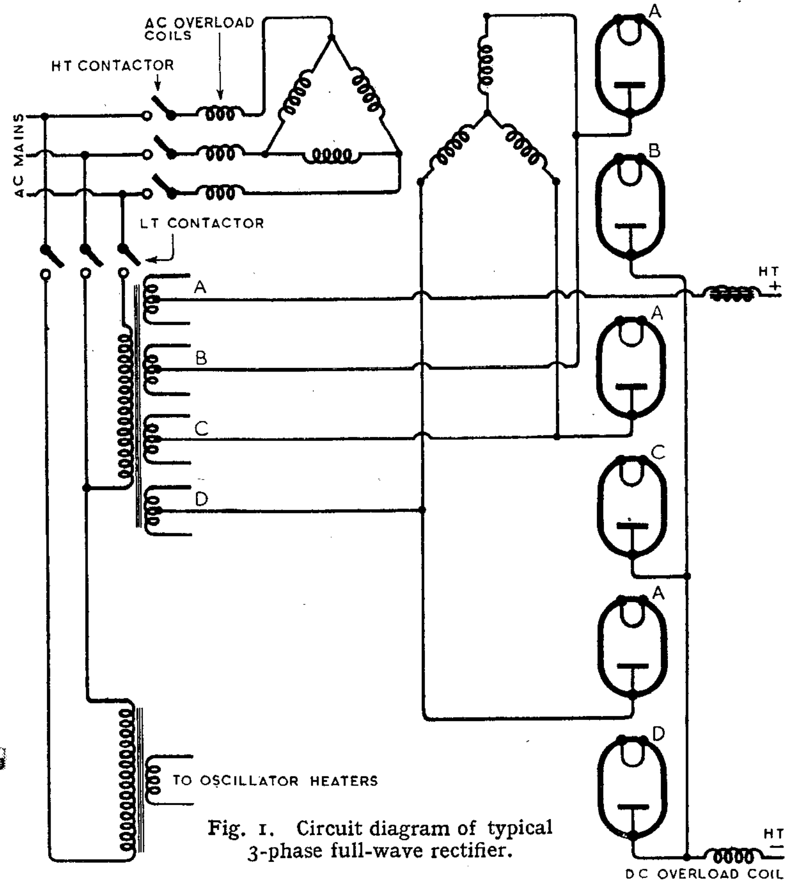


Fig. 1. Circuit diagram of typical 3-phase full-wave rectifier.

The mercury vapour valve is a very satisfactory rectifier, provided that certain precautions are observed. In operation its resistance is very small and the voltage drop across it correspondingly low. The electron emission from the cathode will, if the anode voltage exceeds about 15, ionise the mercury vapour molecules and a blue glow permeates the tube when this occurs. The heavy ions will, if they impinge upon the cathode across a drop exceeding 20 volts, destroy the emitting surface.

If a very heavy load were imposed, the voltage drop across the rectifier would increase, and it is essential to include a choke in the output to limit the instantaneous current that may flow. With a condenser across the output and no limiting choke the instantaneous charging current of the condenser may impose a load large enough to result in the destruction of the cathode.

The first precaution is that the cathode must be given sufficient time to reach full emission temperature before volts are applied to the anode. If this is not done some mercury molecules will be ionised before full emission is achieved and the voltage drop across the valve will, under these conditions, exceed 20, with the consequent destruction of the cathode. Manufacturers prescribe the peak reverse voltage at which the valve may be operated, and if this voltage is exceeded the valve will arc over. The arcing point is controlled in a given valve by the mercury vapour pressure, which is in turn dependent upon the temperature of the atmosphere surrounding the valve.

The second precaution is that there must be no large change in ambient temperature, particularly if the valve is operated nearly up to its peak reverse voltage (which it usually is).

The type of rectifier circuit used will depend to some extent upon the power of the generator. For 2 kW and below single-phase mains supply is usual, while 3-phase mains supply is customary for larger equipments. The supply to most industrial undertakings, excepting the very smallest, is 3-phase, and if a heavy load were imposed on one phase serious unbalancing would result.

An advantage obtained by the use of 3-phase rectification is a large reduction in the AC ripple imposed on the rectified DC. With single-phase full-wave rectification the RMS ripple voltage will be of twice supply frequency and will be equal to 48.3 per cent. of the DC voltage. With 3-phase full-wave rectification, the RMS ripple voltage will be of six times supply frequency and will be equal to 4.2 per cent. of the DC voltage.

The output from a single-phase rectifier must be smoothed before being applied to the generator, but in the case of 3-phase full-wave rectification this is not vital. However, if smoothing is employed the choke required will be of comparatively small inductance, as the frequency of the ripple voltage is six times that of the mains supply.

A circuit diagram of a three-phase full-wave rectifier is given in Fig. 1. The transformer has delta primary and star secondary connections, the secondary RMS voltage per leg being 0.428 of the rectified DC voltage, the secondary RMS current being 0.816 of the DC current and the average valve current 0.577 of the DC current. The peak reverse voltage will be 1.05 times the DC rectified output.

With all equipments having a high-tension supply voltage which would be dangerous to the user, safety devices must be incorporated. No portion of the equipment must be accessible when in operation, and on any door or sliding panel switches must be fitted. Where mercury vapour rectifiers are employed it is also essential to include a device which will not permit the application of anode voltage until their cathodes are up to full mean temperature.

The magnetic contactor, operated by push buttons and the contacts of relays associated with various safety devices, forms a satisfactory method of control, particularly on large equipments. A circuit diagram of such an arrangement is given in Fig. 2, which should be studied in conjunction with Fig. 1. The control circuit operates at mains voltage supplied by a single-phase or between lines of a three-phase supply.

Start-button controls are normally on open-circuit and, when pressed, contact is made. Stop-button controls are normally on closed-circuit and, when pressed, the circuit is opened. Magnetically operated contactors are normally open-circuited and connect the mains supply to the transformer when the contactor coil is energised. There is in a magnetically operated contactor an auxiliary contact, called the maintaining contact, and this closes when the contactor operating coil is energised.

The maintaining contact is wired in parallel with the start-button, and, when this is operated with all the switches and relay contacts in the control circuit closed, the contactor coil is energised and the start-button circuit is completed by the maintaining contact, after the finger has been removed from the button. If a stop-button is operated or any relay contact in the circuit opens, the contactor coil will be no longer energised, and the mains connection to the transformer broken.

It will be noted in Fig. 2 that there are two separate control circuits, one for the LT transformers that supply filament current for the oscillator and rectifier, and the other for the HT transformer. A small transformer, the primary of which is across the LT contactor coil, energises a thermal delay switch, and on operation this will transfer the AC to the bridge metal rectifier, the output of which energises relays 1 and 2. Relay 1 has two contacts, one normally open and the other normally

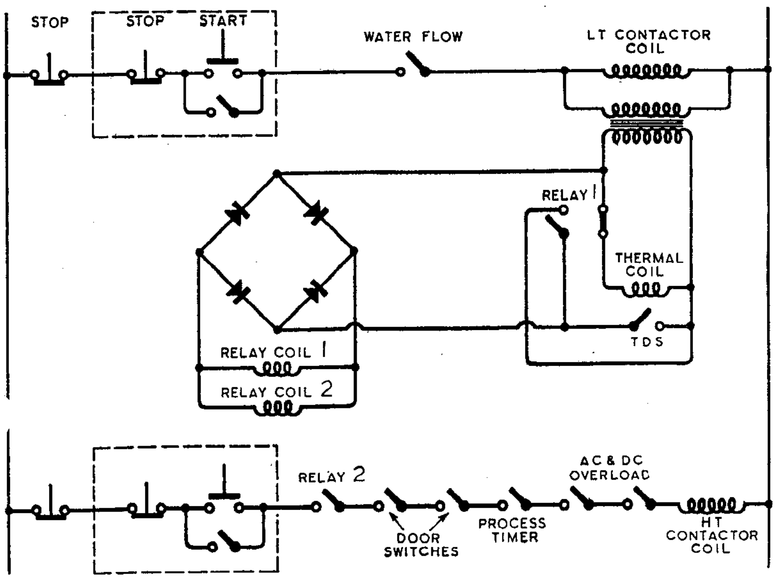


Fig. 2. System of control and safety switches in a high-powered RF generator.

Radio Heating Equipment—

closed. These will, on operation, disconnect the thermal delay switch winding, while still maintaining the supply to the metal rectifier. The contact of relay 2 is in the HT control circuit, and will close when the thermal delay switch has operated and permit the operation of the HT contactor.

Included in the LT control circuit are the contacts of a relay which is controlled by a water flow switch, incorporated in the supply pipes to water-cooled valves. Until cooling water is flowing it will not be possible to start the equipment. Where forced air cooling is employed, the air flow is made to operate a switch which controls this relay.

Door switches and DC and AC overload relay contacts are included in the HT control circuit, as are any contacts associated with process timing controls which switch off the equipment after a stipulated interval. This arrangement enables the HT to the generator to be disconnected without affecting the LT supply, and at the same time ensures that the anode voltage shall not be applied to the mercury vapour rectifiers before full cathode emission is achieved.

Process timing controls which are capable of being varied over a wide range are advantageous for repetition production purposes. For most eddy current heating applications, particularly that of surface hardening, the process times required will be fairly short, ranging from about 3 to 30 seconds. With dielectric heating the process times will be somewhat longer, and may extend up to four or five minutes.

The process timing control must be precise in operation, for the tolerance which can be allowed on, say, a 10-second heating time must obviously be small. Switches operated mechanically by a synchronous motor may be used, but it is also possible to devise satisfactory electronic methods, using relays controlled by discharge tubes in resistance-capacity circuits.

RANDOM RADIATIONS

By "DIALLIST"

Silver Jubilee

THE Silver Jubilee celebrations of the Wireless Section of the Institution of Electrical Engineers was a great show. I don't suppose there has ever been such a gathering of the eminent figures of the world of technical radio. Almost every well-known man of the present day seemed to be there, and the survivors of pioneer days were to be seen in strength. In fact, whilst chatting at the preliminary tea with the Editor of *Wireless World* and Capt. S. R. Mullard and "Cathode Ray," I said that almost the only link with the old days that I hadn't seen was Mrs. Raymond, of Lisle Street, who used to supply so many of us with components! At the meeting itself the task of telling the story of wireless was assigned to former Chairmen of the Section, each being given one aspect to deal with. One of the most entertaining speakers was Professor G. W. O. Howe, Technical Editor of *Wireless Engineer*, who insisted that wireless had made such enormous strides, not because of, but in spite of, the theorists. He said that if Marconi had consulted eminent scientists before making his attempt to transmit across the Atlantic he would never have made it, for he would have known that success was impossible! Again and again, he told us, men of science said that things couldn't be done—and the practical men just went on and did them. Admiral Sir Charles Kennedy-Purvis had more to say in the same strain from the Navy's point of view. "Our experts," he told us, "used to produce calculations showing the impossibility of this or that. Well, we just blundered in and did these things; then the experts revised their figures."

Theory and Practice

The trouble is, I believe that physicists and mathematicians do not always see the full implications of their calculations. Hertz wrote to an inquirer that there was no possibility of ever using electromagnetic waves for the transmission of telephony. The short waves were handed over to radio amateurs because (a) the authorities then regarded the amateurs as a nuisance, and (b) it had been proved (!) that these waves were useless for long-distance communication. The E, or Heaviside, layer had a long struggle for recognition, and only 17 years ago there were front-rank men of science who laughed out of court the suggestion that there was such a thing as an F layer—let alone two of them. The whole business reminds me of the story of a professor of mathematics who published calculations showing the impossibility of hitting a golf ball more than so many yards. His son read the paper, took driver and ball—and performed the impossible. So often there is a factor which is either overlooked or regarded as of negligible importance in the calculations; then, when what they appeared to show couldn't be done is done, revision brings out the importance of that factor after all. Theory and practice must always go hand in hand: theories, when all is said and done, are tentative until practice has confirmed them or otherwise; practice without theory seldom leads to the best possible results.

□ □ □

Who Invented Radar?

AN awful lot of nonsense has been written, mainly in the lay papers, in endeavours to prove that this man or that was the inventor of what used to be known as Radiolocation and is now termed Radar. Again, there have been attempts to demonstrate that if an individual cannot be given the credit, it can at all events be assigned to one country. The truth is that the basic principle on which radar is founded—the reflection of VHF radiation—was world-wide knowledge years ago. Those who visited the National Physical Laboratory's "sideshow" at the Radio Exhibition at Olympia in 1936 or 1937 (or was it even earlier?) may remember the film which showed how this principle was used to measure the height of the E and F layers by transmitting impulses vertically upwards and measuring the time taken for the reflections to return to earth. It was not for some time that any attempt was made to extend the idea to the pin-pointing of aircraft in flight, though the possibility of doing so was no doubt recognised in many countries by scientists working on independent lines. It is one thing to realise possibilities and quite another to produce a practical working system which gives the answers under the exacting conditions of modern warfare. I doubt whether any person can justly claim to have invented radar or whether any country can truly assume the honour of having been its birthplace. But, to come down to the brassiest of brass tacks, this country of ours had in operation when the war broke out real honest-to-goodness working systems which did all that was asked of them—and I very much doubt whether radar had reached a similar state of development in any other country at that time.

□ □ □

Receiver Prices

THE prices of both new and second-hand wireless receiving sets are fixed by regulations if they are sold by dealers in the ordinary course of business. But, as "Free Grid" has recently pointed out, the rules do not apply to private transactions. Nor do they to auction sales. The other day one of these was taking place at a house not far from mine, and being on leave at the time, I looked in to see whether there was anything tempting on offer. One thing I did notice was a table model receiver dating from about 1938, whose original price had been in the neighbourhood of £12. To my knowledge it had been in regular use all these years, so that it had certainly had plenty of wear and tear. In pre-war days the value of a six-year-old set—that is, the amount a dealer would allow for it in part exchange—was a matter of shillings. The bidding for this one started at £10 and ran briskly to £15, at which it was knocked down.

□ □ □

War and Progress

IT is lamentable but none the less true that many departments of applied science make far greater advances in wartime than in the days of peace. Wireless, for example, was in a comparatively rudimentary state when the last war broke out, but by the time that the Armistice came the stage was all set for the development of world communications and of broadcasting. And when this war is over progress almost as spectacular may be revealed in many directions. The reason, I suppose, is that in war development becomes a matter of life or death. Money *must* be found for research, and the energies of manufacturers directed willy nilly to activities for which no opening of a commercial kind may then be apparent. In the last war one firm of lamp manufacturers was asked to make radio valves. They agreed with a sigh: "We suppose you realise," said they, "that you are asking us to instal machinery and equipment for which there can be no possible use after the war!" And so in wartime research and development go forward at a pace unheard of in peace. It's a thousand pities that it should take a war to do this; tragic, again, that science should have to be applied mainly to the devising of methods of death and destruction. But out of evil comes good sometimes, and this is certainly true of the wartime speeding up of scientific activities.

□ □ □

The Ways of Neons

IT hasn't come my way to make much use of neons except in HF fields. Hence I was puzzled at first over something that occurred a few days before writing this. In my home there is an upstairs corridor leading to a couple of bedrooms which had always seemed to me to need a small light of its own that could be switched on or off at either end. Being on leave and thinking of jobs to do, the one of putting in this light seemed just what I wanted to fill in a wet afternoon. I fixed it up in the normal way, with a couple of two-way switches with three wires between them. As time was short and I had some good-quality three-core flex, I used that for the job. A 15-watt lamp gave ample light, and I wondered whether a neon might not possibly fill the bill. It didn't, so, preparing to replace the 15-watter, I switched off. Or, rather, I turned over first one of the switches and then the other, but the neon continued to glow—not, of course, at full brilliance, but there was a distinctly visible luminescence at the end of one of the supports. Reversing the mains leads had no effect. Disconnecting at the junction with the mains, I tested the circuit with a 500-volt megger and obtained an "infinity" reading. A capacity effect, I suppose.

□ □ □

Pedantic ?

THE other day when looking through a little book that had just come into my hands I was interested to see that the author insisted that the correct plural of radius vector was radii vectores. I wonder what readers (and particularly my old Vine Street dock-mate "Free Grid," who, like myself, had something of a classical upbringing) think of that. If the expression were good Latin, I'd plump for radii vectores, even though it be rather a mouthful. But it isn't good Latin. "Vector" to Cæsar or Cicero would have meant a carrier and "radius" a rod or a spoke; neither would be able to make anything of "radius vector." As, then, it's simply a convenient expression that we have made up out of two Latin words, to which we've given specialised meanings entirely different from any that they had when Latin was Latin, I contend that the only thing to do is to treat it as English and make the plural "radius vectors." And, by the way, do let us be consistent; I don't think I have come across "vectores" as the plural of vector in normal mathematical works. Have you ?

WORLD OF WIRELESS

PRESS AND RADIO

THE long-standing controversy in the United States regarding the common ownership of newspapers and broadcasting stations has been ended by the F.C.C. announcement that it will not "adopt any general rule with respect to newspaper ownership of radio stations," applications for licences being considered on their individual merits.

The statement continues: "Aside from the specific question of common ownership of newspapers and radio stations, the Commission recognises the serious problem involved in the broader field of the control of the media of mass communications and the importance of avoiding monopoly of the avenues of communicating fact and opinion to the public."

TELEVISION IN THE STATES

THE National Broadcasting Company of America has outlined its post-war television policy. In a statement to the network's affiliated stations it is predicted that an eastern network of television stations extending from Washington to Boston will be the first link in a nation-wide chain of stations.

Despite the fact that the N.B.C.'s parent company R.C.A. has carried out extensive research and development work on radio relay systems, no definite statement has been made on the means likely to be employed for linking the stations. It is, however, disclosed that plans are made for the installation of between 6,000 and 7,000 miles of co-axial cable in the next five or six years. The statement adds "the ultimate determination of which is to be used will be governed by the relative efficiency of service they render and their comparative costs."

With regard to the present allocation of 18 channels for the use of television stations, which, it is considered, is sufficient for its present needs but may prove inadequate for future requirements, the statement concludes, "If the television [frequency] allocation now in existence were to be changed substantially and a new start in the higher frequencies were required, it would retard the establishment of television as a practical service for a period of years that cannot now be definitely forecast. It is to be hoped, therefore, that post-war television will be permitted to continue on the present frequency allocations."

The Vice-Chairman of the U.S. Radio Technical Planning Board suggests that the Federal Communications Commission should grant post-war licences to commercial television stations on pre-war standards, or with such modifications as can readily be introduced, for a period of at least six years. His point was that receiving sets at present in use would not be rendered obsolete. At the end of this period, during which experiments could continue on frequencies not at present utilised for television, transmitters would be permitted to change to a different standard if they wished to.

Our U.S. contemporary *Broadcasting*, referring to the post-war cost of television receivers, states that there has been a reduction of 60 per cent. to 80 per cent. in the cost of manufacturing CR tubes.

A.B.S.I.E.

IT was recently announced that the B.B.C. had placed a medium-wave transmitter at the disposal of the American Office of War Information for "political warfare" purposes.

The two wavelengths to be employed, 307.1 and 267.4 metres, are both allocated to the B.B.C. under the Lucerne wavelength allocation plan and up to the outbreak of war were employed, respectively, by the Lisnagarvey (N. Ireland Regional) and Stagshaw (N.E. Regional) stations.

A special studio has been equipped in London for the exclusive use of the station, which is known as A.B.S.I.E.—American Broadcasting Station in Europe.

It is understood programmes from the studio will also be transmitted on short waves.

NEW U.S. STATIONS

IN pursuance of the plan of the U.S. Office of War Information to increase the number of international short-wave stations in the States to 36, four 50-kW transmitters are being erected on the Pacific Coast. These transmitters, which it is hoped to have in use in October, will be operated by the N.B.C. for the Government. The call letters KNIB and KNBC have been allocated to two of the transmitters.

The C.B.S. will operate a similar station to be erected at another point on the Pacific Coast in the near future.

According to *Broadcasting*, 21 transmitters are at present being used by the O.W.I., some of them having a power of 100 kW. Ten of these stations being on the West Coast, with their transmissions beamed to the Far East, their call letters, including KGWI, KWID, KWIX, KWU, KWY, KRCA and KROJ, are not well known in this country.

HEROIC RADIO OFFICERS

THE Lloyd's War Medal for bravery at sea has been awarded to three radio officers.

Senior Radio Officer C. S. Marshall received his medal for outstanding courage and devotion to duty. By employing every means and improvisation available he did all that was possible to send out a distress message when the ship in which he was sailing was torpedoed and severely damaged.

Senior Radio Officer J. F. Wilson sacrificed his life by remaining at his post after the crew were ordered to abandon the sinking ship. He managed to repair the transmitter and get a message through to one of H.M. destroyers and was not see again.

Chief Radio Officer S. D. Haines also stayed behind after the crew had been ordered to leave in an effort to repair the wireless gear and to send out a distress mesage.

Chief Radio Officer R. F. Cole receives the M.B.E. Although injured and dazed by the explosion which wrecked his ship, he struggled amongst the debris in the wireless room to get away a distress message on an emergency set, and left only when ordered to his boat by the Master.

WHAT THEY SAY

RADIO is part of the heritage of the modern child, and the teacher owes a duty to his pupils to seek to train their taste in using it. —*A. C. Cameron, secretary, Central Council for School Broadcasting, in an address to the Royal Society of Arts.*

I was, for a time, one of the die-hards who opposed the revolutionary introduction of short waves [int Naval communications] in abo 1923.—*Admiral Sir Charles Kennedy-Purvis, at I.E.E. Wireless Section Commemoration Meeting.*

As to the future, Birmingham will be the first city outside London to have television, but more than that cannot at present be stated.—*Percy Edgar, Midland Regional Director, B.B.C.*

Television, under present standards, is not good enough. It can be good enough (and very quickly) if we do not wantonly dissipate, but use intelligently, the advantage the present hiatus affords us. . . .—*W. Miner, in "Electronics."*

. . . . We must, however, take exception to one minor point: On page 54, it is stated that the leakage resistance of an 0.1μF wax-impregnated capacitor is between 5 and 50 megohms. If capacitors of

European manufacture are that bad, American manufacturers of such items need have no fear of European competition in post-war markets.—*J. H. P. reviewing E. E. Zepler's book, "The Technique of Radio Design," in "Radio" (U.S.A.).*

Has the advice of the B.B.C. technicians been sought in the matter of radio reception in the steel houses the Government propose to erect?—*R. Moscrop, in a letter to "News Chronicle."*

IN BRIEF

Canadian S-W Station.—Priorities have now been granted American manufacturers for the provision of the equipment for the 50-kW short-wave station to be erected at Sackville, New Brunswick, by the C.B.C. It was originally expected to cost $800,000, but will now cost around $1,100,000. The station, which will be equipped with two 50-kW transmitters, is expected to be testing in October and ready for service by January 1st, 1945.

American Sets.—The Board of Trade states that 36,000 American broadcast receivers have already arrived and a further 7,000 are expected shortly. 12,000 sets have already been distributed and a further 12,000 will be available soon.

Long-distance FM.—A C.B.C. station on Mount Royal, Montreal, is receiving FM transmissions from a station at Mount Washington, New Hampshire, U.S.A., 170 miles away!

Sir Ernest Fisk.—The recent thirty-fifth Kelvin Lecture at the Institution of Electrical Engineers was preceded by the presentation to Sir Ernest Fisk of the Certificate of Honorary Membership. He was elected an Honorary Member by the Council of the I.E.E. earlier this year.

B.B.C. Reappointment.—Sir Allan Powell has been reappointed Chairman and Governor of the B.B.C. He has consented to serve in order to ensure continuity of policy for such further period as might be decided.

Radiolocation Award.—The Thomas Gray Memorial Trust Prize of £50, offered by the Royal Society of Arts for inventions connected with the "Improvement and Encouragement of Navigation," has been awarded for 1943 to Drs. J. T. Randall and H. A. H. Boot for their valuable invention in connection with radiolocation. The citation states, "Eminent service has been rendered to the Merchant Navy by their invention for the greater safety of life at sea."

C.B.C. Expenditure. — Announcing the gross annual revenue of the Canadian Broadcasting Corporation for the past year at $2,489,224. Dr. Augustin Frigon, acting general manager of C.B.C., said that expenses amounted to $1,245,870. It is noteworthy that $457,000 of this sum went to pay line rentals.

Sharing Wavelengths.—The Irish Government has given permission for the Vatican City broadcasting station to use, temporarily, the frequency 565 kc/s (531 metres) which was allocated to Ireland under the Lucerne plan. It is understood the Vatican transmitter is using a power of only 1 kW, so that there should not be any interference with the transmissions from the 100-kW Athlone station.

Short-wave Transmission.—"Radio Waves and the Ionosphere" is the title of a new book to be issued by our Publishers. Written by T. W. Bennington, it gives a lucid description of the factors affecting the propagation of short waves. Copies will be available shortly, price 6s.

Invasion Radio.—800 wireless sets to equip a division was the recent estimate given by Lt. Gen. Sir Colville Wemyss, Colonel-Commandant of Royal Signals. "Good communications," he said, "are vital to any operations, especially those involving all the complications of an invasion."

Radio Pictures.—A commercial phototelegram service between Naples and London has been opened by Cable and Wireless, and pictures will now be accepted at the rate of £1 15s. 9d. up to 120 sq. cms. and £2 8s. 6d. for those over 120 sq. cms. up to 234 sq. cms. The service is at present one way only

Photo: Odhams Press

COL. DAVID SARNOFF, President of the Radio Corporation of America, now a member of General Eisenhower's headquarters staff, was recently a guest of the Radio Industries Club in London. With him are Sir Noel Ashbridge, Deputy Director-General of the B.B.C., who was re-elected as President of the Club for a second year, and (right) the Chairman of the Club, H. de A. Donisthorpe, whose seventh year of office was celebrated at the meeting by a presentation from the members.

World of Wireless—

—Naples to London. The circuit between London and Buenos Aires, which was originally opened in March, 1937, but suspended in 1942 at the instigation of the Argentine Government, has been reopened. The rate for phototelegrams is £11 17s. 6d. for a minimum of 150 sq. cms.

Institute of Physics.—At a meeting of the Electronics Group of the Institute on June 10th, at 2.30, in the rooms of the Royal Society, Burlington House, London, W.1, Drs. M. Pirani and B. P. Dudding will open a discussion on "Some Aspects of High Vacuum Technique, viz.: High Vacuum Gauges and Glass Manipulation."

Scottish Branch.—At the request of physicists employed in industry in Scotland the Board of the Institute of Physics has authorised the formation of a Scottish Branch to give local opportunities for the interchange of knowledge and experience of applied physics. The inaugural meeting took place in Glasgow on April 22nd.

NEWS IN ENGLISH FROM ABROAD

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
Algeria			
Algiers	8.965	33.46	1700, 1800, 1900, 2000, 2200, 2300
	12.110	24.77	1800, 1900, 2000, 2200
America			
WRUW (Boston)	6.040	49.67	0900
WCBN (New York)	6.060	49.50	0900
WLWK (Cincinnati)	6.080	49.34	0700, 0800
WKRD (New York)	6.100	49.18	0100, 0300, 0600, 0700, 0800, 0900
WOOC (Wayne)	6.120	49.03	0300, 0400, 0500, 0800, 0900
WBOS (Boston)	6.140	48.86	1000, 1100
WCBX (Brentwood)	6.170	48.62	0800
WGEO (Schenectady)	6.190	48.47	0800
WKTM (New York)	6.370	47.10	0100, 0300, 0400, 0500, 0600, 0700, 0800, 0900, 1000
WGEA (Schenectady)	7.000	42.86	0600, 0800
WKLJ (New York)	7.565	39.66	0300, 0400, 0500, 0600, 0700, 0800, 0900, 1000
WLWO (Cincinnati)	7.575	39.61	0700, 0800, 0900
WOOW (New York)	7.820	38.36	0300, 0400, 0500, 0800, 0900
WGEA (Schenectady)	9.530	31.48	1000, 11,00, 1200
WCRC (New York)	9.590	31.28	1000, 1100
WNBI (New York)	9.670	31.02	1000, 1100, 1200
WKRD (New York)	9.897	30.31	1000, 1100, 1200
WLWO (Cincinnati)	11.710	25.62	2200, 2300
WRUW (Boston)	11.730	25.57	1400
WGEX (Schenectady)	11.790	25.44	2200
WCRC (Brentwood)	11.830	25.36	1530, 1630, 2145, 2200
WGEA (Schenectady)	11.847	25.32	1800, 2200
WGEX (Schenectady)	11.847	25.32	1200, 1400, 1700
WOOW (Wayne)	11.870	25.27	1400, 2200
WBOS (Boston)	11.870	25.27	1200
WRCA (New York)	11.893	25.22	1100, 1200
WRUS (Boston)	15.130	19.83	1400, 1700, 1800, 1900
WOOC (Wayne)	15.190	19.75	1400, 2200
WBOS (Boston)	15.210	19.72	2200
WLWK (Cincinnati)	15.250	19.67	1745, 1900, 2200, 2300
WCBX (Brentwood)	15.270	19.65	1530, 1630, 2145, 2200
WGEO (Schenectady)	15.330	19.57	1745, 1900, 2200
WRUW (Boston)	17.750	16.90	1700, 1800
WLWO (Cincinnati)	17.800	16.85	1400, 1745, 1800, 1900
WCBN (New York)	17.830	16.83	1530, 1630
Australia			
VLI4 (Sydney)	7.240	41.45	1615
VLG (Melbourne)	9.580	31.32	1615
Belgian Congo			
Leopoldville	15.167	19.78	1300
Brazil			
PRL8 (Rio de Janeiro)	11.715	25.61	2130†
China			
XGOY (Chungking)	9.635	31.14	1600, 1800, 2230
Ecuador			
HCJB (Quito)	12.455	24.09	0100, 2130
Egypt			
Cairo	7.510	39.94	1945, 2200

Country : Station	Mc/s	Metres	Daily Bulletins (BDST)
French Equatorial Africa			
FZI (Brazzaville)	11.970	25.06	2045, 2245
India			
VUD3 (Delhi)	7.290	41.15	0630, 1000, 1500, 1750
VUD4	11.790	25.45	0630
VUD3	11.870	25.27	0630, 1000, 1500
Iran			
EQB (Teheran)	6.155	48.74	2325
Mozambique			
CR7BE (Lourenco Marques)	9.830	30.52	2150
Newfoundland			
VONH (St. John's)	5.970	50.25	0015
Palestine			
Jerusalem	11.750	25.53	1715
Portugal			
CSW6 (Lisbon)	11.040	27.17	2100
Spain			
EAQ (Aranjuez)	9.860	30.43	2150†
Sweden			
SBU (Motala)	9.535	31.46	2320†
SBP	11.705	25.63	1800
Switzerland			
HER3 (Schwarzenburg)	6.345	47.28	2250
HER4	11.765	25.50	2250
Syria			
FXE (Beirut)	8.035	37.34	1835
Turkey			
TAP (Ankara)	9.465	31.70	1900
U.S.S.R.			
Moscow	7.300	41.10	0000, 1900, 2000, 2200, 2300
	7,322	40.92	1900
	8.940	33.56	1340
	9.480	31.65	0200, 0300
	9.860	30.43	1340
	10.445	28.72	0645, 1340
	11.830	25.36	1700
	11.950	25.11	0047, 0200, 0300, 1300, 1340, 1420
	12.190	24.61	1340
	12.260	24.47	1320
	15.040	19.85	0047
	15.230	19.70	0047
	15.750	19.05	1800
Vatican City			
HVJ	5.970	50.25	2115
	kc/s	**Metres**	
Algiers	1,176	255	0200, 1500, 1900, 2000, 2100, 2300
Athlone	565	531	1440†, 1945, 2310 (Sun. 2300)
Tunis	868	345.6	0000, 0100, 0200, 2000, 2100, 2200, 2300

It should be noted that the times are BDST—**two hours** ahead of GMT. † Sundays excepted.

Letters to the Editor

New Contrast Expansion Circuit
Cathode-Follower Output

Contrast Expansion

THE article by Mr. M. O. Felix (March issue) describing a contrast expansion circuit induces me to comment on some aspects of his design.

In deducing the operating condition of the circuit Mr. Felix makes the assumption that the output resistance due to the controlled valve is much less than the resistance of the potential divider formed by R1 and R2. Under these conditions, however, the voltage transfer efficiency of the circuit would be very poor, and very high input levels would be necessary. It can be shown that the equation of operation of this circuit is:—

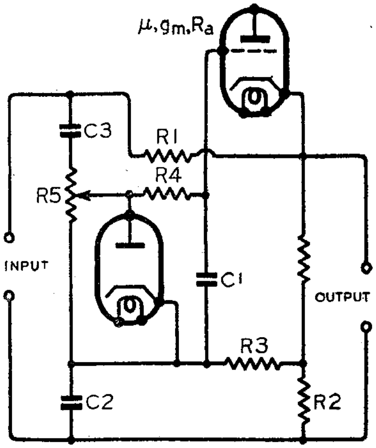
$$\frac{\text{Output}}{\text{Input}} = \frac{R2}{R1 + R2 + \dfrac{R1 \, . \, R2(1+\mu)}{Ra}}$$

The circuit by which Mr. Felix obtains the control voltage for the variable-gain valve is open to criticism. When the slider of R5 in circuit (a) in the accompanying diagram is at its upper end the input to the whole circuit will be shunted by the control rectifier, with consequent severe distortion of the signal.

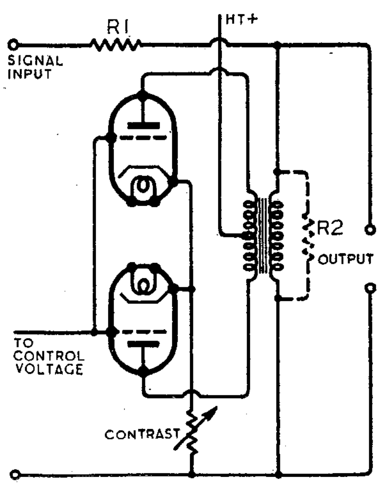
The author states that, by the use of a diode shunting R4, asymmetrical time-constants for charge and discharge of 0.02 and 2 seconds can be obtained. The time of charge of C1, however, will depend on the total series impedance of the charging circuit, which will include C2, C3, the part of R5 above the slider, the diode conduction resistance and the impedance of the circuit feeding the unit. This time is thus greatly dependent upon the setting of R5 and is unlikely to be as low as 0.02 second. The charges acquired by C2 and C3 detract from the available control voltage and may interfere with the operation of the circuit.

To achieve very rapid charging of C1 considerable power at low impedance is required, and as this is unlikely to be available at the input a separate control amplifier is desirable. This is an added complication, but gives increased available control voltage and freedom from input shunting.

When using asymmetrical delays the rapid rise in gain—in this case rise in output resistance—is accompanied by a correspondingly rapid rise or fall in the anode current of the controlled valve, and this causes a pulse to appear in the output, with unpleasant effects. This fault is inherent in a stage



(a)



(b)

Contrast expansion circuits. (a) due to M. O. Felix and (b) a modification of the circuit originally suggested by D. T. N. Williamson.

Letters to the Editor—

whose anode current changes with change of slope, and it can only be obviated by the use of a constant-current amplifier (*Wireless Engineer*, January, 1944) or a balanced or push-pull system.

The inherently low output resistance of the cathode follower necessitates a potential divider R1, R2 of low value which is a considerable disadvantage, as the preceding stage must be of very low output resistance—preferably not greater than one-tenth of R1. This may be overcome by the use of an impedance-matching transformer of suitable ratio to give a secondary impedance of about 0.1MΩ. The circuit could then be fed from a triode with an AC resistance of about 10,000 ohms.

The use of a valve or valves as a variable impedance would seem to have some advantages over their use as a conventional variable-gain amplifier for the purpose of contrast expansion, in that the impedance can be inserted at a point of higher signal level without distortion and is adapted to "single-ended" connection, avoiding the necessity for phase-splitting devices.

The circuit of my own contrast expansion unit (September and December, 1943, issues) could be simplified somewhat by omitting the phase-splitter V1 and the bias network R17, R18, R19 and C10, and substituting for V2 and V3 a variable-impedance stage of the nature of that shown in diagram (b). The valves might possibly be combined in a double triode or triode-connected pentode. The bias supply is no longer necessary since this type of stage requires a control voltage which increases negatively to give increased "gain"; the control rectifiers would require rearrangement to give a voltage in this sense.

This is the simplest arrangement using asymmetrical delays which is likely to be satisfactory.

DAVID T. N. WILLIAMSON.
London, W.14.

Cathode Follower Output Stage

SOME of your readers in this part of the country have read C. J. Mitchell's article on a "Cathode Follower Output Stage" in your April issue with considerable interest. We are afraid, however, that the author's analysis is unsound.

After stating that in this circuit the valve is triode-connected, and that as a triode the AC2/Pen has RA=2,500 ohms, he nevertheless continues to talk of output powers of 3 or 3½ watts. Now it can be shown graphically that even if the valve had ideally linear characteristics only 1 watt of output power would be available without going into regions of positive grid volts, and with any real triode-connected valve an even smaller output will be obtained. Not even cathode-follower connection will do much to reduce the distortion if grid current flows. Here are figures for three typical valves:—

	Output as	
	Pentode	Triode
GF6	3.25 watts.	0.85 watts.
KT63	3.0 ,,	.7 ,,
KT66	7.25 ,,	2.2 ,,

These show that the output power available with triode connection is only about one-quarter that available with pentode connection.

One must conclude, therefore, that Mr. Mitchell has an efficient loudspeaker for which a maximum undistorted output power of rather less than 1 watt is sufficient. Within this limitation very good quality will, no doubt, be obtained.

E. F. GOOD.
Malvern.

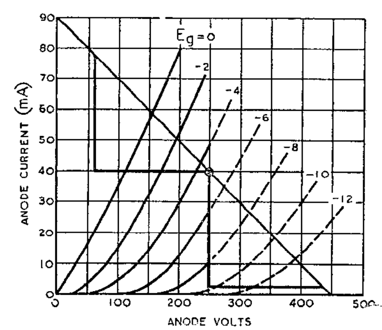
IN his article in your April issue C. J. Mitchell quotes a result which is obscured by the usual "equivalent circuit" treatment of the cathode follower.

The equivalent circuit indicates that *for a given signal input* between grid and earth, maximum power output is obtained by matching the load to the output impedance (approx. $1/g_m$), as with my other generator. This is the usual "impedance-matching" result. But unlike a normal amplifier, the maximum input (grid-to-earth) which a cathode follower can handle is *not* independent of the load, so that in order to obtain maximum power output, proper choice of both load and signal input is necessary; this leads to the result obtained by your contributor, i.e., matching to twice the anode slope resistance of the valve. There is no confusion between the two cases, as he seems to imply; the difference lies merely in the operating conditions. In the first the available signal is limited by other considerations; in the second it can be chosen for maximum output.

Richmond. J. W. HUGHES.

Author's Reply

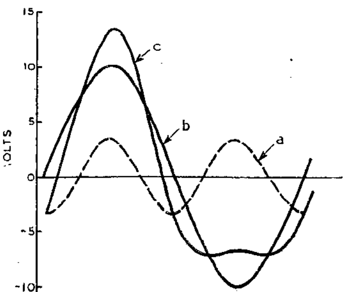
IN reply to your correspondent, E. F. Good, I agree that the claimed output of 3½ watts from a triode-connected AC2/Pen appears rather optimistic, and I must confess that I was surprised at the result myself. When the circuit was tested, the input was increased until most of the persons listening to the test programme noticed distortion; the output was then measured by observing the cathode potential fluctuations o a cathode-ray oscilloscope. The total peak-to-peak swing was found to be 375 volts (approx.), which corresponds to an output of 3½ watts. When the input was increased still more, the total peak-to-peak swing was more than 450 volts, and a considerable difference between positive and negative excursions of the cathode potential was obvious.



Characteristics of AC2/Pen when connected as a triode.

Under these conditions there is no doubt that the distortion introduced within the valve was enormous, but the large negative feed-back reduces this distortion in the same proportion as it reduces the gain of the circuit. Obviously, there are limits to the extent to which feed-back can correct distortion, but with 100 per cent. negative feed-back as much as 50 per cent. distortion can be reduced to negligible proportions. I enclose two diagrams, one showing the characteristics of the AC2/Pen, when triode connected, and the other showing the modified input waveform of a cathode follower giving an output containing 2 per cent. second harmonic distortion. It is seen from this last figure that the distortion produced within the valve is in the order of 35 per cent.

Replying to Dr. Hughes' comments, I agree with his statements that as a rule there should be no confusion between the two cases quoted, but I have met several



Waveforms in cathode follower stage (a) harmonics in output (b) difference between output and input voltages at a fundamental frequency *f*. (c) Resultant input. Input voltage (grid - to - earth) = 180 V. Output voltage = 170 V + 3.5 V second harmonic. Resultant input = 180 − (170 + 3.5 at 2*f*) = 10 + 3.5 at 2*f*.

people who labour under the belief that the load in a cathode follower should be matched to the output impedance of the circuit; one of my colleagues, in fact, suggested that by designing an output stage with a sufficiently low output impedance, it might be possible to dispense with a loudspeaker coupling transformer. My remarks concerning the theory of the cathode follower were essentially brief and were purely for the guidance of readers not acquainted with the circuit.

Ilford. C. J. MITCHELL.

Anti-interference Motors

YOUR contributor "Diallist" (May issue) is in error regarding the maximum speed of induction motors working on a 50-c/s supply.

The synchronous speed of any induction motor on any frequency is given by the expression "speed equals 60 times *f* divided by P," where P is the number of *pairs* of poles. The minimum number of poles is obviously two, which is one pair, therefore, the speed is equal to 60 times 50 divided by one, which is equal to 3,000 r.p.m. Owing to its characteristics the squirrel cage machine always has a slight amount of slip, and the actual speed would therefore be of the order of 2,950 r.p.m. With regard to the starting conditions of the induction motor, when switched on direct it takes from 4½ to 6 times full load current, depending on the design of the machine, but in the case of a toy motor, such as used for a vacuum cleaner no disturbance whatever to the domestic mains should be caused.

JOHN H. P. DE VILLIERS.
Bearsden, Dumbartonshire.

"DIALLIST" does not deal with the limitations of this type of motor.

Very large numbers of induction motors are in use where the type is applicable. The reasons that it is not even more extensively used are: (1) Separate machines are needed for AC and DC operation; an important point where the apparatus must be inexpensive or of universal application. (2) Starting torque is poor. (3) Speed is not variable over a wide range. (4) Special starting switches must be used on any but the smallest sizes. (5) Power/weight ratio is not so good as in the universal motor. (6) The ratio stalling torque/full load torque is low. Thus for applications needing high speed, high starting torque, wide speed variation or small bulk, the induction motor is inappropriate.

To obtain greater speed by means of gears is hardly practical. The gears would need to be of very high quality, pressure lubricated. Maintenance would be prohibitive. Further, as the power output of a motor depends on the speed, a geared drive would impose a very heavy load initially on a motor of poor starting characteristics.

The commutator motor can be made practically non-radiating by wiring it so that the field is electrically on both sides of the armature. The circuit is: one end of each field coil to a brush, other end of each field coil to a mains lead. The coils then act as effective chokes at the armature frequency and that reduces radiation. Condensers can be added if needed. Earth the frame and keep all condenser leads short.

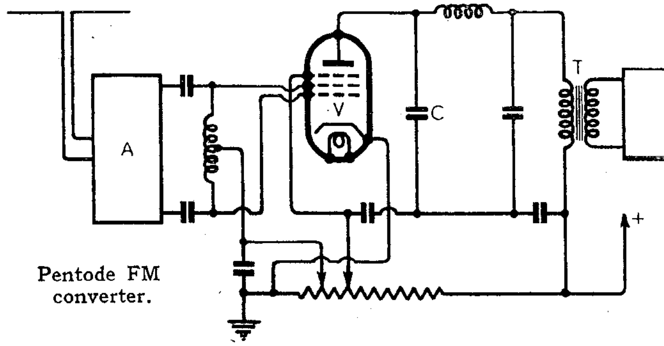
H. H. JONES.
Stourbridge, Worcs.

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

FM RECEIVERS

FREQUENCY-MODULATED signals are first passed through the initial stages A of a normal superheterodyne receiver, and are then fed in push-pull to the two inner grids of a pentode valve V, the third grid of which is biased to a slightly higher level than the other two. The result is that current through the valve is cut off, except at those times when the FM wave passes through zero. This occurs momentarily twice in each cycle, the valve V then operating to discharge a shunt condenser C, which is permanently connected to a positive source of voltage through the input transformer T of the loudspeaker.



Pentode FM converter.

The rate of condenser discharge thus varies with the original modulation frequency, and the corresponding charging current into the condenser will actuate the loudspeaker. For satisfactory reproduction it is necessary (a) that the valve V should be biased to ensure that its conducting periods are shorter than the time-constant of the condenser C; and (b) that the time-constant of the condenser charging circuits is greater than the longest period between consecutive discharges through the valve.

The pentode valve can be replaced either by a multivibrator or by a blocking oscillator, provided the time-constants of these devices are adjusted as described above.

Marconi's Wireless Telegraph Co., Ltd. (assignees of C. W. Hansell). Convention date (U.S.A.) June 17th, 1941. *No.* 556724.

TELEVISION SCANNING

BECAUSE of the high self-inductance of the magnetic deflecting coils and of the transformer coupling them to the saw-toothed oscillator, resonance conditions are liable to occur particularly during the fly-back period of each scanning cycle, and so give rise to undesirable oscillations.

To remedy this state of affairs a hard valve is connected between the chassis or earth and the scanning coils and transformer, including the casual capacities which tend to resonate. The valve is normally biased beyond "cut-off," so that it cannot distort the scanning stroke, but is automatically unblocked during each fly-back stroke. Any parasitic oscillations produced in this interval are thus absorbed or shunted to ground.

Standard Telephones and Cables, Ltd., P. K. Chatterjea and D. M. Ambrose. Application date July 24th, 1942. *No.* 558927.

AERIALS

A SHORT-WAVE aerial with a broad band characteristic consists of two bow-shaped radiators which are arranged to form a loop with one end left open, the other end being "closed" through a coupling condenser. The two opposite ends are joined by two lateral wires, forming a transmission line to the centre of which the main feeders are connected.

A certain asymmetry is introduced by the insertion of a loading condenser nearer to the "open" end of each of the bow-shaped radiators. In addition, the transmission line wires are "crossed" between the centre feed-point and the same open end. The aerial impedance is thus made to appear resistive and capacitive when viewed from the main feeder in the direction of the closed end, whilst it is resistive and inductive towards the open end.

As the signal frequencies vary, the reactances alter in opposite directions, thus maintaining the effective impedance resistance over a comparatively wide operating band.

Standard Telephones and Cables, Ltd. (Assignees of A. Alford). Convention date (U.S.A.) April 12th, 1941. *No.* 557942.

CONTROLLING SIGNAL STRENGTH

A THERMALLY sensitive resistance is connected in series with a receiving aerial to serve as a volume control. The resistance device, known as a "Thermistor," may be designed to have either a positive or negative temperature coefficient. It is conveniently mounted inside a glass tube, with or without a separate heating filament.

In one arrangement, the "Thermistor" is shunted across the primary winding of the aerial coupling transformer and thus damps the signal input to an extent which depends upon its effective resistance, this in turn being controlled by the prevailing temperature of the heating filament. The latter may be connected to the LT supply through a variable resistance to give manual control, or it may be coupled to an existing source of AVC.

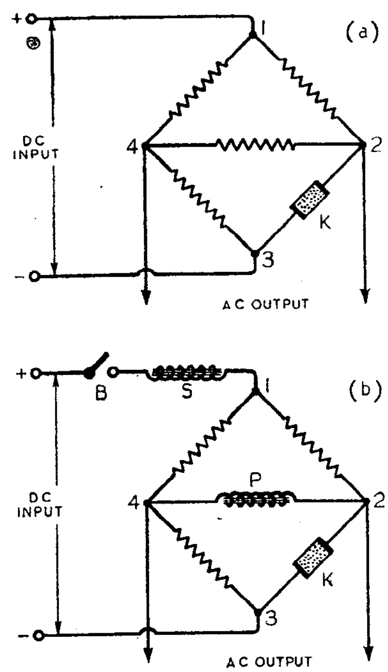
The "Thermistor" also serves to safeguard a highly sensitive set from the effect of too-powerful signals.

Standard Telephones and Cables, Ltd., C. T. Scully and L. W. Houghton. Application date June 5th, 1942. *No.* 557864.

AC GENERATORS

SYNTHETIC substances are known which show a marked falling off in resistance as the voltage applied to them is increased. This characteristic is applied to generate an alternating or oscillatory current from a DC source, without the use of electron valves or mechanically moving parts.

The principle of the invention is illustrated in diagram (a), which shows a bridge circuit with a "negative resistance" element K, of the kind mentioned, in one of the arms. One diagonal of the bridge is fed from a DC source, the adjustment being such that the potential of the point 2 is higher than that of the point 4, so that



Negative resistance AC generator.

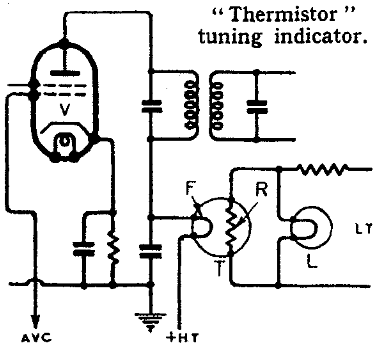
a current flows through 2, 4. Any increase in the DC input voltage will now cause the resistance of K to fall, and so reverse the direction of the current through the line 2, 4.

Diagram (b) shows a circuit arrangement in which the diagonal 2, 4 includes the primary winding P of a transformer, the secondary S being in the DC supply line. When the switch B is closed, the first surge through P induces a back EMF across S which, as it reaches K, causes the primary current through P to reverse, as explained above. This in turn reduces the voltage across K and so restores the original current through P. The cycle will be constantly repeated, until the switch B is opened.

R. J. Stevens. Application date August 13th, 1942. No. 557342.

VISUAL TUNING INDICATORS

"THERMISTOR" is the trade name of a mixture of certain metallic oxides which exhibits a marked change in electric resistance with variation of temperature. The control heat may be due to current passing directly through the mixture, or the latter may be indirectly heated by a separate filament.



"Thermistor" tuning indicator.

According to the invention a "Thermistor" is used to increase the sensitivity of visual tuning-indicators, and, in particular, to allow an ordinary small incandescent lamp to be used.

As shown, the valve V is the last IF amplifier of the set, and its anode current is passed through the filament of a "Thermistor" tube T, thereby indirectly heating the sensitive resistance R. An incandescent lamp L is inserted, in parallel with the device T, across the usual LT supply.

When the set is correctly tuned the anode current falls to a minimum, so that the heating effect on the element R is low and its resistance is high. The lamp L then takes maximum current and glows brightly. At any "off-tune" setting, the anode current rises, the resistance of R drops, and the indicator lamp is dimmed. Alternatively, the lamp may be connected in series with the sensitive resistance R, the tuning point then being indicated by minimum instead of maximum brilliance.

Standard Telephones and Cables, Ltd., and D. M. Ambrose. Application date June 5th, 1942. No. 557862.

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.

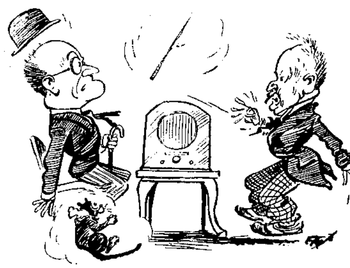
UNBIASED

Radiomancy

By

FREE GRID

RADIO has been pressed into the service of men for all sorts of purposes, ranging from its original function of a message carrier to that of a healer of the ills to which the flesh is heir. It has even been used for divining the presence of water; it was pointed out some time ago that the Rhabdomancer's rod, or whatever he calls it, is in reality nothing but a dipole and that USW is in some manner or another at the bottom of the whole business. It will, in fact, probably be remembered that I myself conducted certain experiments in this matter and got very misleading results owing to the dowsing rod leaping into the air when brought near a loudspeaker, owing to the wetness of some of the B.B.C. programmes.



Radio-rhabdomancy.

I see, however, that according to a well-known Sunday journal the latest use to which radio has been put is prophesying the future and so rivalling astrology. "According to a well-known radiologist" (*sic*), says this journal, "the war, or at any rate the German part of it, will end on Friday, October 27th." Nor is this the final wonder of radio science. According to the same journal, I learn that, since the invention of radiolocation, ships are being navigated across the ocean by means of the "Radio Sextant," which takes the place of the old-fashioned sextant in which you looked through a sort of telescope and measured the angle twixt sun and horizon.

The modern radio sextant contains a USW transmitter which shoots out a string of waves at the sun, which hit it and bounces back to you. The beauty of the idea, of course, is that it doesn't matter whether the sun is obscured by cloud or mist provided that you have some rough idea of the part of the heavens at which to aim.

I must confess that this radio sextant idea sounds delightfully simple, and even the fact that it takes about eight minutes for the waves to get to the sun and another eight minutes to get back doesn't entirely invalidate the idea, as the error due to the quarter-of-an-hour lag is constant and can be allowed for. Nevertheless, there are still one or two snags about the idea which occur to my unromantic mind. The first snag, of course, is our old friend spatial attenuation, and I am wondering how many kilowatts the sextant has to have fed to it. Then, of course, there is the question of getting through the various ionospheric layers. I wrote to the technical correspondent of the newspaper concerned, asking for a little light on these mysteries, but he has taken refuge in the Official Secrets Act and the various Defence Regulations, and I can't get anything out of him.

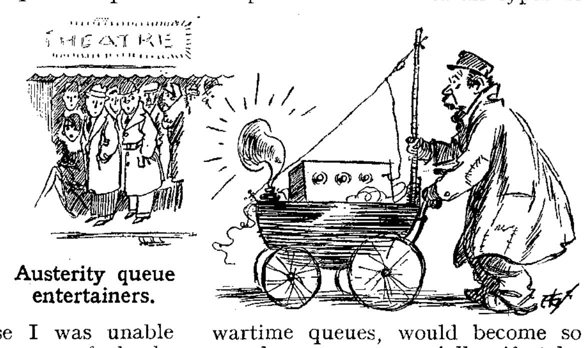
Radio to the Rescue

THE instinct to join a queue immediately we see one has become so strong in us that we are apt to tack ourselves on to one automatically, sometimes with extremely embarrassing results. In my own case I have not infrequently fallen in behind a queue of waiting females and wasted much valuable time before being made aware by the titters of my fellow queuers-up that it was no place for a member of my sex, with the result that I have crept shamefacedly away without even finding out what the queue was really for.

In pre-war days it was a frequent habit of mine to take my place in a theatre queue, not because I was unable to afford the luxury of booking a more expensive seat, but for the very simple reason that I almost invariably derived far more pleasure and æsthetic satisfaction from the efforts of the queue entertainers than I did from the far less gifted performers inside the theatre. In fact, I made it an invariable rule to leave the queue as soon as it started to enter the theatre, thereby exciting on more than one occasion the suspicions of the police, who made it their business to enquire of the remainder of the queue whether anybody had lost his wallet or other valuables.

Nowadays, owing to the drastic effects of the military and industrial call-up, more often than not the queue entertainment is provided by a seedy-looking individual operating a dilapidated gramophone or wireless receiver carried in a still more dilapidated pram, notwithstanding any infringement that might be of the rights and privileges of the B.B.C. and the Performing Right Society. But the P.M.G. presumably has no objection to the practice, now that the ban on wireless in road vehicles has been lifted. In any case, is not a pram a pavement vehicle?

It was while reflecting on these matters the other evening after a damp and dismal two hours in a queue that the idea came to me of rationalising and centralising the best remaining talent among the queue entertainers and distributing it *via* the ether. Unfortunately, the B.B.C. refused to be interested in the idea, even when I pointed out that it was a golden opportunity for them to interlard the turns liberally with their own moral uplift stuff, since, of course, the queuers-up would be utterly at their mercy and compelled to listen unless they thought it worth while to sacrifice their places in the queue. That, I was forced to admit, a great many of them might do. My idea, if adopted in the case of all types of wartime queues, would become so popular, more especially if television were added after the armistice, that it could become an end in itself, queues forming for the sole purpose of enjoying the entertainment. Seats and other amenities would eventually have to be provided, and an entirely new industry would be born, so bringing much new grist to the Chancellor of the Exchequer's mill.



Austerity queue entertainers.