EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorial Views.

Valve Capacities.

WE are sure that our readers will be deeply interested in the article by Messrs. Hartshorn & Jones, giving the results of tests at the N.P.L. on the capacities of valves (p. 263), not only because (in conjunction with Mr. Chapple's article last month and Mr. White's letter in our correspondence columns) it gives valuable information on a point as to which published data are scanty, but also because of the very interesting account of the method of measuring small capacities, and the many points to be allowed for in finding a true capacity independent of earth effects.

This article has great educative value for all experimenters in showing how tricky it is to make accurate measurements. Whereas quantitative work of an approximate nature is easy and extraordinarily fascinating, accurate work—just as fascinating—is most difficult. When new types of measurement are being done, it really requires a special sort of genius which smells out hitherto unguessed sources of error.

With regard to the particular subject of this article, we should like to emphasise very strongly the point made by Mr. Hartshorn, that the capacity of a valve as measured in this way is by no means the same thing as its apparent capacity when working. This point was strongly brought out in the paper by Miller referred to by Mr. Hartshorn, and we have long been anxious to apply Miller's equations to British valves under ordinary working conditions. Now that we have definite data to work on (for the effective capacity is a function of the measured capacity) we already have this in hand, and we hope to have the results available in the near future.

Readers' Suggestions.

From time to time we receive from readers suggestions as to articles which they would like to see in E.W. & W.E.—incidentally, we should like to say that we welcome such suggestions, and would like even more of them. Sometimes the suggestions are such that we can accept them or refuse them without difficulty. Often, however, we find it hard to decide whether such articles would really fill a need or not.

We have in mind two recent suggestions. One of these is for a series of articles dealing in a simple way with circuit calculations, beginning right at the beginning. Such articles, if they are to be easy to read (and yet give accurate information) are difficult to write ; but we shall be glad to have them written if they are called for.

Another suggestion is for articles in the setting up and use of a " wireless laboratory," *i.e.*, first, what instruments *must* be bought ; how to calibrate home made standards from these, and how, finally, to conduct measurement work.

We shall be glad to hear from any readers who have decided views for or against the inclusion of such articles.

International Language.

Among our correspondence in this issue is a letter on the subject of international language. The writer of this letter is a believer in a language called "Ido," and a considerable portion of his letter was devoted to pointing out in detail some matters in which he claims that Ido is a better language than Esperanto.

We have taken the rather unusual step of cutting out this part of his letter, and we feel that some explanation of this is due to our readers.

The point is that E.W. & W.E. is not a philological paper ; it is a wireless paper, and the study of an international language has been recommended for wireless purposes. We chose Esperanto from among the various international languages because the largest national wireless amateur organisation (the A.R.R.L. of America) had already done so, and because the forthcoming international wireless congress at Paris is doing so.

When the A.R.R.L. made their decision, they refused to pronounce on the comparative merits of various languages. They said, very sensibly, that this was not their job. They decided on Esperanto because it is already the most used (we believe we are safe in saying that at a conservative estimate there are about ten times as many users of Esperanto as of all others), and therefore the most useful, and we agree with their point of view.

We have seen in other wireless papers some very bitter discussions of the comparative merits of this or that language, and we believe that our readers will support us in saying that such discussions shall have no place in the columns of E.W. & W.E. In fairness, however, we are prepared to insert one reply from an Esperantist to the letter in this issue.

Calibration.

As will be seen from p. 276, the E.W. & W.E. calibration department is now again open, but under new conditions.

We trust that our readers will approve of these conditions, which are in essence that (apart from present subscribers, who are specially dealt with) the service is now open to all readers at a fee instead of gratis and confined to subscribers. There are many reasons why the restriction of the service to subscribers was unsatisfactory. It was originally adopted mainly to discourage a large number of casual readers who, when the department was first opened, sent in large quantities of apparatus of indifferent quality.

To be perfectly frank, the fees now to be charged are designed largely with this same object. We are prepared, within limits, to calibrate anything, but the calibration of badly made components is largely wasted labour, and we feel that the payment of a fee will help to bring home to readers that if it is worth while having something calibrated it is worth while making a sound job of its construction.

From the inquiries received while the department was closed, we suspect that there may be a rush of apparatus now that it is re-opened. In case this should occasion any delay in the work, we should like to state that instruments are taken in rotation as they arrive, and that it is useless to offer extra payment in the attempt to influence our testing staff to make exceptions. We should have thought it hardly necessary to make such a statement were it not for actual experience during the last few months.

The Arrangement of Wireless Books and Information.

Part V: R400 and R500. [R025·4

These two sections are not divided into such detail as the previous ones, which has enabled us to find room for both of them in one issue.

R400 Systems of Working.

This section is devoted to description of the essential features of wireless communication systems *as systems*, as apart from the theory or practice of instruments used. There may at first be some difficulty in allotting some matter correctly: the only method is to look into the point of view of the article or book.

Just as an example, take the subject of self-heterodyne working. Matter dealing with the generation of local oscillations by a valve, as such, goes in R133; the combination of detection and self-oscillation in R134·7; and the design of receivers of this type in R343·4. But a description of the action of two H.F. currents in producing beats is of the essence of the system itself, and should be placed in R426. Remember that descriptions of stations (except when given simply to illustrate a system), are dealt with under R600. We shall insert cross-references to the other sections.

In the original B.S. Extension there are two headings,

R402 High power,
R401 Short wave,

which, as in other cases already mentioned, might clash with the form division. We therefore suggest that they be not used. Where it is necessary to make a distinction between stations of varying power and wave, we suggest a special subdivision of 012, which reference to the form division will show to be "classification and special branches," as follows :—

R401·2 Systems: classification and special branches.
- ·21 Special points in and systems for extra high power work.
- ·22 Simple systems for low power.
- ·23 Special arrangements, etc., for extra long waves.
- ·24 Special arrangements, etc., for extra short waves.

The figures 0121 to 0124 will be applicable to any sub-division of R400, *e.g.*, R412·0123, long-wave telephony.

R410 Modulated-wave systems.

R411 Spark systems.
- R411·2 Quenched spark.
- ·4 Rotary gaps, synchronous.
- ·6 Rotary gaps, asynchronous.
- ·9 Other spark systems.

	R412	Telephony systems. (See also R135 and R345.)
	R413	L.F. modulated systems (*i.e.*, tonic train, etc.)
	R414	H.F. modulated systems. (See also R460, multiplex, etc.; also secret systems, R435, which often depend on H.F. modulation.)

R420 Continuous-wave systems.

R421		H.F. alternators. (See also R154 and R354.)
	*R421·1	Fessenden and Alexanderson direct H.F. alternators.
	* ·2	Goldschmidt alternators.
	* ·3	Separate frequency-raiser systems. (See also R357.)
R422		Arc systems (See also R153 and R353.)
	R422·1	Spacing waves.
R423		Valve systems. This entry must be used with care. Most valve matters are better dealt with under R130 or R340.
R424		Timed spark systems.
R425		Impulse excitation.
R426		Beat reception. (See also R134·7 and R343·5.)
R427		Tikkers, tone wheels, etc.
R429		Other methods of receiving C.W.

R430 Interference elimination. (See also R162.)

R431		Eliminating atmospherics. (For data on atmospherics, see R114.)
R432		Avoiding interference from other stations.
	*R432·1	Rejectors, wave-traps, etc.
R435		Secret systems.

R440 Remote control of wireless stations.

R450 Linkage, relaying, etc.

R460 Duplex and multiplex systems.

R470 " Wired wireless."

R480 Recording and relay-operating systems.

R485 High-speed working.

R487 Printing systems.

R490 Other systems.

R492 Buzzer sets.

R493 The Fullerphone.

R495 " Tree Telegraphy."

R500 Applications and Uses of Wireless.

This important section will, like R400, contain matter treating of subjects which have often been dealt with in R100 or R300; again, like R400, the criterion is the *point of view* or *object* with which the matter was written, for which its preservation is desired.

R510 Navigation.

Do not confuse this with " ship traffic," which is essentially a commercial service. It is curious that in the B.S. Extension there appears to be no special subsection for ship traffic as distinct from general commercial traffic. We take it, however, that it is intended to deal with it under 531, and have done so. R510, therefore, will be devoted to navigation work, apart from broadcast reports on navigation subjects, which come under R550.

* These subdivisions are proposed by us as a tentative further extension.

R511		Distress signals.
R512		Radio beacons, *i.e.*, land stations for ship D.F. work.
R513		Fog signalling by wireless.
R514		Radio compass, *i.e.*, ship stations for D.F. work.
R515		Submarine wireless.
R516		Life-saving service.

R520 Aircraft wireless.

R521		Aircraft reception.
	R521·1	D.F. work.
	·3	Magneto interference.
	·5	Receiver helmets and fittings.
R522		Aircraft transmitters.
	R522·3	Aircraft microphones.
R523		Reception from aircraft.
R524		Transmitting to aircraft.
	*R524·1	Technical points.
	·3	Local landing signals.
	* ·5	Aircraft navigation work generally. (Divide like R510 if needed, *e.g.*, R524·51, Aircraft distress signals.)
R525		Aircraft aerials.

R530 Commercial and allied services.

R531		Traffic. Note that the actual *handling* of traffic will mostly be dealt with either under technical headings or under R620, station operation and management. But there are many points to do with wireless services which are not exactly station management, and these are grouped here.
	R531·1	Codes and ciphers (for abbreviation and secrecy: not the Morse code, which is dealt with under Alphabets.).
	·15	Speed of code reception.
	·2	Station call letters.
	·3	Abbreviations.
	* ·31	Official service abbreviations ("Q" calls).
	* ·36	Service abbreviations.
	·4	Alphabets.
	* ·41	International Morse.
	* ·42	American Morse.
	* ·43	Special forms of Morse (Squier codes, etc.).
	* ·49	Other alphabets.
	·5	Coupling to land lines.
	·6	Coupling to cables.
	·7	Rates and charges.
	* ·8	Special services (reply paid, delayed service, letter services, etc.).
R532		Press service (over commercial systems: special installations owned by the Press are under R540).
R533		Railway service work. (See note to R532.)
R534		Agricultural service. (This, we believe, refers to American Government services.)
R535		Forestry service. (See note to R534.)
R536		Wireless in mines.
R537		Wireless for long-distance power supplies.

R540 Private installations.

This covers both experimental (and broadcast reception) work and also private business installations, *e.g.*, for communication between separate branches of business firms (forbidden in the United Kingdom).

* These subdivisions are proposed by us as a tentative further extension.

R541 Business installations, for inter-branch working. Installations for the reception of *broadcast* matter for business purposes (*e.g.*, market reports) come under R542.
R542 Broadcast reception.
R545 Amateur wireless work.
*R545·1 Transmission.
* ·6 Reception.
* ·9 Special experimental work.

R550 Broadcast transmissions.

This is to be interpreted in the wide sense of the word, and includes all matter intended for reception by anyone, as distinct from messages to a specific addressee.

R551 Time signals.
R551·1 Longitude determination.
*R552 U R S I and similar signals for the measurement of attenuation, etc.
R553 Meteorological signals.
*R554 Signals for mariners: sea weather reports, gale warnings, etc.
R555 Calibration waves.
R556 Market reports.
*R557 "Entertainment" broadcasting.

This must obviously be the subject of a considerable extension at an early date. It is, however, too large a matter to undertake at the moment. For the present, we suggest the use of the form division.

R560 War service wireless.

R561 Military.
R565 Naval.
*R568 Air service.

R570 Distant control by wireless.

R580 Sundry applications:—

R581 Wireless power transmission.
R582 Transmission of pictures, etc.
R583 Radio-therapy (*i.e.*, medical applications).
R584 High-frequency furnaces.
R585 Wireless toys.
*R586 Television.

R590 National Developments.

This is rather hard to distinguish from history. It is probably best to keep the history of detail subjects (*e.g.*, valves, or aviation work) under its own heading, with the form divisions R090·1 to R090·9, while keeping the general history of development by countries in this section. It will be noted that the territorial division is the same in both cases.

R591 Wireless in the U.S.A.
R592 British Empire.
592·2 United Kingdom.
R593 France.
R594 Germany.
R595 Italy, Spain, Portugal.
R596 Norway, Sweden, Denmark.
R597 Asia, Africa.
R598 S. America.
R599 Elsewhere.

*** These subdivisions are proposed by us as a tentative further extension.**

The Inter-Electrode Capacities of Thermionic Valves. [R220 : R333 : R382·8

By L. Hartshorn, A.R.C.S., D.I.C., B.Sc., and
T. I. Jones, A.R.C.S., D.I.C., B.Sc.

The Authors draw attention in this paper to the importance, in some instances, of the frequently-ignored capacities between the grid and filament of valves. The method of measurement is particularly interesting.

The Importance of Valve Capacities.

THE capacities between the electrodes of a valve are known to be very small (generally less than $10\mu\mu F$), and thus for many purposes they may be neglected, but cases do arise in which these small capacities form the greater part of the capacity in a circuit, and thus a knowledge of their magnitude and power factor becomes of the greatest importance. Consider, for example, the input circuit of an amplifier. Here the capacity between the filament and grid of the valve forms a large part of the capacity in the circuit, and although this capacity is very small, it constitutes a load in the input circuit. The work of Miller, which will be referred to later, has shown that as a consequence of the capacity between the grid and anode, this capacity load in the input circuit may be considerably magnified, and further, that the effective power factor of this capacity load may be quite considerable, depending on the load on the anode circuit and probably to a still greater extent on dielectric losses in the valve. In such cases there will be a comparatively large loss of power in the input circuit and consequently a serious loss in efficiency of the amplifier.

Perhaps the most obvious case in which these small inter-electrode capacities play a leading part is that of circuits for the generation and reception of very high frequency radiation.

From an historical standpoint, it will be interesting to recall that Mr. W. C. White* in 1916 published an account of a method by which he succeeded in reaching a frequency of 50 million cycles per second. The attainment was of theoretical interest only since the amount of power that was rendered available was very limited and only served the lecture room purpose of demonstrating stationary electric waves of about six metres in length. For tuning the experimenter depended entirely upon the inter-electrode capacity of filament to grid and the inductance produced merely by the disposition of the leads in his circuit. Thus the inter-electrode capacity, on the one hand, and the least possible length of connecting wire and the area enclosed by it marked the limits of the frequency which he could hope to attain. For power purposes he was further handicapped by the inadequacy of the coupling between the filament-grid and the grid-anode circuits, as he had to rely entirely upon the capacity of anode to grid.

Work of a more applied nature was undertaken by Franklin,* Marconi,† and still later by Dunmore and Engel ‡ of the Bureau of Standards. The work of the latter is particularly interesting as they give full working details of their circuits and appliances in their experiments with a wave-length of ten metres. Their generating arrangement was a Hartley circuit and consisted of a single turn 17 cm. (7 inches) in diameter for plate coupling and a similar coil for grid coupling. "With these coils the internal capacities between the elements of the valve formed the oscillatory circuit and determined the upper limit of frequency." At the receiving end, the coupling between the antenna and the receiving set consisted merely of two coils 1 foot in diameter in either circuit and

* White, *General Electric Review*, Vol. 19, 771, 1916.

* Franklin, *Wireless World and Radio Review*, Vol. 10, 219, 1922.

† Marconi, *Proc. Inst. Radio Engineers*, Vol. 10, 215, 1922.

‡ Dunmore and Engel, *Bureau of Standards*, Paper No. 469, 1923.

could not be increased without, at the same time, rendering the capacity in the receiving circuit impossibly small to obtain or to vary for tuning purposes. The valve used for transmission was a 50-watt tube.

It is instructive to obtain a rough estimate of the amount of capacity permissible in the receiving circuit referred to. The coils mentioned would possess an inductance of the order of 1 microhenry. A wavelength of 10 metres represents a frequency

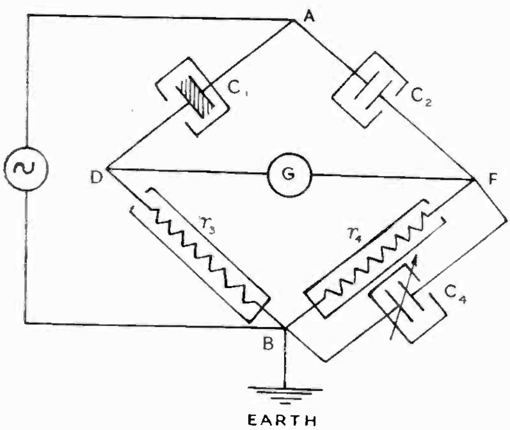

Fig. 1.

of 30 million cycles per second. From the relation $LC\omega^2=1$ we find that

$$C(\mu\mu F) = \frac{10^{12}\times 10^{6}}{4\pi^2\times 900\times 10^{12}} = 28.$$

It will be seen on perusing the results given later in this paper that a frequency of about twice the value quoted above would be the utmost limit permitted in such a case if the ordinary type of valve were employed.

Other cases frequently occur in the course of general wireless experimental work in which an idea of the capacities between the electrodes of valves is of great importance. As there seemed to be no published information on this subject we decided to undertake a series of measurements on typical valves in order to obtain an idea of what the capacities are in any particular case, and what variation is likely to exist between valves of different types, between different samples of the same type and make, and between those of the same type, but different makes.

Method of Measurement.

(a) The Bridge.

Before proceeding to give numerical examples, we shall describe very briefly the method employed. The essence of the method has already been published by one of us,* so that here we shall confine ourselves chiefly to the practical side. It is an adaptation of a more general form of alternating current bridge first described by Schering,† and subsequently used largely at the Physikalische Reichsanstalt. This is a particularly convenient bridge for Capacity and Power Factor measurements where good standard variable air condensers are available for comparative purposes. This arrangement is indicated in Fig. 1. Owing to the high impedance of the bridge the voltage can be pushed upwards until the necessary sensitivity is reached and is only limited by the insulation of the condensers employed. It is highly advisable to have the condensers and resistance arms screened and connected up in the bridge in the manner shown, as stray capacities of various members of the arms to earth are thereby definitely located and practically eliminated in their influence on the capacity to be measured. We make no apology for including a brief description of the Schering Bridge as we consider that it is by no means as well known in England as it deserves to be.

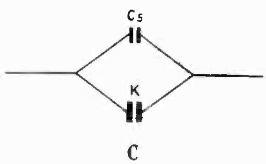

Fig. 2a.

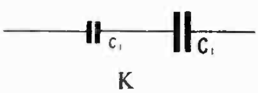

Fig. 2b.

(b) Vernier Capacity Standard.

The adaptation of this bridge for small capacity measurements depends for its efficacy upon the usual relations connecting the capacities of condensers in series and in parallel.

In parallel $C=K+c_5$

In series $K=\frac{c_1.C_1}{c_1+C_1}$

Let us suppose that C (Fig. 2a) is the capacity of one arm of the bridge to secure a balance.

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* Hartshorn, *Proc. Phys. Society*, Vol. 36, 399, 1924.

† Schering, *Zeitschr. fur Instr.*, Vol. 40, 124, 1920.

Then, if c_5 is diminished by a small amount, *e.g.*, by disconnecting one of the leads to it, K will have to be increased by the same amount to maintain a balance. If, however, K consists of two condensers c_1 and C_1 in series (Fig. 2*b*), of which $C_1=nc_1$, and the change in c_5 is taken up entirely upon the larger unit C_1, then it can be shown that the amount by which K has changed will be

$$\left(\frac{c_1}{c_1+C_1}\right)^2 \text{ or } \left(\frac{1}{n+1}\right)^2$$

of the amount by which C_1 has to be altered to compensate for it. This is only strictly true for small changes in C_1. A more accurate expression for deducing the change k in K in terms of the original C_1 and the final value C_1' is given below:—

$$k=\frac{c_1^2}{(c_1+C_1)(c_1+C_1')}(C_1-C_1')$$

By suitable choice of the value of "n" a wide range of magnification may be provided. For the purpose of these tests the authors used the following values of c_1 and C_1. c_1 consisted of a fixed mica condenser of ·001 microfarad. C_1 in addition to a mica condenser of ·01 microfarad had a standard variable air condenser of a maximum capacity of ·002 microfarad in parallel with it. Thus c_1=·001; c_1+C_1= ·013 (approx.), gave a magnification of the order of 160, permitting measurements correct to 1/100 micro-microfarad to be secured by reading off the standard condenser to the nearest micro-microfarad.

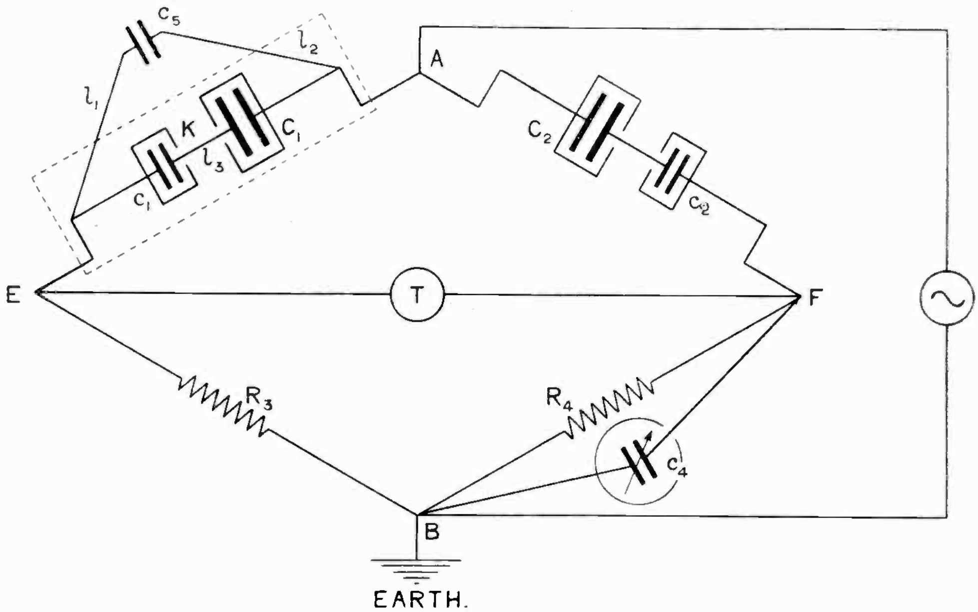


Fig. 3.

Such are the simple elements upon which the method rests. The manner in which they are utilised is indicated in Fig. 3.

(*c*) *Practical Details.*

The condenser to be tested is C_5. By means of a pair of rigid leads (l), it may be inserted in Arm No. 1 of the bridge in parallel with the combination standard K_1 made up of the two condensers c_1 and C_1. Arm No. 2 of the bridge is practically a duplicate of Arm No. 1, the idea being to make the bridge as symmetrical as possible. Arms 3 and 4 consist of non-inductive resistances each of 5 000 ohms, and in parallel with one of these is a small variable condenser (C_4) which is for the phase angle adjustment. As the value of C_4 could not be reduced to zero, it was necessary to balance its minimum capacity by means of a small fixed capacity connected across the ratio arm R_3. For this purpose a short length of flex was found very convenient, as a suitable value could be obtained merely by choosing an appropriate length. R_3, R_4 and C_4 are all enclosed in metal screens which are connected to the earthed point B of the bridge. The screens of the large condensers C_1 and C_2 are connected to the point A. Their capacities to earth are thus merely a shunt across the whole bridge, and do not affect the balance. The screens of c_1 and c_2, which are much smaller, are connected to the points E and F respectively. Their capacities to earth are shunted across the arms R_3 and R_4. They thus are balanced one against the other. These condensers must be placed as far away from the observer as possible, so that their capacities to earth are as little as possible affected by his movements. These earth capacities can, of course, be entirely eliminated (being located at the corners of the bridge) by Wagner's earthing device, but this is an additional complication. In the arrangement shown, since the impedances of the Arms 1 and 2 are enormous compared with those of 3 and 4, the points E and F are not much above earth potential, and thus the earth capacities at these points are only of comparatively small effect. The extreme fineness of adjustment referred to above would, of course, be of no advantage unless the bridge could be made correspondingly sensitive. It is comparatively easy to do this with the Schering Bridge. The voltage applied to the points A and B is simply raised until the sensitivity is sufficient. The current carried by the resistances R_3 and R_4 has to pass across the very high impedances in Arms 1 and 2 of the bridge, so that this current is always small. The voltage which can be applied is only limited by what the condensers will stand. Several hundreds of volts may be used quite safely in nearly all cases. In some cases, of course, it will not be desirable to use such high voltages for other reasons. The bridge takes very little power, and thus a very small transformer is sufficient to step up the voltage to the required amount. In practice the leads to the bridge were connected to a coil of several henries inductance, and this was brought near to the inductance coils of an oscillating valve set until the required voltage was obtained.

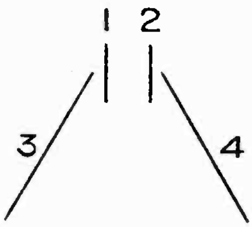


Fig. 4.

The capacities c_1 and C_1 include the capacity between the lead l_3 and the screen of the condensers. This must not be lost sight of in making the calculations. The lead should be of fine wire, and this lead capacity will be very small, and will not depend very much on the length of lead beyond 10 cm., say. The capacity between the two screens is merely added to the total capacity in Arm 1 and does not affect the ratio $(C+c)/c$.

(*d*) *Effect of the Leads.*

In Fig. 4 let 1 and 2 be the plates of the small condenser, whose capacity is to be determined and let 3 and 4 represent the leads used to connect the condenser to the bridge. This system of four conductors possesses ten capacity constants, viz., C_{1e}, C_{2e}, C_{3e}, C_{4e} the earth capacities, and C_{12}, C_{13}, C_{14}, C_{23}, C_{24}, C_{34} the mutual capacities. The quantity to be determined is C_{12}. It is to be noted that the bridge arrangement described above measures mutual capacities only. The earth capacities on the A side of Arm 1 may be regarded as a shunt across the whole bridge, having no effect on the balance, while those on the E side act as a shunt across R_3, and are balanced by adjusting C_4. Thus, in considering the capacity balance we may ignore all capacities to earth. The procedure to be adopted is as follows :—

(*a*) Connect 1 and 2 to 3 and 4 respectively, and note the bridge reading when balance is obtained. The effective capacity between the leads is now the inter-capacity of the two combined conductors 1, 3 and 2, 4—*i.e.*, of $C_{12}+C_{14}+C_{32}+C_{34}$.

(*b*) Break the connection 1—3 without disturbing the lead appreciably, connect 1 to earth, and again take the balance reading. The capacities C_{12}, C_{14} have now become earth capacities, and are thus eliminated, and the effective capacity between the leads is $C_{32}+C_{34}$.

(*c*) Again make the connection 1—3, break the connection 2—4 and earth 2. The balance reading now corresponds to a capacity between the leads of $C_{14}+C_{34}$.

(*d*) Break both the connections 1—3 and 2—4 and earth both 1 and 2. All the capacities except C_{34} now become earth capacities, and thus the effective capacity between the leads is now C_{34}.

Taking the differences of the readings (*a*)—(*d*), (*b*)—(*d*), (*c*)—(*d*) we obtain the values of $C_{12}+C_{14}+C_{23}$, C_{23}, and C_{14} respectively, and thus C_{12} may be determined. The positions of the conductors must not be disturbed in taking any of the readings or some of the capacities may be changed. For example, the capacity between the leads C_{32} is influenced by the presence of the plates 1 and 2, and thus the leads reading must be taken with 1 and 2 in position.

As a check of the method employed a case was investigated in which the capacity was amenable to calculation and the remarkable degree of agreement is evidenced by the results quoted in the proceedings of the Physical Society of London (*loc cit*).

(*e*) *Application to a Valve.*

The three electrodes of a valve form a system of conductors possessing three mutual capacities: C_{ga}, C_{fg}, C_{fa}. Each of these was measured separately in the precise manner described above. The electrode not actually under observation must be earthed during a series of measurements, *e.g.*, while taking the four observations necessary to determine C_{fa} the grid must be earthed. If this is done, our method measures the true mutual capacity C_{fa}, which is a measure of the number of lines of force for a given voltage passing from filament to anode through the spacings of the grid. If the grid is not earthed, and the method of measurement does not allow the elimination of earth capacities, then what is measured approximates to the total capacity between filament and anode C_{fa}', where

$$C_{fa}' = \frac{C_{fg}C_{ga}}{C_{fg}+C_{ga}} + C_{fa}$$

This is a measure of the total lines of force passing from filament to anode, including those which pass from filament to grid, and then from grid to anode. (These are represented by the first term in the above equation.) In practise C_{fa} is the important constant, and this is determined directly by the above method.

Specimen Test.

In the first instance we shall give a specimen set of results showing the magnitude of the extraneous inter-capacities to be eliminated in their relation to those that are to be measured. Coupled with the fixed (values $c_1 = 1\,025$ micro-microfarads and $c_1 + C_1 = 11\,132$ micro-microfarads) we have the readings of the variable air condenser. These readings are given below in the table, where the cases (*a*), (*b*), (*c*) and (*d*) have the significance attached to them above.

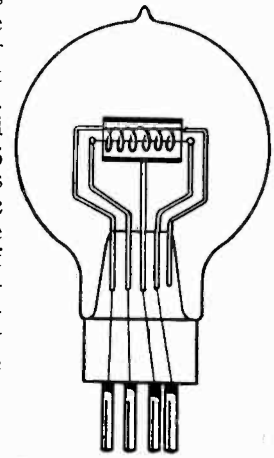


Fig. 5. *"R" Type Valve.*

Valve A. Holder X. (*See Fig. 7, p. 269.*)

Case	Variable Condenser Readings $\mu\mu$F.	Differences.	Capacity differences.	Inter-electrode capacity. $\mu\mu$F.
	Filament to Grid.	*(Anode earthed.)*		
(*a*)	1 017	908	6·02	5·79
(*b*)	1 899	26	0·16	
(*c*)	1 913	12	0·07	
(*d*)	1 925			
	Filament to Anode.	*(Grid earthed.)*		
(*a*)	1 184	740	4·83	4·60
(*b*)	1 189	27	0·17	
(*c*)	1 914	10	0·06	
(*d*)	1 924			
	Anode to Grid.	*(Filament earthed.)*		
(*a*)	1 483	445	2·77	2·66
(*b*)	1 920	8	0·05	
(*c*)	1 918	10	0·06	
(*d*)	1 928			

Results.

(a) *R Valves and their Holders.*

We now give the values for three R valves of the same make taken at random. The variations in capacity from one valve to another are quite considerable when allowance is made for the holder.

Valve.	Holder.	Capacity in $\mu\mu$F.		
		C_{fg}	C_{fa}	C_{ga}
A	X	5·79	4·60	2·66
B	X	6·11	4·92	3·16
C	Y	7·70	5·99	3·67

These results may be taken as typical of an R type valve. It is instructive to compare them with the V type valve.

Type.	Capacity in $\mu\mu$F.		
	C_{fg}	C_{fa}	C_{ga}
R	5·79	4·60	2·66
V	0·95	0·98	1·64

The actual size and disposition of the active part of the electrodes is roughly the same in the two cases, but the capacities in the R type are several times greater than for the V type. This, of course, means that the greater part of the capacity in the R type valve lies in the leads in the pinch of

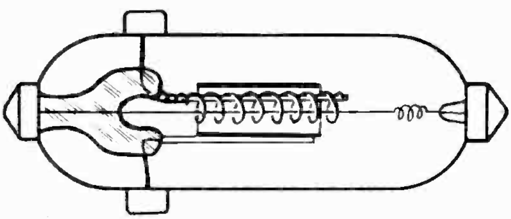


Fig. 6. *V-24 Valve.*

the valve. Again, in the V type valve, the capacities to the filament are the smallest, which is to be expected since the filament is the smallest electrode ; but in the R type, they are by far the largest, which is due to the fact that the filament has two leads in the pinch of the R valve and each of these had considerable capacity to the other leads.

In the previous table it will be observed that the third case differs from the other two as regards valve-holder. This led to our investigating the contribution of the two valve-holders separately. Valve-holder "Y" was of the usual commercial embedded type, whereas "X" had its sockets supported on good ebonite and surrounded by air. The lower values of A and B are due to this difference as will be made clear by a comparison of the figures for the holders themselves.

Holder.	Capacity of sockets, $\mu\mu$F.		
	C_{fg}	C_{fa}	C_{ga}
X	1·11	0·86	0·19
Y	2·65	2·08	1·16

It will thus be obvious that the holder contributes very largely to the effective inter-electrode capacities of this type of valve, and that the holder with sockets embedded in insulating compound is at a disadvantage as regards capacity. In fact, the results endorse the comment made in the comparison of the R with the V type of valve.

Before we leave the R type we include figures for two valves of a different make from the others.

R Valve.	Holder.	Capacity in $\mu\mu$F.		
		C_{fg}	C_{fa}	C_{ga}
Horizontal Filament	X	5·71	5·72	2·38
Vertical Filament	X	11·25	9·09	4·27

Here it is obvious that the second valve is much inferior to the first from the point of view of capacity. The bridge readings also showed that in the second case the capacities were of much higher power factor. On close examination of the two valves it became evident that the difference was due to the black insulating compound in which the pins of the valve are set. It was of a different nature in the second case and probably of poorer quality.

Values of three types of D.E. valves are given below :—

Valve.	Holder.	Capacity in $\mu\mu$F.		
		C_{fg}	C_{fa}	C_{ga}
A	X	5·94	4·78	2·43
B	X	5·86	5·32	3·01
C	X	5·27	4·24	2·04

(*b*) *Power Valves.*

Two specimens of Power Valves were tested and gave the following results :—

Valve.	Holder.	Capacity in $\mu\mu$F.		
		C_{fg}	C_{fa}	C_{ga}
Power Amplifying	X	8·13	5·88	4·42
Transmitting (T)	—	6·37	2·30	4·55

Here the larger valve (T) has the smaller capacities. This, of course, is due to the fact that the T valve is used without a holder.

(*c*) *V Valves and Holder.*

We shall now give a few figures referring to the V type and for the clip-holder in general use with this class of valve.

Valve.	Holder.	Capacity in $\mu\mu$F.		
		C_{fg}	C_{fa}	C_{ga}
A	Z	1·25	1·16	1·71
B	Z	0·71	0·84	1·72
C	Z	0·98	1·16	2·01
D	Z	0·95	0·98	1·64

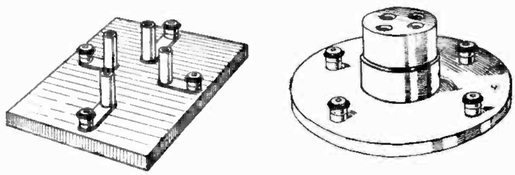
The following values for the clipholder Z are probably only correct to within about ·03$\mu\mu$F, owing to difficulties of contact with bridge leads.

	C_{fg}	C_{fa}	C_{ga}
Clip-holder Z	0·10	0·16	0·12

These values compare very favourably with the four-pin holder. It will be observed that we have not attempted to derive from the combined capacity of holder and valve the amount residing in the valve itself. The direct difference will only give it approximately.

(*d*) *Coil Holders.*

Finally, we give values obtained for various coil holders. Cases A, B and C were of the one pin, one socket type mounted up



X Y

Fig. 7.

on a spindle complete with leads of single flex 8 cm. long about 1·5 cm. apart to the terminals (Fig. 10). Case D was tested with its lead on and its lead off. The lead in this case consisted of about 12 cms. of twin flex. Case E was just one pin and one socket in an ebonite block.

Coil Holder.	Capacity between terminals, ($\mu\mu$F).
A	5·51
B	5·52
C	6·13
D	>12·0
D (without lead)	0·98
E	1·64

What is very striking about these figures is that an elaborate design of a coil to overcome self-capacity is of little value when a coil holder of the type D (with lead) is used.

Some Effects of these Capacities in Practice.

Confining our attention to the grid-filament circuit, we can indicate approximately the upper limits of frequency to which each of the preceding types can give rise. Let us assume that the coils employed are circular, of radius a and made of wire of radius r. An approximate value of their inductance at high frequencies can be obtained from the formula

$$L = \frac{4\pi a n^2}{1\,000}\left(\log_e \frac{8a}{r} - 2\right) \text{ microhenries}$$

where the number of turns n only slightly exceeds unity.

Taking 12 inches as a convenient diameter for a coil, we obtain for wires of the gauges mentioned the inductance quoted below :—

No. 6 S.W.G. 1 turn : Inductance = 0·81 microhenry.

2 turns : Inductance = 3·24 microhenries.

No. 18 S.W.G. 1 turn : Inductance = 0·99 microhenry.

2 turns : Inductance = 3·95 microhenries.

Suppose that we take mean values for the two cases, viz. (*a*) 1 turn : ·9 microhenry ; (*b*) 2 turns : 3·6 microhenries. To get a frequency of ten million cycles per second the capacities required for tuning will be (*a*) 280$\mu\mu$F, (*b*) 70$\mu\mu$F.

Coming to the types of valves measured it will be obvious that the extreme frequency attainable will be given by

$$(a)\ \sqrt{\frac{28\,000}{C_{fg}}}$$

$$(b)\ \sqrt{\frac{7\,000}{C_{fg}}}\ \text{million cycles per second.}$$

R. Type. C_{fg} (mean) $\doteqdot 6\mu\mu$F.

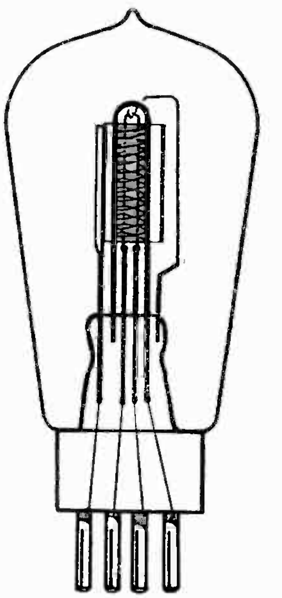


Fig. 8. *L.F. Power Amplifying Valve.*

(*a*) $n_{(max.)} = 68$ million cycles per second ;

$\lambda_{(min.)} = 4{\cdot}4$ metres.

(*b*) $n_{(max)} = 34$ million cycles per second ;

$\lambda_{(min.)} = 8{\cdot}8$ metres.

V type. $C_{fg(mean)} \doteqdot 1\mu\mu$F.

(*a*) $n_{(max)} = 167$ million cycles per second ;

$\lambda_{(min.)} = 1{\cdot}8$ metres.

(*b*) $n_{(max.)} = 83$ million cycles per second ;

$\lambda_{(min.)} = 3{\cdot}6$ metres.

These figures, it will be understood, leave no margin whatever for a variable condenser for tuning purposes, and are based solely upon the measured geometrical capacity of the elements concerned. In practice the effective values would most certainly differ from those measured, but would still be functions of them. To derive an idea of the effective capacity in the input circuit under working conditions great assistance is rendered us by a theoretical treatment initiated by Mr. J. M. Miller,* and substantiated by him as a result of a thorough experimental investigation. He deduced that the existence of the capacities between the elements of a three-electrode vacuum tube causes the input impedance of the tube to depend upon the nature of the load in the plate circuit. Representing the input impedance by an apparent resistance r_g in series with an apparent capacity C_g, he obtained values for C_g under various conditions prevailing in the plate circuit. If the resistances in the output circuit of the valve be r_p (internal), and R_p (external), and μ be the amplification factor, then, for the case of a pure resistance load in the plate circuit, C_g may have the following values :—

Case (1). At low frequencies where terms in ω_2 are negligible,

(say, $\omega < 10^6$)

$$C_g = C_{fg} + C_{ga}\left(1 + \frac{\mu . R_p}{r_p + R_p}\right)$$

This gives for a maximum increase over C_{fg} the amount $(\mu+1)\ C_{ga}$, when R_p is large compared with r_p.

Case (2). For very high frequencies where terms in ω^2 predominate,

$$C_g = C_{fg} + \frac{C_{ga} . C_{fa}}{C_{ga} + C_{fa}}$$

This case applies more particularly to the circumstances under discussion. Here C_g is virtually the capacity between filament and grid when the plate circuit is open, *i.e.*, C_{ga} and C_{fa} in series across C_{fg}.

Proceeding now to observe the effect of these considerations upon our deductions of $n_{(max.)}$ for the types of valves discussed above, we find at high frequencies that C_g for the *R* valve exceeds C_{fg} to the extent of 30 per cent. so the $n_{(max.)}$ will be 15 per cent. lower than we derived in assuming it to be C_{fg}. In the case of the *V* valve we find C_g to be 60 per cent. greater than C_{fg}, which results in a diminution of 30 per cent. in the estimated $n_{(max.)}$

* Miller, *Bulletin Bureau of Standards*, Vol. 15, 367, 1919.

At low frequencies we find a very marked difference between C_g and C_{fg}. The actual difference depends upon the relative magnitude of r_p and R_p, and can amount in an extreme case to as much as :—

R valve. $\mu=9$; $C_g=32\mu\mu F$, as compared with $C_{fg}=6\mu\mu F$.

V valve. $\mu=6$; $C_g=12\mu\mu F$, as compared with $C_{fg}=1\mu\mu F$.

From the practical point of view the importance of this high value rests in the fact that it corresponds to a large consumption of power in the input circuit.

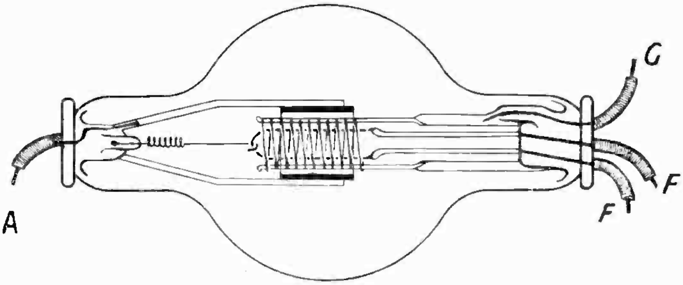


Fig. 9. *Power Transmitting Valve.*

We wish to state that the measurements here described were made with current of telephonic frequency. Radio frequencies could be used and could probably be made to yield much higher sensitivity with a suitable detector (*e.g.*, a heterodyne arrangement with an amplifier, if necessary). However, the variations of capacity with frequency are known to be exceedingly small from the point of view of such measurements, and the choice of working frequency is solely a question of available apparatus and convenience.

Power Factor Measurements.

It is obviously important to obtain an idea of the power factor of the various capacities we have investigated. A high power factor means loss of energy and therefore a decrease in efficiency. We have mentioned that in our bridge the phase angle or power factor adjustment is provided for by the small variable air condenser C_4. This small condenser also plays a part in the elimination of earth capacities, and in order to avoid confusion, we have found it desirable, when accurate capacity measurements are required, first to determine the capacity as described above without paying any particular attention to power factor readings. Then, if power factors are required, they are determined by another set of measurements. If, however, the capacity is required only approximately, then it is possible by means of two observations only, to determine both capacity and power factor. In this case the procedure is as follows :—

(*a*) Connect up the valve to the bridge exactly as before, earthing the third electrode. When balance is obtained, note the capacity reading and also the C_4 reading.

(*b*) Disconnect the valve from the lead attached to the point A of the bridge, disturbing the lead as little as possible. Again, balance and note the new reading of C_4 and also the capacity reading.

The difference between the two capacity readings gives the capacity of the valve approximately. The effect of leads is not entirely eliminated. Our previous measurements show that the probable error is about $0{\cdot}1\mu\mu F$. If ΔC_4 is the difference between the two C_4 readings, then it is easy to show that the power factor of the valve capacity measured is approximately

Power factor =

$$\frac{C}{c}.\Delta C_4.r_4.\omega \times 10^{-6}$$

where C = total capacity in Arm 1 of bridge.
c = capacity of valve (difference in C readings).
$\omega = 2\pi \times$ frequency.
ΔC_4 = difference in C_4 readings (in $\mu\mu F$).

In our case $C=945\ \mu\mu F$.
$r_4 = 1\,000$ ohms.
$\omega = 5\,000$.

so that

$$\text{Percentage Power Factor} = 0{\cdot}472\ \frac{\Delta C_4}{c}.$$

Here both ΔC_4 and c are in $\mu\mu F$.

In taking the second reading for power factor it is important not to disconnect the valve from the lead attached to the point E of the bridge. This would affect the value of C_4 and thus introduce error into the power factor measurement.

Power Factors of Valves.

Using this method, two R valves were tested to obtain a rough estimate of the power factor of the three capacities C_{fg}, C_{fa}, C_{ga}. As it happened, the two were of a different make, although there is nothing outstandingly different about them.

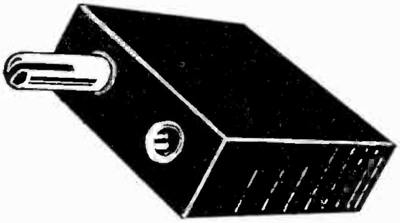


Fig. 1. *Coil-holder E.*

R Valve I.

$C_{fg}=5{\cdot}98\mu\mu F.$	$C_4=99\mu\mu F.$	P.F.= 7·8%
$C_{fa}=4{\cdot}90\mu\mu F.$	$C_4=100\mu\mu F.$	P.F.= 9·6%
$C_{ga}=2{\cdot}84\mu\mu F.$	$C_4=17\mu\mu F.$	P.F.= 3 %

R Valve II.

$C_{fg}=6{\cdot}05\mu\mu F.$	$C_4=115\mu\mu F.$	P.F.= 9·0%
$C_{fa}=4{\cdot}95\mu\mu F.$	$C_4=120\mu\mu F.$	P.F.=11·4%
$C_{ga}=3{\cdot}19\mu\mu F.$	$C_4=88\mu\mu F.$	P.F.=13·0%

V Valve.

In this case the power factor was found to be less than 1 per cent. $C_{ga}=1{\cdot}79\mu\mu F.$ $C_4=2\mu\mu F.$ P.F.=0·5 per cent.

The valve of high power factor previously referred to had succumbed before these tests were inaugurated, else we might have fixed a probable upper limit to the power factors to be met with in practice. It is not very apparent why there should be such a difference in the power factor values for the capacities C_{ga} in the two R valves. The only obvious difference was in the greater separation of the leads in the pinch of the valve I. Absence of homogeneity in either the glass or the black insulating compound could give a possible explanation. A difference from 500 to 2 400 megohms in the insulation resistance would suffice. Nothing is more certain than that the divergency exists.

Distribution of Capacity in a Valve.

The same method of attack enables one to estimate the distribution of capacity and power factor amongst the various sections of a valve. Tracing the leads from any two pairs of electrodes, *e.g.*, anode and grid, we discern four distinct localities. Referring to the diagram (Fig. 11) there are the capacities :—

(*i.*) Due to the electrodes proper at A.

(*ii.*) At B in the pinch where the leads are embedded in glass as dielectric.

(*iii.*) At C where the dielectric is gaseous ; and

(*iv.*) At D where the pins are surrounded by a black insulating compound.

These regions of different dielectrics will make unequal contributions to the capacity and to the power factor of the complete valve. Before proposing to cut down either the capacity or the power factor of a valve it is very necessary that manufacturers should obtain an estimate of the quantities involved so as to know the vital points where each enters to the largest extent. By way of obtaining such an estimate a disused valve, in which only the grid and anode elements remained intact, had its envelope removed and was set up in a holder. The capacities between the terminals were measured simultaneously with observations of their power factor under the conditions given below :—

(*a*) First of all the valve was taken as it stood.

(*b*) Secondly, the electrode projections above the glass pinch were removed.

(*c*) Thirdly, the glass pinch was crushed leaving only the leads in air.

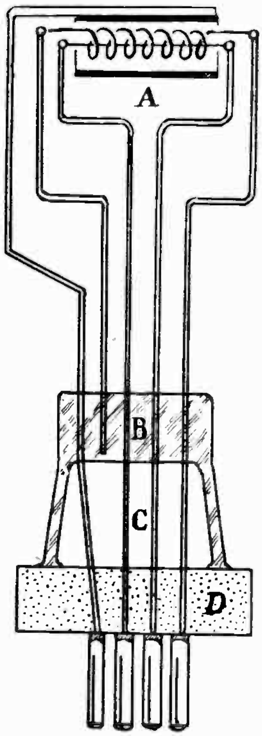


Fig. 11.

(*d*) Fourthly, the leads that still penetrated above the black substance were clipped off.

(*e*) Fifthly, the pins were removed out of the sockets leaving only the holder.

(*a*) Gave the total capacity.

(*a*) – (*b*) The capacity due to the electrodes themselves, A.

(*b*) – (*c*) The capacity located in the glass pinch, B.

(*c*) – (*d*) The capacity due to the leads in air C.

(*d*) – (*e*) The capacity contribution in the black compound, D.

Readings.	Capacity $\mu\mu$F.	Power Factor.
(*a*)	3·82	0·21
(*b*)	1·65	0·31
(*c*)	1·11	0·24
(*d*)	0·97	0·23
(*e*)	0·26	0·00

Hence the contribution due to the sections are given roughly :—

	Section.	Capacity $\mu\mu$F.
Electrodes ..	A	2·17
Pinch	B	0·54
Leads to pinch	C	0·14
Pins	D	0·71

It would not be safe to make a quantitative deduction of power factor, but an examination of the results indicates that the power factor is higher in the glass than in the black insulating compound.

In any case the power factor values appear extremely high and are, undoubtedly, higher in contact with air than they would be in vacuo under working conditions in the absence of moisture, etc. A comparison with the previous set of results obtained with sealed valves would indicate this. Nevertheless, when such small capacities are involved an insulation resistance as low as 1 000 or even 10 000 megohms has an astounding effect on power factor and this could easily be accounted for by surface leakage.

A Year Ago.

By Léon Deloy (F8AB). [R545·909

Our contributor—the well-known French amateur who was one of the pioneers of short-wave transatlantic communication—reviews the work that has been done in the same direction since his success.

IT is just over a year since there was established the first short-wave transatlantic communication, which took place between amateur stations—that of my friend Mr. F. H. Schnell, at Hartford, Connecticut, and my own station at Nice. This achievement created considerable excitement at the time, and the news rapidly spread through the world, the most startling point at that time being that the communication took place on about 100 metres, a wavelength which up to that time had been considered incapable of reaching long distances. The immense possibilities of long-range work with these short waves were immediately appreciated, and both Government and commercial stations busied themselves in studying on the new lines. The time now seems opportune to indulge in a short review of the results of this development. First, however, it is necessary to see what was the position a year ago, and how those early experiments of ours were carried out.

After the war, wireless amateurs were much more numerous in all countries than had been the case before. Most of them had been engaged in wireless work during the war, and were anxious to continue experimental work after demobilisation. After considerable hesitation, most of the Governments involved ended by assigning to amateurs a band of wave-lengths for transmission somewhere between zero and 200 metres. It seems fairly obvious that this band was thrown to amateurs like a bone is to a dog, because it was considered practically useless for serious work at more than a few miles. While we saw on every side giant commercial stations with dozens of masts hundreds of feet high, and aerials a mile or two long, the unfortunate amateur—limited to 200 metres for wave-length and a kilowatt of input power in France (in most cases 10 watts in Great Britain)—was forced to devote his attention to getting the maximum efficiency from his station. The success of many amateurs was remarkable, and by means of endless patience and hard work, they succeeded in covering hundreds and then thousands of miles. As a general rule, professional engineers of the commercial companies were very sceptical. "What!" they said. "The amateur talks about crossing the Atlantic on 200 metres? He must be entirely ignorant of the laws of long range transmission." However, it was done. Amateur signals made themselves heard across the Atlantic. But in spite of steady efforts extending over three years, and experiments between the amateurs of U.S.A. and Canada on one side, and all Europe on the other, two-way work was never successful on the wave-lengths of 200 metres or thereabouts first used. It was only when some of us tried 100 metres that success came.

These short waves then had proved that they could cover considerable distances, but it still seemed hardly probable that they could be used for commercial purposes. Firstly, their range by day was very low; and secondly, even at night they were subject to curious fading effects which often made it extremely difficult to take down a complete message. I had always had confidence in the shorter waves by some sort of instinct, and when my station succeeded in being the first French one to be heard in America—one other European station beat me by two days—I was using 195 metres, although my licence allowed anything up to 300.

In May, 1923, I happened to be listening to a signal sent from Paris on 45 metres. I received this at Nice on a single valve with such strength night and day that it made a great impression upon me. Next month, in June, I heard even more strongly experimental transmission by Poldhu on 94 metres. I was so much impressed that although I was due to leave Nice for the summer within three days, I hastily rigged up a transmitter for 100 metres, and made some experiments. Signals were received very strongly at all hours, and from that moment I decided to attempt transatlantic work on 100 metres as soon as I returned to Nice in October.

During the summer I made a short tour of America, where I found wireless workers nearly as sceptical as here on the possibilities of short waves for any useful work. In fact, one specialist in short-wave work told me that he was absolutely convinced that they could never cover more than 500 miles or so. There were, however, some amateurs who were rather more optimistic, and eventually it was decided that we should make some experiments. On my return to Nice on October 28th I began immediately to reconstruct my station to work on 100 metres. Preliminary tests were carried out with England, whence I received reports of extremely strong signals. I then decided to try forthwith to get across to America, although my station was not really ready, and I could only just use 500 watts. I cabled to Schnell to tell him that I would be calling for an hour on the night of November 25th and 26th. On the first attempt he got me perfectly; the next day I passed him two messages, and by the 28th he had completed a 100-metre transmitter so that he could reply to me, and we were in touch all night, working with the greatest ease. An English amateur who heard this first transatlantic conversation wrote to me later:—

"It was really striking to see how easily the two of you were working, while at the same moment high-power stations were making desperate efforts to keep up regular communication, without result."

Schnell and I will never forget this morning of the 28th November, 1923, during which we succeeded at last in what had been for us the task of years. Hiram Percy Maxim, President of the American Radio Relay League, said during a speech which he made some months ago at Paris: "It may be difficult for others to grasp the emotion which we felt when we first heard in America the signals of 8AB."

All those who were present at this first experiment understood immediately the enormous effect which it was going to have on long-distance communication. From that moment I expressed the conviction that in less than five years the commercial traffic between Europe and America would be carried out entirely on short waves. Most people thought that I was exaggerating the practical possibilities of this system. I had on the other hand under estimated, and only about five months later commercial telegrams were being exchanged between the old and new worlds in this manner. But let us return again to November 28th, 1923, and continue our notes on the progressive development of short-wave work.

That same morning, after having been working for an hour with Schnell, I received a signal from Reinartz, who had hastily brought down his wave-length to 100 metres, and had got over to me at the first attempt. During the following days, numerous stations came down to 100 metres, both American and Canadian, then English and other French stations, till finally Dutch and Italians. This wave-length of 100 metres seemed to be almost magic ; stations which had for years been making fruitless efforts to cross the Atlantic, succeeded immediately on the short wave. One could maintain communication with powers of 20 to 30 watts, and the most remarkable fact was that in this work one did not get the periodic fading which had hindered work on 200 metres.

Immediately, official and commercial wireless engineers interested themselves in the question : the saving which might result from short-wave low-power working could not be neglected. For example, a high-power station with a range of 10 000 miles or so would probably be of many hundred kilowatts, with an enormous aerial. The capital expenditure on it would very likely be half a million pounds, a large staff is required to run it, and the cost of supplying energy is heavy. On the other hand, a short-wave station of equal range could very likely be set up at the cost of £20 000 or £30 000, its staff would consist of one or two, and the consumption of power would be at the rate only of three or four kilowatts. In France, the Ministry of War, and then that of Posts and Telegraphs, were much interested in my work, and shortly afterwards the Eiffel Tower undertook a series of transmissions on short waves with the idea of accumulating scientific data on the propagation of these waves. In England, the Marconi Company took up again the transmissions from Poldhu, and in a few months succeeded in making telephony heard right to the Antipodes, with the result that the Australian Government decided immediately on the construction of a short-wave station to communicate directly with England. In America, all the great commercial companies, and also the Navy, devoted much energy to the study of short waves, and in Italy Signor Ducati, the first Italian amateur to succeed in transatlantic working at 100 metres, was asked by the Navy to install a two kilowatt station of this kind at Rome and another on a warship which was crossing to South America. It was enabled to keep in direct communication with Rome on 100 metres during the whole of the journey. In France and Germany the great commercial companies experimented on direct traffic with South America with 100 metre waves, and in most cases it was found that Buenos Ayres received easily short-wave messages from France with only a few kilowatts behind them, while, at the same time, it could not receive long-wave signals sent with a power of several hundred kilowatts.

During all this time, amateurs the whole world over, were using these waves, and communication was established between different continents with extraordinary ease. Recently, as we all know, there has been regular communication between Europe and New Zealand, and a certain amount of work with Australia, using a power of a few hundred watts and apparatus capable of being housed completely in a small cupboard. This is evidently only a beginning. Modern short-wave work is only a year old, and the enormous progress which has been made in this short time gives us great hope for the future. The most important thing is to increase the range by day, but the solution to this problem is well on the way. Already we have succeeded on many occasions, and it seems that by the use of shorter waves still, between 80 and 30 metres, one may have permanent success, and, in fact, find work easier by day than by night. The consequences of this revolution in communication will certainly be of great importance. Certainly it will shortly permit a reduction in the tariff for commercial telegrams to a small fraction of what it has been hitherto. Practical telephony between the most distant parts of the earth should now only be a question of months. Direct touch between a ship or airship and its port will be possible wherever the ship may be, and, lastly, there is the enormous avenue of private communication with friends across the world. Let us hope that this last application of short-wave work will have the important influence that one would expect in bringing peoples into touch with one another, and making future wars impossible.

Our Calibration Department.

[R206

Readers are asked to note carefully the new organisation of this department.

AT the moment of writing, our two main standards have not yet returned from the N.P.L., but we have every hope that they will be back with us before this is in the hands of our readers, and we have pleasure in stating that we are now again ready to receive apparatus; but under rather different conditions.

To prevent misconception, we should like to state that the new conditions do not apply to existing subscribers until the end of their present subscription.

The new conditions, briefly, are that in future we shall make a charge for calibration work, but at the same time the service will be thrown open to all readers.

Details of the Service.

We give now the types of instruments, etc., which we can test, the fees for each type of calibration, and the approximate accuracy with which we can do the work. It must be clearly understood that a general statement as to accuracy does not necessarily mean that this accuracy will be maintained by the apparatus after test. Just as an example, we have had wave-meters sent in which could certainly not be depended on to repeat their readings within 5 per cent., owing to bad condensers, coils on non-rigid formers, etc.

Further, we make no attempt to compete, as to accuracy, with the great testing institutions, such as the N.P.L., Faraday House, etc., to whom should be sent all laboratory standard and sub-standard instruments. Perhaps we may be permitted to state that the fees charged do not cover more than about one-third of the bare labour cost of testing.

General Conditions.

Readers desiring tests not mentioned in the list below should write and inquire what can be done, as we can often make special arrangements for other types of work.

When sending apparatus, please send a letter *under separate cover*, enclosing the calibration coupon cut from the advertisement pages of the number of E.W. & W.E. current at the time, also the cost of return postage or carriage, the appropriate fee, and the technical information asked for in connection with the particular work to be done.

All apparatus must be sent carriage paid.

Apparatus must be securely packed; all instruments and heavy components should be in wooden cases with ample packing material; it is particularly requested that screws and *not* nails be used for the lids.

Each separate item or part must have securely fixed to it a label with the name and address of the sender.

Although every care is taken of all apparatus, we accept no responsibility whatever for loss or accidents either in transit or in our hands.

Please see that apparatus is in proper order before despatch; valve wavemeters which do not oscillate, buzzer wavemeters which do not buzz, and instruments of indifferent quality (and therefore unlikely to maintain reasonable accuracy) are liable to be returned uncalibrated.

Details of Tests.

WAVEMETERS, for wave-length at various settings.

Valve Wavemeters.—These can be calibrated for any frequencies between 5 000 and 15kC (60 to 20 000 metres) to approximately 1 per cent. accuracy.

Fees.—For a single range, 2s. For each additional "range," *i.e.*, swing of condenser over its full scale, add 1s.

E.g., a meter with two sets of coils and to be used with or without a parallel fixed condenser has four ranges, and the fee would be 5s.

Valve wavemeters must be accompanied by the actual valve to be used.

Information required.—Filament, anode, and grid volts to be used; minimum and maximum wave-lengths expected on each range.

Buzzer Wavemeters.—These can be calibrated between 3 000 and 50kC (100 to 6 000 metres) to 2 to 4 per cent. according to quality.

Fees.—For first range, 1s., each additional range 6d. (For "range," see above under valve wavemeters.)

Information required.—Voltage required for buzzer if battery not enclosed in meter; minimum and maximum wave-lengths expected on each range.

CONDENSERS.

Fixed condensers, of not more than ·002μF, can be measured at one radio frequency, to approximately 1μμF. Condensers can be tested for H.F. resistance; see under that heading.

Fee.—9d. For sets of condensers sent at same time, 6d. for each after the first.

Information required.—Which terminal it is desired to have maintained at earth potential during test.

Larger condensers are tested at audio-frequency to approximately 1 per cent.

Fee.—1s.; for sets of condensers sent at same time, 9d. for each after the first.

Variable condensers.—These can be calibrated at any one radio frequency, between 500 and 30kC (600 to 10 000 metres) to approximately 1μμF.

Fee.—1s. plus 3d. for each position tested. Unless special arrangements are made we test at 12 positions over the scale, making a total fee of 4s.

Information required.—Which terminal it is desired to have maintained at earth potential during test. Number of points to be tested. At what frequency it is desired to have the test.

Inductors, fixed, air core (we do not test iron-core coils).—Coils between about 50 and 50 000μH can be tested for inductance and self-capacity at radio frequency. The test extends over wave-lengths covered by the coil with capacities of about .0001 to .0005, and the inductance is assumed constant. Accuracy of inductance measurement approximately 1 per cent.; of self-capacity, about 10 per cent. Inductors can be tested for H.F. resistance; see under that heading.

Fee.—2s. 6d.; for sets of coils sent at same time, 2s. for each after the first.

Inductors, variable (variometers and tapped coils).—Each tapping or position of variometer will be treated as a separate coil.

Fees.—See above.

Information required.—For variometers, number of readings. For both types, which terminal is to be maintained at earth position during test.

Resistance, D.C.—Robust apparatus, capable of carrying normal bridge currents, can be tested for resistance to the following approximate accuracy: below 1 ohm 1 per cent.; 1 to 10 000 ohms 0·1 per cent.; above 10 000 ohms 1 per cent.

Fee.—9d.; for additional tests within the same group, 3d. each.

Delicate instruments, such as galvanometers, etc., are tested for resistance to 1 per cent. only.

Fee.—As for tests above.

Information required.—Maximum safe current

Resistance, H.F.—*Resistors* of 1 to 30 ohms, approximately non-reactive, can be tested to within approximately ·05 ohm at any one desired radio frequency between 2 000 and 15kC (150 to 20 000 metres).

Fee.—2s. 6d. Additional resistors sent at same time, or readings at other frequencies, 2s. each.

Information required.—Maximum safe current for delicate resistors; desired frequency of test.

Inductance Coils can be tested for total loss, expressed as equivalent series resistance, at any one radio frequency within the range of the coil with a capacity between ·000 2 and ·001μF. Accuracy, to ·05 ohm approx.

Fee.—As for resistors; but if the same coil is also to be tested for inductance, the extra 6d. for the first reading is not charged.

Information required.—As for other tests on Inductors.

Condensers can be tested for total loss, expressed as equivalent series resistance and/or power factor, at any one radio frequency between the above limits. Accuracy, to ·05 ohm approx. (A good air condenser should have a resistance scarcely measurable by us.)

Fee.—As for resistors. But if the same condenser is being tested for capacity the extra 6d. for the first reading is not charged. In the case of variable condensers 2s. for each setting or each frequency.

Voltmeters, D.C., of maximum reading 2 to 250 volts. can be tested to approximately 1 per cent. of maximum reading. If the scale is blank, only light pencil graduations will be put on.

Fee.—6d. plus 3d. for each reading.

Information required.—Approximate maximum voltage.

Ammeters, D.C., of maximum reading 10 microamps to 5 amps, can be tested to approximately 1 per cent. Conditions as for voltmeters.

Voltmeters, H.F., Moullin type, complete with plate ammeter, can be tested at any one radio frequency between 2 000 and 20kC (150 to 15 000 metres), to approximately 2 per cent. Limits of voltage ·1 to 10 volts.

Fee.—1s. plus 3d. per reading.

Information required.—Exact steady voltage to be applied to anode and grid, reading on plate ammeter with no applied H.F. voltage, whether voltmeter is of grid-leak type or not.

Milliammeters, H.F., complete, or thermo-junctions, can be tested at any one radio frequency within above limits of wave-length and accuracy. Limits of current 1 to 500 milliamps. Tests at larger and smaller currents can be carried out on D.C.

Fees.—As for H.F voltmeters.

Information required.—Approximate maximum current. In case of separate thermo-junctions, D.C. resistance of indicating instrument to be used with them.

Conclusion.

As stated above, this scale of fees does not apply to existing subscribers, for whom we shall carry out this work gratis as we have undertaken. It should be understood that this exemption only applies until the present subscription expires.

Lastly, may we appeal to readers to pack carefully, and only to send us reliable and robustly-built apparatus worthy of calibration. Thus they will save us much labour and trouble, and themselves much disappointment.

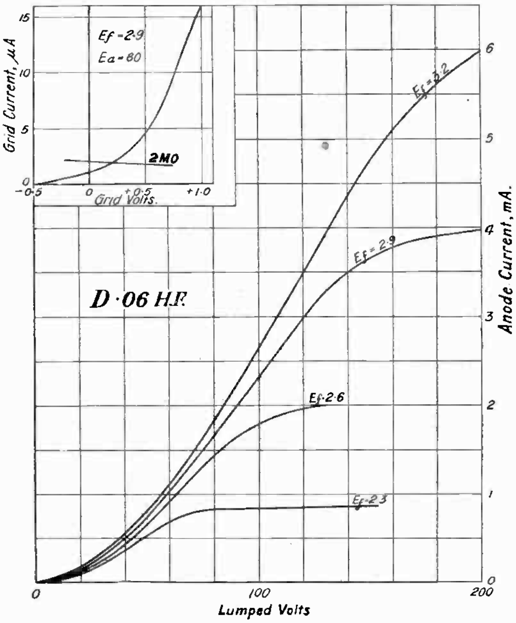
Six New Mullard Valves.

[R333·009

These are the four valves lately produced by the Mullard Co. for use on receivers for ordinary as distinct from power work, together with a new power valve. Two of them supersede the D.F. Ora, while the other two are intended for operation off one cell of an accumulator. The power valve is one of extra-low current consumption.

The D·06 H.F.

THIS is rated as usual for the ·06 amp type of valve. We tested it at 2·3 to 3·2 volts. As regards its construction, the electrodes are of the usual cylindrical type, the ∩-shaped electrodes lately introduced by the Company for their new bright valves not being suited to dull emitters. Like the other valves of this group, the caps are entirely of moulded material, the usual metallic



outer cap having been discarded. They are sent out with a sealed wire shorting grid and filament, so that they cannot be used before sale, although the filament may be tested.

Our curves show the anode current under various conditions, and it will be seen that there is a fairly good "straight" working portion. The valve being sold as for H.F. work, one naturally does not insist on straightness to the extent required in an L.F. valve.

On examining the table, we see that the highest μ is got at low filament heat, as usual. Probably the best working heat is about 2·6 to 2·8 volts, as the impedance is here much lower. It will be noted that the filament takes a little more than its rated current. This, coupled with the value of 27 for the "filament efficiency" at 3·2 volts, inclines us to believe that the filament of the sample tested was a little on the thick side, and was running cooler than usual.

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Imped-ance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
	mA.					
2·3	66	0·8	57 000	9·5	1·6	5·6
2·6	68	2·1	40 000	9·3	2·2	11·6
2·9	71	4·0	29 000	7·8	2·1	19·0
3·2	75	6·5	25 000	7·5	1·7	27·0

A grid-current curve at likely working values is also shown. The line marked 2MO cutting it shows the current through a leak of this valve connected to + of a four-volt battery. This value, or one rather lower, say 1·5MO, would seem likely to give results: it would probably be just as satisfactory to use lower filament heat and perhaps a lower anode voltage—say 2·7 and 60.

The D·06 L.F.

This appears to be a valve essentially similar to the one described above, but with the grid more open or of finer wire, giving lower μ and R_a. As will be seen from the curve sheet, the characteristics

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Imped-ance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
	mA.					
2·3	65	1·3	44 000	7·3	1·2	8·6
2·6	69	2·6	25 000	5·8	1·3	14·5
2·9	73	4·7	20 000	5·3	1·4	23·0
3·2	76	7·5	15 000	4·5	1·4	32·0

are very good for straightness at voltages of 2·8 or over, and it is a further advantage that the low impedance and fairly low μ allow of the use of the necessary bias without needing very high anode voltages. Thus at 2·9 volts on the filament, where I_s is 4·7, full power will be got at an anode current of about 2·4mA, which requires 70 lumped volts. The permissible swing will be about 60 anode volts (one from 40 to 100), equalling about 11 grid volts. This would mean 6 volts bias, and a battery of 100 volts would be sufficient. At 3·2 volts on the filament, this valve should handle a small loud-speaker quite well.

The grid curve shows that it will detect quite well, though the μ is rather low for this. It will be noted that grid current begins at about $-0{\cdot}3$ volts, so for amplification this much must be added to half the input to get the least permissible bias.

The D·3 H.F.

As already stated, this is one of two substitutes for the L.F. Ora valve (which has now been on the market for a long time). It is rated at about ·3 amp, 1·8 volts, and we tested it at filament voltages of from 1·4 to 2·0V. The current varied from ·29 to ·36A, as will be seen from our table. The saturation current was larger than that of the corresponding ·06 type, rising to 11·0mA at full heat. The μ and R_a are nominally the same as for the ·06 type, but it will be seen that there are curious differences in the effect of filament heat on μ and the factor we have called "P." The "filament efficiency" of 15 at full heat is normal for this type of valve.

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
1·4	·29	1·0	80 000	8	1·8	2·5
1·6	·31	2·0	50 000	10	2·0	4·0
1·8	·34	5·7	33 000	9	2·5	9·2
2·0	·36	11·0	25 000	9	3·2	15·0

We show the grid current at 1·9V on filament and 100 on anode, also the straight line characteristic of a 2MO leak connected to filament positive. It would seem that a rather lower leak would bring the working point nearer the bend and give the best detection, although the exact figure would, of course, depend on the chosen filament and anode voltages.

The D·3 L.F.

This, the companion valve to the last, is intended for L.F. work, and is designed with a more open grid, to give low impedance. We tested it at the same filament voltages as used for the D·3 H.F., and found the filament to take a fraction more current, while it gave twice the output, the anode current rising to 20mA at full heat.

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
1·4	·31	2·5	37 000	4	1·3	5·7
1·6	·34	5·9	25 000	5	1·0	11·0
1·8	·36	12·5	16 500	4·5	1·2	19·0
2·0	·39	20·0	14 000	4·5	1·5	25·0

The anode impedance is satisfactorily low, being 16 000 ohms at the rated filament voltage of 1·8. Curiously, the μ *fell* at 1·4 volts, instead of rising as is usually the case. The rather low "power amplification" is, of course, due to the rather low μ of 4·5. The filament efficiency $\left(\frac{\text{output mA}}{\text{input watts}}\right)$ is quite exceptionally high for this type of filament, there being quite enough power to handle a small loud-speaker without distortion, always providing the valve gives a satisfactory life on full power.

From the grid current curves it will be seen that the grid should be maintained below $-0{\cdot}5$ volt for amplification, even on the most positive part of its swing.

The D.F.A. 3.

This is a type of valve which we have not previously tested. The grid and anode are (as far as one can see through the flashing) similar to those of the well-known D.F.A. 0 and 1, but the filament is rated to take 60mA at 6V.

As usual with 5·5V or 6V valves, we tested at 4·5, 5, 5·5 and 6 volts on the filament. We found, in our particular sample, that the filament current was about 50 per cent. above its rating, ranging from ·092 to ·105 amp. This, however, did not strike us as important in view of the very great filament efficiency. For the output is really surprising, reaching no less than 40mA, with a "filament efficiency" practically twice that of any other valve we have yet tested.

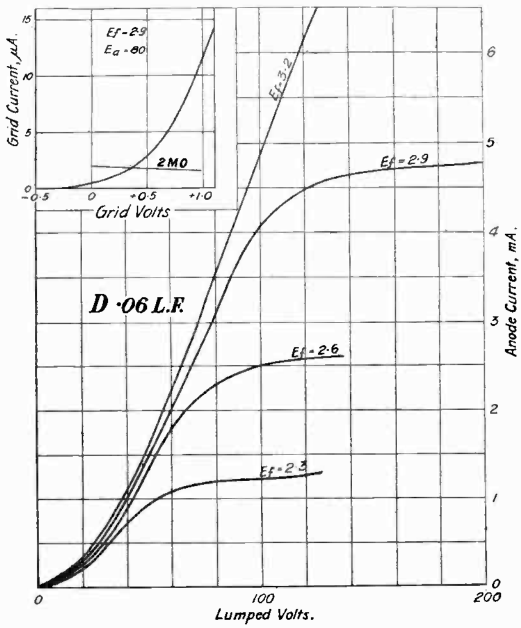
In this connection there is one quite important point: what is the filament current? It must be remembered that the anode current (treating it as a *positive* current), comes from the anode to all parts of the filament, but is led away back from one point; it therefore passes in part through the filament. What the exact current distribution is depends on many factors, but often one small part of the filament will carry the whole, and where, as in this case, the emission is comparable with the filament current, part of the filament may be seriously overheated if the valve is used carelessly. For this reason, although the valve has a saturation current of 40mA, we should consider 20mA as the maximum *safe* load.

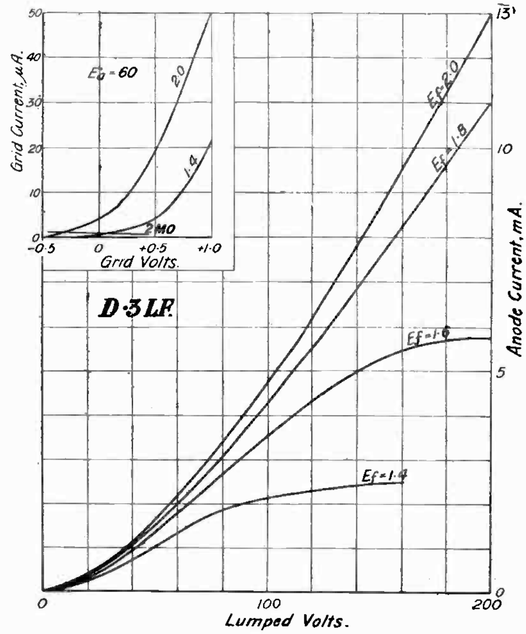
Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
4·5	·092	14	13 000	6·5	3·5	36
5·0	·096	21	10 000	5·0	2·5	43
5·5	·101	30	8 000	4·0	2·0	55
6·0	·105	40	6 500	3·8	1·8	64

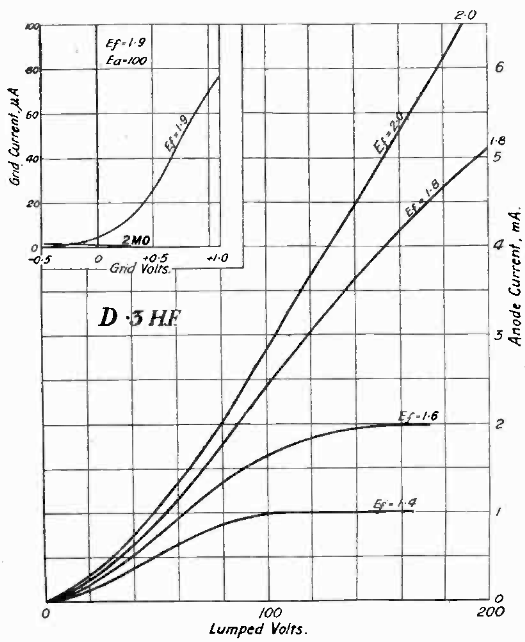
It may be this that causes several curious points in performance. As our curves show, the valve does not answer markedly to increased filament heat, the four curves lying very close together. Also, the change produced by a given grid voltage was practically constant, while the μ varied in proportion to the impedance.

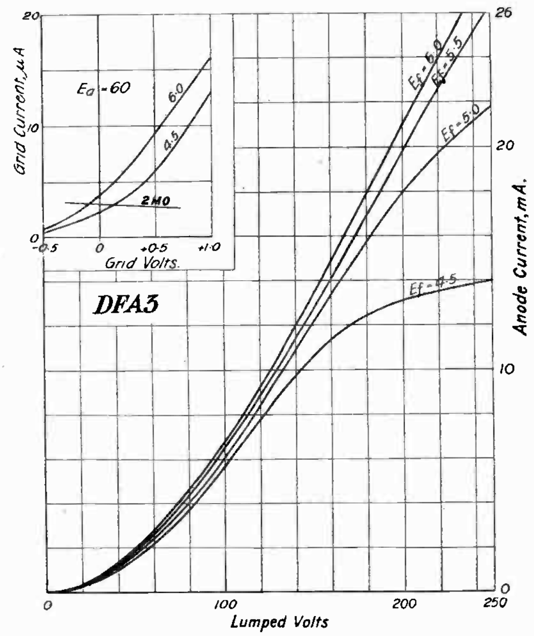
Altogether a very interesting valve: the grid current curve shows that the grid should always be below -1 volt.

(*For characteristic curves see p.* 280.)


D ·06 L.F.
Grid Current, μA.
Ef - 2·9
Ea - 80
2MO
Grid Volts
Ef - 3·2
Ef = 2·9
Ef = 2·6
Ef = 2·3
Anode Current, mA.
Lumped Volts.


D·3 LF.
Grid Current, μA.
Ea - 60
2·0
1·4
2MO
Grid Volts.
Ef - 2·0
Ef - 1·8
Ef = 1·6
Ef = 1·4
Anode Current, mA.
Lumped Volts.


D ·3 HF
Grid Current, μA
Ef = 1·9
Ea = 100
Ef = 1·9
2MO
Grid Volts.
Ef = 2·0
Ef = 1·8
Ef = 1·6
Ef = 1·4
Anode Current, mA.
Lumped Volts.


DFA3
Grid Current, μA
Ea = 60
6·0
4·5
2MO
Grid Volts.
Ef = 6·0
Ef = 5·5
Ef = 5·0
Ef = 4·5
Anode Current, mA.
Lumped Volts

A Useful Range of Meters. [R205·09

WE have recently seen some very interesting small ammeters and voltmeters made by Messrs. Ernest Turner, at Chiltern Works, 53/73, Totteridge Avenue, High Wycombe, Bucks. These are of the type of apparatus which is particularly useful for the serious experimenter, in that they are at the same time small, accurate and fairly reasonable in price.

One of the features of this series of instruments is the universal set, of which large numbers have been supplied to the General Post Office. We illustrate the complete instrument, and also its appearance dismantled. Taking first the movement itself, this is of the highest class, the pivots working in jewels. The current required to give full deflection on the movement unshunted is 10 milliamps, and the resistance 10 ohms. By the use of alternative terminals, shunts can be put across the movement so that the instrument serves as an ammeter reading either 50 milliamps or 500, and by the use of the switch shown at the right on top of the instrument, series resistances can be thrown in so that it will read either 5 or 50 volts, the total resistance being 500 ohms as a 5-volt meter, and 5 000 ohms as a 50-volt meter. The resistance as an ammeter is 2 ohms when measuring up to 50 milliamps, and ·2 ohms when measuring up to 500. The instrument is priced at £6 10s. If a wider range of measurement is desired, this can easily be obtained at extra cost.

Standard shunts for outside connection are available to read 5 amps or other values up to 50 amps. Our illustrations show 5 amp and 25 amp shunts. Again, external series resistances are available in the particularly ingenious form shown in another of our illustrations. These "resistance pots," as they are called, are arranged to screw on to the voltmeter terminal, and receive the outside connection on their own upper end. They can also be screwed one into another, and can be obtained to add either 50 volts or 100 volts to the normal full scale reading. Thus with two of the 100-volt "pots," the total reading becomes 250 volts, other readings being, of course, in proportion. An important point made by the makers is that the instruments themselves are so carefully standardised that shunts can be supplied from stock which are usable with any instrument; there is no necessity to calibrate the shunts with the particular instrument with which they are to be used.

Another interesting line of meters is a series of thermo-ammeters suitable for high frequency work. They are a combination of thermo-couple and moving-coil milliammeter, and are made in various ranges from ·5 amps to 12 amps. They are guaranteed to be correct within 1 per cent. and to stand 50 per cent. overload; the cost varies with the range, but is in the neighbourhood of £5.

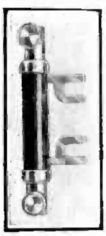
Showing the interior construction of the universal set described here.

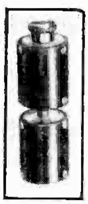
In addition to these instruments, there is a complete series of single range ammeters and voltmeters giving full deflection for anything between 5 milliamps and 20 amps, or 15 millivolts and 100 volts. All have zero correctors, and are individually calibrated and guaranteed correct within 1 per cent. Their prices are in the neighbourhood of £2 10s.

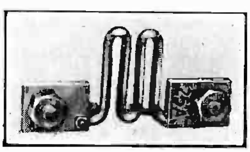
Lastly, we might mention one particularly ingenious two-range voltmeter in which the range is changed from 10 volts to 100 volts by a switch, which simultaneously changes the actual figures on the scale. These are made as standard in the following ranges:—

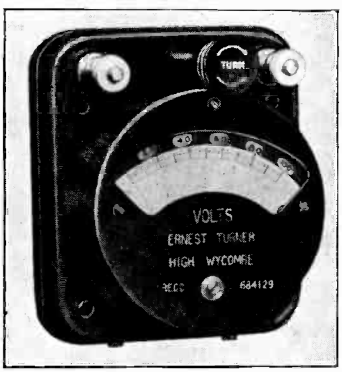
5 and 50, and 10 and 100 volts; or
10 and 100, and 50 and 500 milliamps.

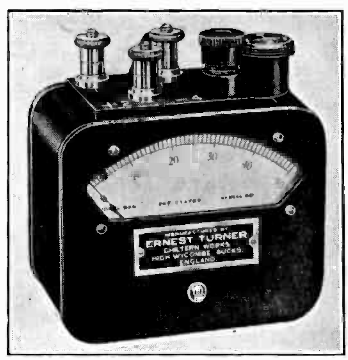
They were originally designed, we believe, for Post Office use, but should be extremely useful for wireless purposes.











Above we show the standardised series and shunt resistances used with the Turner meters, also the double-range and multiple-range instruments described.

A Good Grid-Leak & some other Components.

In view of the general opinion that it is difficult to find a variable grid-leak or anode resistance which shall be reasonably constant, considerable interest attaches to the report of recent tests made by the National Physical Laboratory on a series of six Bretwood leaks. We believe that facsimile copies of the N.P.L. report are available from the makers of the leaks, Messrs. Radio Improvements, Ltd., of 95, Great Portland Street, but owing to the demands on our space, we can only give a few of the more important results.

The first test made was to check the resistance of each leak for various numbers of turns from the fully screwed in position. The results are shown on the curves herewith, in which it will be seen that although there is a fairly large variation between individual leaks, they all showed thoroughly even curves with practically no irregularity. It is stated that the results obtained while unscrewing agreed reasonably closely with those obtained when screwing up. The next test was to measure the resistance of three of the leaks, at one turn, 12 and 24 turns, every day for a week, and again after 7 weeks and 15 weeks. The results were extremely good for apparatus of this type. For example, in one case, No. 3 leak unscrewed 24 turns varied between 5·0 and 5·9 megohms; at 12 turns, between 2·3 and 2·8. The curious point here was that all three leaks gradually increased in resistance during the first week, and went back to their normal values at 7 and 15 weeks.

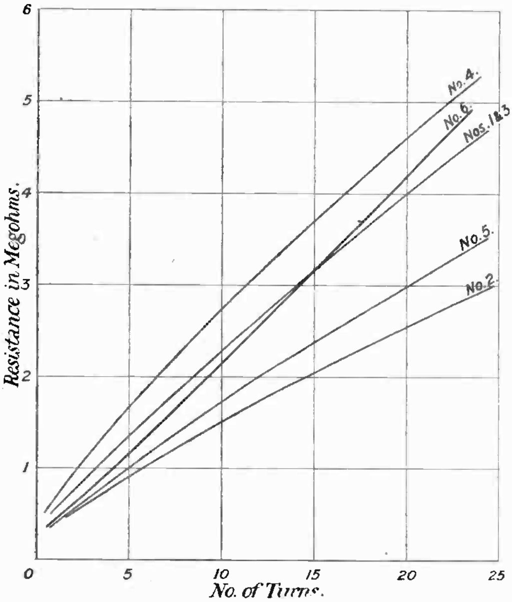


Fig. 1. *Curves showing the remarkably regular variations in resistance of the grid-leaks.*

The third test was to see how constant the resistance was when the leak was left at a fixed adjustment. The three leaks were tested as in the former test, every day for a week, and then after 7 and 15 weeks, at 12 turns from the screwed-in position. The results were that one leak varied between 2·9 and 3·3, another between 1·7 and 1·8, and the third between 2·7 and 3. Altogether the results may be considered quite exceptional for resistances of this nature.

It will be remembered that the company also manufacture anode resistances of the same type, having a resistance varying from 0 to ½ megohm. No N.P.L. results are available for these, but we might state that we have used them considerably in our laboratory when we have happened to want resistances of a few hundred thousand ohms, and rough tests have shown them to be of the same fine quality as the leaks.

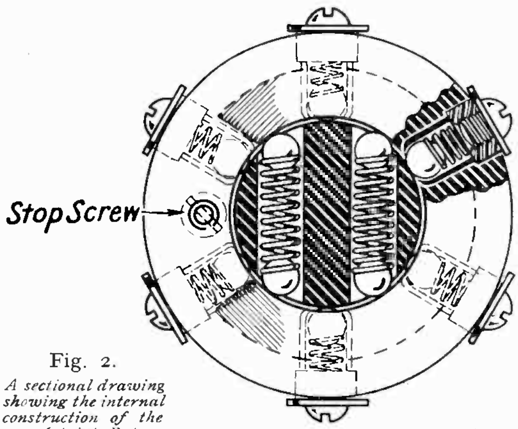


Fig. 2.
A sectional drawing showing the internal construction of the new 6-point Rotary Switch, by Radio Improvements.

The company have also introduced some other accessories which should be distinctly useful to the experimenter. Their patent valve holder, of which the construction is shown in our sketch, has the advantage of making a very definite contact even where the valve legs are not absolutely standard, and at the same time appears to have a low capacity, although this is not a matter which we have actually tested. The same ball plunger principle is made use of in an ingenious six-point circular switch, which can be used either as a reversing, series-parallel or dead-end switch, and also for other purposes. As will be seen from our illustration, this is very compact

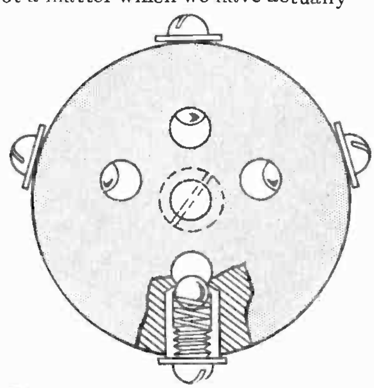


Fig. 3. *A section of the Patent Valve Holder by this Company.*

Power Amplification for Loud-Speakers used at Wembley.

By Ernest W. Braendle.

(*Research Dept., Metropolitan-Vickers Electrical Co., Ltd.*)

[R542 : R587

A description of apparatus used and work accomplished against abnormal difficulties.

IN view of the large amount of wireless work which was carried out at the British Empire Exhibition, it will no doubt interest readers to be given some idea of the apparatus and magnitude of the work involved.

One may say that there were three main attempts to meet the public demand in this direction, namely, the Western Electric Public Address System, which transmitted music, etc., throughout the grounds; the British Broadcasting Company's simultaneous broadcast of the "Wembley Half-Hour" and the loud-speaker system installed by Messrs. Vickers on the outside of the Palace of Engineering, for the purpose of giving the public the time as chimed from the belfry adjoining the Research Section. It is with the last-named that I propose to deal, although I have no doubt that some of my remarks apply equally well to the others, particularly with regard to the great difficulties that had to be overcome. In order to avoid confusion, it is as well to point out here that the British Broadcasting Company, when transmitting the Vickers' carillon from Wembley, employed their own apparatus entirely.

The apparatus used by Messrs. Vickers (see Fig. 1) consisted of a small 20-watt transmitter, which enabled the chimes to be heard at Vickers House, Westminster; a five-valve receiver for the reception of broadcasting and supplying music to the private roof-garden on top of the Research Section; a magnetophone and five stages of power amplification, which either modulated the transmitter or supplied current to the loud-speakers. Both the transmitter and receiver being of the normal type, there is no need to deal further with them here, and it is therefore to the modulation and loud-speaker system that I am devoting my space.

The magnetophone was of a type developed for broadcasting purposes by the Metropolitan-Vickers Electrical Company, Ltd. The particular instrument employed at Wembley was actually in use for several months at the original Manchester Broadcasting Station (2ZY), and a similar magnetophone was used

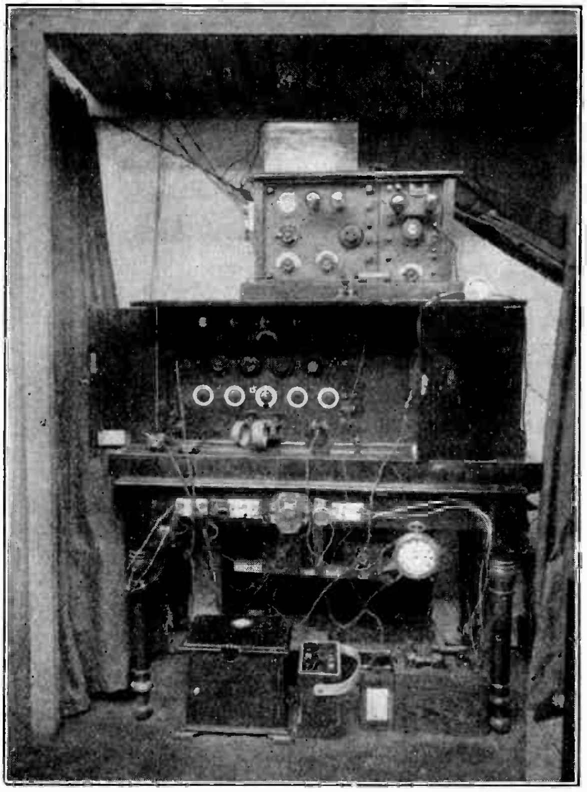


Fig. 1, *showing, from top to bottom, the transmitting, receiving and amplifying units of the apparatus used at Wembley. The "control-clock" can be seen in the right-hand bottom corner.*

for announcement of the KDKA relay tests from the Metropolitan-Vickers Station (2AC).

Anybody who has ever tried to use two or three stages of low-frequency amplification will appreciate the difficulties involved in obtaining reasonably distortionless amplification combined with freedom from self-oscillation—although it may here be remarked with advantage that the former is not infrequently due to the latter, which may be taking place at a frequency above the audible range of the listener.

Now, the average serious experimenter is usually content when he has amplified a signal just audible in the phones to a strength, we will say, suitable for a large room—or perhaps the garden—in his own home, where interference and line-capacity troubles are almost negligible. In the case of the amplifier in question, however, the smallest number of amplification stages had to be found which would suitably raise an input of three or four micro-volts from the magnetophone to a power capable of producing sufficient sound to flood some hundreds of acres of ground, over which there already existed a considerable volume of sound. After a large amount of experimental work, five transformer-coupled stages were decided on, the first four being supplied from the same high and low tension supply. The last stage had its own low tension and a supply from the transmitting generator of 500 volts high tension passing 40 milliamps—that is to say, the last stage alone was passing approximately 20 watts, a power equal to that taken by the transmitter.

As may be imagined, to obtain this the amplification efficiency had to be fairly high, and it is worthy of note that the only damping used for stabilising was a ·025 mfd. condenser on the input to the last stage, which had the effect of reducing the output by 3 to 5 per cent.

Having finally obtained a suitable system of amplification for the loud-speakers—the lead-covered leads to which required nearly 1 000 yards of cable—and having overcome the difficulties involved in making that system suitable for modulating the transmitter when required, attention was next directed to the relative positions of the source of sound and its pick-up—in the shape of the magnetophone.

In a broadcasting studio nearly all the sounds to be transmitted are, comparatively speaking, highly damped, and this damping is further accentuated by the prevention of echo by wall damping in the studio itself. In the case under discussion, however, the sounds to be dealt with were derived from a peal of bells, some of which, once struck, could be heard ringing for ten seconds or more, producing complete chaos of sound. Besides this trouble, the bell-chamber was utterly devoid of any form of damping, and in consequence did more to accentuate the effect of one note slurring into the other than otherwise. Unfortunately, the large volume of outside noise in the Engineering Hall made attempts at picking-up anywhere other than in the bell-chamber quite out of the question. Despite this handicap, a position in the bell-chamber was decided on, the magnetophone was adjusted to operate with very high damping, and was suspended by rubber hangings to prevent wall vibration from taking effect.

Two main factors had to be taken into account in the positions chosen for the loud-speakers—namely, positions most suitable from a technical point of view ; and positions to which the Exhibition authorities would agree, great care having to be taken that the general architectural outline of the building should not be affected.

With these points in view, two large "Leviathan" Amplion loud-speakers were mounted on special platforms on the roof some twenty feet back from the parapet, one on either side of the south entrance, overlooking the lake and pointing S.E. and S.W. Two others were mounted immediately beneath the roof on the western face of the building.

From this it will be seen that, given sufficient power, the whole area facing the southern and western sides of the building could be covered fairly evenly, although, actually, the two over the south entrance appeared to have more directional effect than might be desired, owing to the fact that the sounds were not merged, as was the case with those on the western face. Another point of interest arose in respect of these positions in the fact that, although the loud-speakers were connected in series, and were therefore being supplied with the same current, those under cover on the western side were apparently from four to five times as powerful as those on the south, due to the screening effect of the roof of the colonnade. This had to be balanced by shunting the leads to the loud-speakers on the western side with a fairly high resistance, which, while reducing the current in these, slightly increased that available for those on the south side.

One of the most astonishing features was the effect the presence of the general public in the grounds had on the sound—an effect which may be divided into two headings: (*a*) increase in the threshold of sound, and (*b*) actual sound damping due to the continual breaking of reflecting surfaces.

It was essential during all the earlier tests that these should be made either on a Sunday, or some other time when the public were not present, and therefore due allowance had to be made. This was done, and some 40 per cent. for the former and 10 per cent. for the latter was allowed, which, when tried out, was found to be far from sufficient. In fact, it was necessary to double the then existing output before the volume of sound was anything like satisfactory.

As may be imagined, the loud-speaker system being used almost exclusively for the ringing of the hours, half-hours and quarter-hours, it was not a practical proposition to have a man continually present to switch on the apparatus, neither could it be left running for any length of time without attention. It was therefore necessary to devise some method whereby the whole apparatus, including the high-tension generator, could be automatically switched on every quarter of an hour for just sufficient time to ensure the satisfactory recording of the chimes. It was also found important that when the ordinary broadcast receiver was being used, it had to be switched off for the period during which the amplifiers were in use, as the magnetic coupling between the two was sufficient to allow the received signal to make nearly as much noise as the bells themselves. For this purpose a system (shown diagrammatically in Fig. 2) was developed which depended entirely on a contact made by the rotating minute hand of an ordinary clock, in connection with the necessary relays for its control.

From Fig. 2 the sequence of events can easily be followed. On contact being made by the clock, current was allowed to flow through the filament of the valve of the last stage of amplification, and also through the exciting magnets of the two relays, which in turn lit the filaments for the first four stages of amplification and also started up the high-tension generator. (It will be noticed that the relay for the valve filaments had two contacts, one at normal and one when excited, the former being connected to the broadcast receiver valve filaments, which were thus disconnected when the amplifier was in action.)

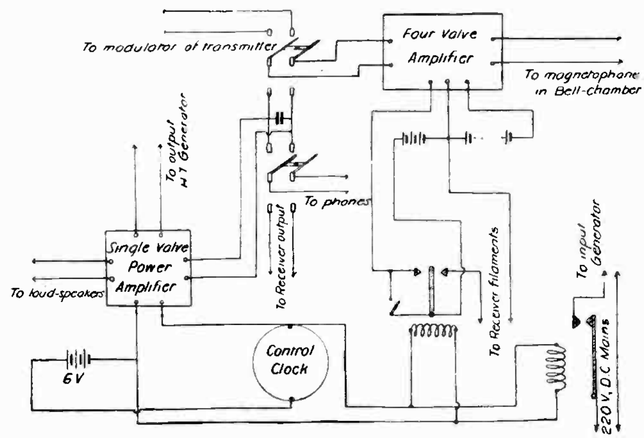


Fig. 2.
A diagram of the Wembley apparatus.

It will also be seen when examining the connections to the double-throw switches that it was necessary to disconnect the last stage from the first four stages of amplification in order to connect the latter to the wireless transmitter. This prevented any tests, etc., which may have been made with the transmitter from being put out on to the loud speakers.

In conclusion I would like to say that, although many difficulties were met with, many of these were considerably lightened by the courtesy and generosity of the stand-holders, who were good enough to lend apparatus.

Long Distance Work.

By Hugh N. Ryan (5BV).

[R009-2

SOME four years ago, the amateurs of Europe, America and Australasia set out to make the whole world their range, and now, to all intents and purposes, they have succeeded. The tasks immediately before them are to "polish off" the few countries still not in touch with the rest, and to organise themselves internationally on such questions as wave-lengths and working schedules, so that they may use to the best advantage the results they have obtained.

The two places with whom we should soon be in regular communication are South America and South Africa. Signals from Argentina, Chile and Mexico are now quite often heard in England, and at least three of our stations have been heard in one or more of these countries, so no difficulty should be experienced in communicating, beyond the usual initial trouble of getting used to each other's time and wave-length.

South Africa presents a somewhat harder task. We understand that there are many keen amateurs there, but we have very little information as to their transmitting activities. (Perhaps some South African reader of these notes will let me have full information ?) At any rate, we gather that they are not yet well established on the shorter waves, as a whole, but no doubt they will be soon when communication with them should be easy enough. As far as I know, 2SH is the only British station who has been heard as yet in South Africa, though a number of us were heard in Northern Africa over a year ago.

The only other part of the world then left will be Asia. Amateur radio is quite active in Japan, and we may soon expect reports on our signals from there, while Japanese signals have already been reported in this country, though the reception is not yet confirmed. Many of our stations have been heard in the more westerly parts of Asia, and many have worked with a station in Mesopotamia.

The only remaining "blind spot" in Europe is now filled by the starting-up of a Czechoslovakian amateur, at a place with the exciting name of Plzen (a name, I think, more readily transmitted by a key than a microphone). His call sign is OK1.

The New Zealand and Australian signals have entirely disappeared for the present, and British stations have been occupied almost entirely in working Americans and a few (surprisingly few) Canadians. During most of the past month American signals have been very profuse indeed on the 75-80 metre band of wave-lengths, and a number of our stations, working between 90 and 100 metres, have been very successful in communicating with them, though recently (since about the first week in January) there has been a considerable falling off in the number of American signals.

Strangely enough, the Americans who are still heard are of good strength, so it would appear that the decrease in signals heard is due to less transmission in America rather than to bad atmospheric conditions.

The earlier half of the second week in January was notable for the great increase in QRN, which culminated on the morning of January 10, when it made American work almost impossible. It is curious to note that at midnight the same day (if one may so express it) there was a complete absence of QRN, and the signals of Canadian 1AR were stronger than I have heard them since last January and February.

The star stations in transatlantic work, judged by the number of Americans worked, are 2KF, 5LF, 5NN, 6LJ and 6NF. (I have not included 2OD, as I don't know how many he has worked ; but, of course, he can work every American he hears—and he hears more than most of us.)

A number of our stations, though they have not worked such a large number of Americans as those just mentioned, have done some very good work in this direction. These include 5SZ, 6VP, 6XG and several others who have only recently connected with America, but are doing their best to make up for lost time. 5QV, hitherto better known as a telephony station, has worked American 1CMP. His telephony also reaches out exceptionally well. 2TO, who appears to be the only other DX station in the Eastern Counties, is not working for a time, his mast having blown down.

In the west 6RY is apparently keeping the "good work" going, though I don't hear much from him.

5SI, who, since the departure of 5KO has shared with 6RY the job of keeping DX alive in the west, has unfortunately been ill during practically the whole DX season, and is not yet back "on the air." Before his illness he worked a number of Americans and Canadians on powers below 15 watts. 2UV, of London, another of our well-known men, has also had the bad luck to be ill just when he most wanted to work.

There are so many stations now in London that I must necessarily report their work very briefly, or else they will occupy most of the article.

2KF, 2NM, 2OD and 5LF need not be reported upon at all. The number of stations they work depends only on the number they call—everyone hears them. They have all worked some 50 or more Americans and Canadians this month. 2KF has also been heard in Indo-China.

2SH has just made the amazing discovery that, though he has had a perfectly-good rectifier, with two 250-watt rectifying valves, running for many months, he had apparently forgotten to connect it up, so he has been feeding the set with raw A.C., with the rectifier merrily lit up—doing nothing!

In spite of this, he has been covering some good distances, and claims a number of records supposedly held by other people. He apparently was the first British amateur heard in America, having two confirmed reports previous to that upon which 2JF's claim to the honour rested, so 2JF would appear to be the second, and not the first.

2SH has also a confirmed report from Iowa, U.S.A., where his signals were heard when it was daylight nearly the whole way across, thus beating 8AB's daylight record (established on 32 metres). He heard several Mexicans before 5NN (who was thought to be the first to do so), has been received in Johannesburg, and worked an enormous number of Yanks and two New Zealanders; and, finally, one of his valves, presumably feeling the strain of such a record-breaking season, has gone soft.

2DX is steadily working Americans, with a master oscillator and a superheterodyne. He has worked nearly every district in U.S.A. 6NF is devoting himself almost entirely to transatlantic work, though he has also worked the station in Mesopotamia. He has worked over 50 Americans, including 5CN, who is thus one of the first American "Fives" to connect with this country.

6LJ has worked some 35 Americans, as well as Mosul. He has been heard by New Zealand 4AB, and has heard Australian 3BD, in addition to two Mexicans and 1 083 Yanks. He starts hearing Yanks at 6.30 p.m. and loses them about the following mid-day! 6XG has worked American 1BHM, with 10 watts input to a D.E. receiving valve, although jammed by an 80 kilowatt station on the other side.

5NN is rapidly becoming (if he has not already become) one of the longest range stations in the country. He has been heard on the Pacific coast of America, and in Argentina and Africa. Five New Zealanders have heard him, and he has worked three of them. All reports say he is the strongest and steadiest station ever heard, but one seems to find that foreign reports say that about most of us. I hope we all deserve it as much as 5NN!

6QB has increased his input from 3½ watts to 4 watts, but in spite of this enormous power he seems to have done better work with the receiver than the transmitter this month, having heard several American "Sixes" and a Mexican.

5BV has done very little, since as soon as the new transmitter was finished it christened itself by blowing all its condensers (including some borrowed from 2ZT), and then sending two 150 watters soft. An expensive christening. However, the transmitter appears to be a success, apart from these little troubles, since, when it was coaxed into action for a few days, its signals were reported to be very strong everywhere, including America and Czechoslovakia. Some very successful daylight work was also carried out with Danish 7QF. By the time these notes appear 5BV should be working regularly again.

That concludes the activities in London itself, but two stations a short way out, 6VP and 6UV, have been doing good work. The former has worked seven Americans and Canadians. While he was working Canadian 1AR on Christmas Day he wished him the compliments of the season, and received the following reply: "SAME TO U OM, FROM ENGLISHMAN HI! (Pause for filling glass.) NW DRINKING UR HEALTH, OM, HERE'S TO U. . . . NW DRINKING HEALTH TO ENGLAND, GOD BLESS HER." An excellent sentiment, but a little rough, I think, on the "dry" Americans listening!

6UV is a newcomer to DX, but he is already heard everywhere within 1 500 miles or so, and has received Australia and New Zealand.

In the Isle of Wight 5TZ appears to have the air to himself. He has been working on both 10 and 50 watts, but so far has had little success with the latter. On 10 watts he reaches Finland, Italy, Scandinavia and Czechoslovakia. He has received four New Zealanders, two Australians, two Mexicans and Argentine DA8.

In Northern England the most active stations are 5MO, 2CC, 2KW, 5SZ and 5DN. The first four are now in regular communication with America, though 2CC has been having generator trouble. 5SZ is new to transatlantic work, but is doing very well at it. He is also doing good work with Italy and other European countries.

5DN has been carrying out some low power schedule tests with America, but has not yet heard the results. He has also worked French 8BV with 2·5 watts input.

So much for England. My note on the lack of activity in Scotland has brought forth a number of letters, which show that 2OA is far from being the only station working there. I have discovered eight stations so far, but apparently only three of these (2OA, 2TF and 2MG) are at present engaged in short-wave DX. My failure to hear the others last month is evidently due to the fact that they work on the longer waves (above 110 metres).

2OA has been ill, but has worked Canadian 1AR. 2MG has worked Finland and Switzerland, the latter on telephony, and received Australian 3BQ very strongly. He is not working at present, owing to valve trouble, but will be on again soon.

I have three reports from Ireland, two of which are from the Free State, in response to last month's appeal. Mr. Neill, of Co. Antrim, hears about 50 Americans and Canadians every Sunday morning, and has heard three Australians.

The two Free State reports are from Mr. McCormick, of Dublin, and Mr. Goldsbrough, of Fethard, Co. Tipperary. Mr. McCormick works chiefly in co-operation with 2ZK, 2VF, 6NI and 2II, all of Liverpool, but he also receives telephony from a number of other English stations. Mr. Goldsbrough listens more for morse stations, and has sent me a very long list of stations heard, which includes most of the well-known stations in Europe, and one Canadian.

British work has taken up so much space this month that I can only review Continental activities very briefly.

The two most interesting events are the entries of Denmark and Holland into the list of countries now in touch with America. The leading amateurs of each country have now worked across the Atlantic (Danish 7EC, 7ZM, 7QF and Belgian P2, W2).

I have just heard from Belgian 4C2 that he has been unable to join in the work owing to illness, and that a gale has just carried away all their aerials. Bad luck!

For some years we have been hearing two Swiss stations (XY and XZ) at very irregular intervals, but recently quite a number of Swiss stations have appeared, with call signs beginning with the numeral 9. 9BL is the strongest of these, and I have had several conversations with him.

That concludes the report, but a number of my correspondents have asked me to raise the question of the serious jamming of American stations by Frenchmen using raw A.C. supply. They do not, of course, realise the trouble they are causing us, but if this should catch their eye, might I ask them to move their wave-lengths up 10 or 15 metres, or else to smooth their supplies, preferably the former? It would be better for all concerned if Europe kept the 75-85 metre band quite clear during transatlantic hours. All other countries are now doing this, and our French friends will be helping us very much if they will do the same.

The Americans are listening for Europe on 85 to 110 metres, where there is less jamming from their own stations.

The M-L Anode Converter. [R355·2·009

A description of some interesting converters which are being made for either transmission or reception.

WE have received for test two types of the "Anode Converters" made by the M-L Magneto Syndicate, Ltd., of Coventry. The purpose of these converters is to provide a high-tension D.C. supply, the primary source of power being an accumulator. The machine is made in four types :—

A	6 volts	to	66 volts.
B	6 ,,	,,	105 ,,
C	12 ,,	,,	295 ,,
D	12 ,,	,,	530 ,,

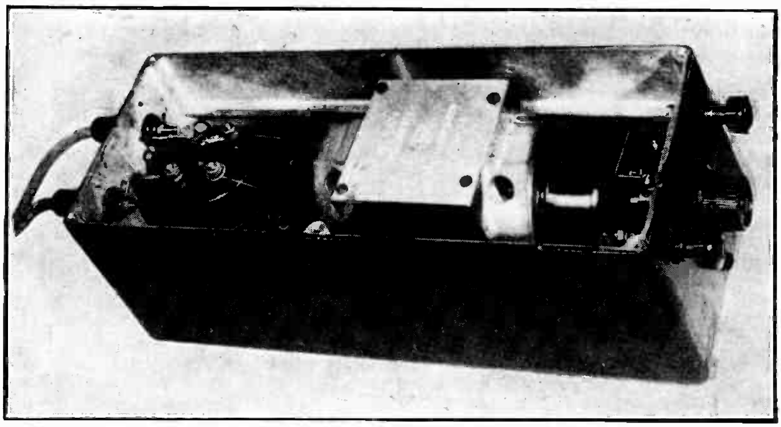
These voltages are on the full output load of 20mA ; at no load the voltage is about 30 per cent. higher. The machines sent were the B and D types. In general design they are similar.

The converter consists essentially of a small motor-generator having an armature which carries two commutators and two separate windings. In order to minimise ripple the number of commutator segments and armature poles is made larger than is usual in such small machines. Permanent field magnets of cobalt steel are used, as this involves a smaller no-load current than would be possible if field windings were used. The rotating part is well balanced, running on ball-bearings, and the machine stands loosely on four rubber buffers, so that when the lid of the case is in place the amount of noise to be heard is inappreciable. The input—and therefore the output—is simply and conveniently controlled by a variable resistance included in series on the low-tension side. A smoothing circuit is provided on the H.T. output side comprising two 1μF condensers and a double choke. The converter, smoothing circuit and control resistance, are all contained in a case which appears to be of cast aluminium. The overall dimensions of the whole apparatus are : length, 15 in.; width, 4¾ in.; height, 5 in.; weight, 14½ lbs. It has therefore a great deal to commend it where compactness or portability is required.

As for the actual results of our tests, the D Type Anode Converter appears to do everything which is claimed for it by the makers. It gives satisfying results on 10 watt C.W. transmission, and the amount of hum to be detected in the carrier-wave is a negligible quantity provided the machine is in proper adjustment and is not overloaded. It might be mentioned here that the particular machine we have tested did not work properly when we first tried it, the running being irregular and the output having a bad ripple. It was some time before we discovered the cause of the trouble which proved merely to be that one of the L.T. input brushes fitted rather too tightly in its holder and was not adapting itself properly to the commutator. This was remedied by filing down the copper-carbon brush slightly to enable it to slide more freely in its holder. This small attention removed the trouble referred to and the machine ran very steadily, giving a smooth output.

The makers supply a curve-sheet (reproduced) showing the relation between input L.T. current and H.T. volts and milliamps output. When there is no load on the H.T. output the input current is just about 1.3 amp while the input on full load (12 watts) is about 2·5 amps. The efficiency on full load is 44 per cent., which is good for so small a machine.

There are one or two minor criticisms which may be passed. For one thing we do not consider an output of 25mA quite sufficiently liberal even for a 10 watt transmitter. There is no latitude for a satisfactory choke-control set, as the current supplied to the control valve should be at least equal to that in the oscillator, and this at once involves an input of at least 20 watts. Then again a certain margin of safety is desirable in both experimental and routine work. For instance, one's oscillator valve may cease to oscillate, an occurrence which not infrequently results in a



An internal view of the converter, which gives an impression of its extremely compact construction.

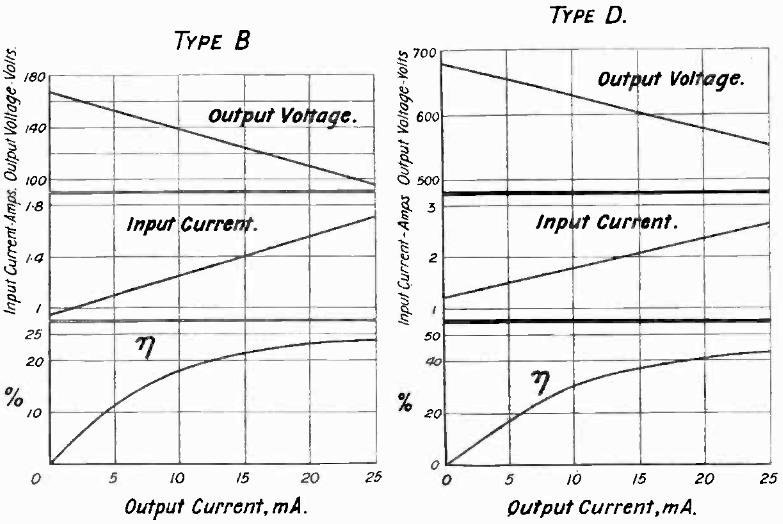
large overload on the H.T. supply. The large variation of H.T. voltage with load which the converter shows is a disadvantage in some ways. Thus we found it unsatisfactory to key a transmitter by breaking the H.T. supply to the anode, or, for that matter, in any manner which makes a large change in the load, as the generator races when the key is up, causing an increase in voltage which falls off rapidly when the key is again depressed. This is hardly conducive to a steady C.W. note. The input control resistance, which is made on the lines of an ordinary filament resistance, seems a little flimsy for the job and gets rather hot near full load; once we noticed it smoking slightly.

The machine is very nicely constructed, and should be a most useful piece of apparatus to those who load, with an input of 1 to 1·7 amps at 6 volts and an efficiency of 25 per cent. at full load. In actual practice we used it mostly on about 6mA load, with some of the regulating resistance in, and it then took about 1·3 amps.

The important point for receiving purposes is, of course, silence. Some most interesting points are brought about in the makers' excellent leaflet. Among these is the fact that while the output smoother is sufficient, there is the possibility of imposing a ripple on the supply, which might give trouble if the generator is fed from the filament battery. However, a special low-resistance choke is provided as an extra to avoid this, and we found it most effective. When feeding the last valve (a power valve of the 6V ·25A type) the hum was not audible from the loud-speaker even in silence, though it was there in the phones. Even here it was not enough to interfere with signals of comfortable strength.

When running at or near full speed there was so little mechanical noise that on one occasion we forgot it when shutting down and let it run all night; but there is a critical speed—just over half speed in our sample—at which there is a distinct noise.

To meet the need for supplying valves at different voltages, a series resistance box is available which gives 60-80 volts when the full output is about 140. This is inductively wound, and acts as an extra smoother for the earlier stages—an important point, for any hum here is, of course, amplified.



These curves afford a means of judging the efficiency of the two types of converter tested.

can afford it. The latter point, we might hint, will prove the stumbling block where many experimenters are concerned, as the D-Type Anode Converter is priced at £18. It would, perhaps, have been happier if the makers had allowed a rather higher power rating, say, 30 watts at 500 volts.

This, of course, would very likely involve an input power too large for easy handling by such accumulators as the amateur usually possesses, and there would appear to be distinct possibilities in a similar machine to run off D.C. mains. The company supply a generator giving 30mA at 500 V for mechanical drive, but this again seems to us hardly sufficient.

With regard to the B-Type instrument (160 to 105 volts), the basis of criticism is naturally different. The curves in our second figure give the performance of this, and it will be seen that at full speed it gives 170 to 100 volts according to

We have made an estimate of the comparative cost of feeding a set from the generator or batteries, and there is no doubt that the generator is more expensive for a set such asour own taking 5 to 8 mA. But it has some important advantages. The voltage can be sweetly regulated without the interruption caused by plugging: and it is entirely free from the scratchings of an old dry battery. For demonstration work needing 15 or 20mA it is much more portable, with its accumulator, than big batteries. From the general design of the generator itself we should put its life at about twice that of a magneto—say 25 years.

Unfortunately it is not, and can never be, a really cheap instrument: the type B costs £11 5s., the resistance box £2 15s., and the extra primary choke 10s. But we should not hesitate to install it if we were building a set where reliability and convenience were desired, and extra cost could be faced with this object.

Increasing the Range of D.C. Measuring Instruments. [R250

By E. H. W. Banner, M.Sc., A.M.I.R.E.

In the following article the author shows how various commercial electrical measuring instruments can be conveniently and cheaply adapted to meet the needs of those engaged in serious experimental work.

THIS article gives the principles underlying the change of range of various classes of instrument. It is not constructional, but gives the theory and calculations for application to any instrument, not one in particular.

Certain converted instruments are described as examples.

Classification.

There are various means of classifying measuring instruments. For the purpose of this article they can all be classed into one of two groups—Portable and Switchboard instruments.

The former are usually wood-cased instruments, and are not intended for permanent inclusion in a circuit but for general use in different circuits. The latter are almost always connected in a particular circuit permanently.

For all-round use a portable instrument should therefore have an infinite number of ranges, while a switchboard instrument usually only needs one.

A portable instrument of single range is thus of less scope than one of two or more ranges, but the switchboard instrument permanently in circuit needs no more than its initial range. In certain cases portable instruments are connected permanently to circuits and switchboard type instruments are mounted on stands to be portable. For these cases the class as described above should be reversed. Any instrument acting as a portable instrument, *i.e.*, not permanently included in a circuit, can with advantage have more than one range. The cost of converting a single range instrument, within the limits stated later, is only a few per cent. of the cost of the instrument, and so the addition of several extra ranges will cost less than the cost of the original instrument.

For example. A cell-testing voltmeter reading to 3 volts might be available. The same instrument can be converted to read equally well on, say, 3, 15, 30, 60, 120, etc., volts and so become of greater use to the experimenter.

Definitions.

It is necessary to consider a few definitions here in order to prevent mistakes arising from unaccustomed nomenclature.

A voltmeter or ammeter is an instrument, not a meter. A meter is one that integrates the value of the applied unit, *i.e.*, ampères or watts, with time. Meters, therefore, read in ampère-hours or watt-hours.

The indicator is the instrument proper and includes the moving and fixed systems, together with the pointer and scale. If the whole of the working parts are contained in one case with the indicator it is called a self-contained instrument. In the case of ammeters with external shunts and voltmeters with external resistances the whole combination is the instrument.

Types of Instruments.

As there are several types of instrument in use and the methods of altering the ranges of each are usually different it is necessary to give a brief résumé of the principles of each type likely to be met with.

The types of instrument are these :—

1. Moving coil permanent magnet (d'Arsonval).
2. Moving iron attraction and repulsion types.
3. Thermal expansion and thermo-electric types.
4. Dynamometer.
5. Induction.
6. Electrostatic.

The first two are common and the thermal (hot-wire) instruments are used extensively for high frequency work, *i.e.*, the aerial current in transmitters.

The last three are not generally available, being rather more expensive than the others and having a different sphere of application.

The last one, however, the electrostatic instrument, is theoretically the best. If it could be made to be portable and of low range it would have greater application in radio work. It is only possible, however, in high ranges.

The first three will now be dealt with, and the remainder ignored.

Moving Coil Permanent Magnet Instruments.

The moving system consists of a light coil pivoted on its axis, and able to swing in the gap of a permanent magnet.

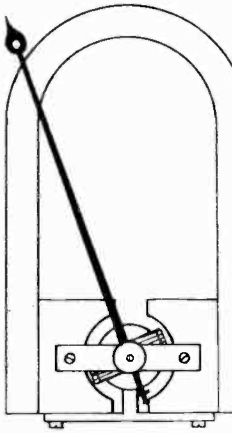


Fig. 1.

One of the two springs constrains the coil to a position as shown in the sketch, Fig. 1, the coil being connected via the springs or extra ligaments to the circuit. A current in the coil tends to rotate the coil in a direction depending on the polarity of the leads, the polarity of the magnet and the direction of winding the coil. An iron core is usually inserted in the space between the sides of the coil for the purpose of maintaining a radial field, and consequently a uniform deflecting force.

At any given temperature the coil has a fixed resistance, and if a certain current is required to produce full-scale deflection, it is seen that by Ohm's Law the voltage drop across the coil is fixed. This fundamental fact is the reason why there is no essential difference between a voltmeter and an ammeter. In a particular case the moving coil of an instrument had a resistance of 5 ohms, and by measurement it was found that 15 milliampères produced full-scale deflection. By Ohm's Law the voltage drop is 75 millivolts, and so with this instrument connected in series, *i.e.*, as an ammeter, its range was 15 milliampères, similarly by connecting in shunt to the circuit, such as measuring the drop across a resistance coil, the range was 75 millivolts.

For the simple instrument described there is no reason why it should be called an ammeter in preference to a voltmeter, and *vice versa*, excepting by the scale. If the scale is calibrated in volts and ampères (or millivolts and milliampères) a volt-ammeter is available. Fig. 2 (*a*) shows the connection as a milliammeter and (*b*) as a millivoltmeter.

Moving coil instruments, by using a permanent magnet, are "polarised." That is, they will reverse their direction of rotation with reverse of polarity of the supply.

This makes them unsuitable for alternating currents, but for D.C. they are almost ideal. The fact of their being polarised makes them available as central zero instruments when required.

Moving Iron Instruments.

This is one of the earliest forms of indicating instruments and is used extensively for alternating current circuits. On direct current it is not so good as the moving coil type, but it is cheaper, and so used to some extent where the highest accuracy is not necessary. The construction is usually a bobbin of wire or strip metal and in the attraction type a piece of soft iron pivoted so that it is attracted into the centre of the bobbin when the coil is excited.

The repulsion type has two small pieces of iron, one fixed and one pivoted. When a current is passed through the winding the two irons become similarly magnetised and repulsion ensues. The pointer is arranged to indicate on a calibrated scale in both types. There is no difference in the alteration of range for the two types. Both are electrically similar. This type of instrument is very robust and will usually stand a large overload safely. They should be used for low frequency A.C. only, as at high frequency the effect of the high inductance is to increase the apparent resistance so that less current is passed for a given voltage.

The hot-wire ammeter has very small inductance and capacity and so is satisfactory at high frequencies.

Thermal Instruments.

These are frequently employed by experimenters and are of use in transmitters.

The hot-wire type consists of a wire which carries the current to be measured, the resulting heating increasing the length of the wire. This increase in length, or more commonly, the sag, is arranged to operate a pointer against a control spring.

The thermo-electric instruments are rather more expensive and so are not dealt with. They are marketed by the Weston Electrical Instrument Co. and other firms.

Hot-wire instruments should only be used for high frequency circuits as their consumption of power is high and their overload capacity low.

General Observations on Range Changing.

In the example given on the moving coil instrument it was stated that that particular coil required 15 milliampères (mA) and 75 millivolts (mV) to produce full-scale deflection. This current and voltage requirement is unalterable, and so no lower range is possible. If a range of 150mV is desired, a series resistance equal to that of the coil (5 ohms) must be added. Similarly for any other range. For an ammeter a shunt must be provided which will cause a drop of 75mV across its terminals when the required current is passing. For a low range, resistance of the coil must be taken into account also, but this will be dealt with later.

In general the consumption of power in a moving-coil instrument is less than in a moving-iron instrument of similar range, while a thermal instrument requires far more power. The lowest ranges usually made are as follows :—

Moving coil	..	5mA.	50mV.
Moving iron	..	1 A.	10 V.
Thermal	..	·5A.	2 V.

Moving iron instruments of lower ranges than above are not much more than toys, and are not very reliable, and their power consumption is considerable.

The above figures apply to the usual pivoted instrument, not to more delicate instruments of the galvanometer class.

Possible Ranges.

As previously stated, the minimum range is settled by the winding, and if the instrument is sealed and cannot be opened (such as a Weston sector type instrument of about 4 inches diameter), no lower range than the original can be fitted, although that may be considerably more than the voltage or current required to operate the coil if of moving coil type. Higher ranges, however, can be fitted *ad infinitum* and, if required, without opening the case. Another consideration is the scale fitted. If the range is 10, either volts or ampères, it will be seen that a range of 3 or 30 will not fit the scale, and although another scale could be made or added to the present one, this is not recommended. The ranges available then should be multiples or sub-multiples of 2, 5 or 10, but in the case of a scale which is a multiple of 3, *i.e.*, 3, 15, etc., a factor of 3 is often necessary.

Calibration.

For the purpose of making a satisfactory job of the instrument it is essential that either another instrument of at least as high accuracy is available, or in the case of voltmeters, a Wheatstone Bridge is at hand. For voltmeters it is often sufficiently accurate to measure the resistance added, by a Bridge, and use the instrument, but it is advisable to calibrate with a good instrument if at all possible.

Range Changing.

If the available instrument is of a range which is not wanted and one other range is to be fitted in its place, the matter is simpler than fitting a number of ranges.

Range changing for different classes of instruments will be described in turn.

(1) Moving Coil Voltmeter.

If the required range is higher than that of the scale, measure the resistance of instrument between terminals, if it is not stated

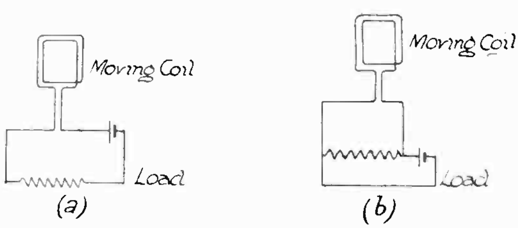


Fig. 2.

on the scale. Call this R_1 and the range V_1.

If the new range is V_2 the added resistance must be

$$\frac{V_2R_1}{V_1} - R_1$$

This can be measured on a Bridge, leaving a little extra wire, then after winding the wire can be adjusted to give the current scale reading when calibrated with another instrument. For a required range lower than that pertaining to the scale it is necessary to open the case. The connections will be found to be as follows :—

From one terminal to the coil, from coil to internal resistance, probably wound on bobbins or cards, and then to the other terminal.

It is now necessary to find the pressure drop across the coil when the pointer is fully deflected. This is the value corresponding to the 75mV in the fictitious case considered earlier. In general it will be between 50mV and 1V. Another voltmeter is required for this purpose, unless a milliammeter is used in series, and the drop calculated from Ohm's Law after the resistance has been measured. No lower range than this is possible, but any range between this and the original is available without extra wire. The resistance bobbin may be removed and the new resistance calculated as before, where the resistance of the coil is R_1 and the coil drop is V_1. The original resistance and range are of no consequence. The added resistance must then be inserted in place of the previous resistance.

It can be done by unwinding wire from the bobbin and frequently trying it with the standardising instrument until the reading is correct, *i.e.*, full-scale deflection for the required number of volts.

The resistance wire, and method of winding, etc., will now be stated.

Constructional Details.

The resistance wire can be either manganin or constantan. The former is somewhat better but rather more expensive. The gauge should be about 30 or 32 S.W.G. It may be wound on the existing bobbins if there is room, if not, another bobbin or card will have to be provided. If the required length is in one piece and not too long it is best to double the wire from the centre and to wind on from here, *i.e.*, bifilarly. The two ends are then accessible for connection and final adjustment.

The object of bifilar winding is to make it non-inductive and is desirable. If the added wire is very long and already on a spool, it can be wound on the bobbin by winding one layer, binding the end of the layer with cotton, and winding alternate layers in reversed directions. This latter method is better if the range is a few hundred volts, as in a bifilar winding a high pressure exists between the free ends of the wire, and as these are together the insulation is insufficient and may break down. Shellac varnish should frequently be applied to keep the wire in position and improve the insulation. Any insulation is suitable, but silk covering is best. This additional bobbin can be inside the case, if there is room, or external to it. On calibrating, the scale figures must be altered to their new values, but the scale marks should not be redrawn.

(2) Moving Coil Ammeter.

The ammeter is not quite so simple as the voltmeter, as there is a small resistance in series with the coil, the whole being across the shunt. This series resistance is called the "swamp" and has a resistance of about four times that of the coil. Its purpose is to reduce the temperature error of the instrument, and so it must be left intact. Voltmeters having a series resistance have no separate swamp, as the resistance itself serves this purpose.

For a higher range it is only necessary to add a resistance across the terminals, this may be internal or external, as convenient, but it must be calibrated after fitting, as if external the resistance of the leads will affect the reading.

Measurement of the shunt resistance by a Bridge is not usually satisfactory, as the Bridge method is not reliable below about 1 ohm, and shunts are frequently of less resistance than this. The best means of conversion is therefore by trial. The calculations are as follows :—

A_1=present range.
A_2=new range.
R_1=present resistance of coil and swamp.
R_2=resistance corresponding to range A_2.
R_s=resistance of shunt required.

$$R_2=\frac{A_1R_1}{A_2}$$

and $$R_s=\left(\frac{A_1}{A_2-A_2}\right)R_1,$$

the value of the shunt to be fitted.

Manganin is the most suitable material for the shunt, and should be in strip form.

Its advantages are :—

(1) High resistivity.

(2) Low temperature coefficient.

(3) Low thermo-electric force with copper.

The section of the shunt is determined by the current to be carried, the minimum section being about ·5 mm. square for 1 ampère. Thus a shunt for 20 ampères should be about 1 cm. × 5 mm. as it is important to have flat strip in order to get a large radiating surface.

The above section gives a drop of ·075V with about 4 cm. length. A larger section is better, but becomes more bulky. The section should not be less than this value however.

The strip may be corrugated if it is too long to fit the instrument case. It should be as open as possible. After final adjustment, which can be done with a fine file, it is necessary to shellac varnish the manganin as it oxidises rapidly in air.

(3) Moving Iron Instruments.

It is usually best to remove the existing wire from the bobbin and rewind. The strength of field in the coil depends on the ampère-turns, not on the watt consumption, and so only general considerations can be given. For a voltmeter to have a higher range its resistance must be increased. This may be secured by additional wire in series with or wound over on the bobbin, or by completely rewinding. It is necessary to note that the bobbin must be wound inductively, and the series resistance, if used, non-inductively. The wire may be either copper or constantan. Some instruments are wound with all the wire of constantan on the working bobbin, others have a copper winding on the bobbin and the series resistance, or another bobbin or card, of constantan. It is necessary that the ratio of constantan resistance to copper resistance should be not less than about 3 or 4, to keep the temperature coefficient down. The gauge of wire used should be similar to that already on, and usually rather thicker than that required for a moving coil instrument, as the current is greater.

Moving iron ammeters are not quite so simple to alter as voltmeters. The section of the wire or strip must be proportional to the current carried. In voltmeters the current is relatively small, about 100mA, and nearly constant for all ranges. The working current density must not exceed 4 ampères per square millimetre, for copper and for resistance wire 1 ampère per square mm. A high-range instrument will therefore have only two or three turns of thick strip, and a low range instrument a great number of turns of thinner wire.

Calibration must be done by trial, and if done on D.C., which is usually most convenient, it must be noted that the reading

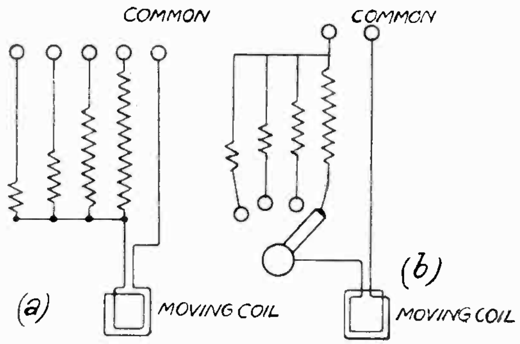


Fig. 3.

with increasing volts or current will be slightly lower than the corresponding value of decreasing volts. This is on account of the hysteresis of the iron. Reversal of the D.C. current at each reading will provide a useful indication of the mean value.

(4) Thermal Instruments.

This type is the least amenable to alteration. A new wire can be fitted, but is not advisable as it is a very delicate operation. The range may be increased, however, by shunting if an ammeter, and by series resistance for a voltmeter. This must be done by trial, as the resistance as measured on a Bridge, when cold, is about one-third or a quarter the resistance when hot under full load. A shunted instrument must be calibrated at its working frequency.

Multi-Range Moving Coil Instruments.

After finding the lowest possible range, as previously described, and from inspection of the scale, the ranges to be fitted may be settled. Any number is permissible ; the only limit is in the accommodation for the resistances. The values of these for each range is calculated as before and the means of changing from one range to another is as follows :—

Two methods are available. (*a*) A separate terminal for each range, and one "common" terminal. (*b*) One pair of terminals and a switch or plug and sockets. (See Fig. 3.)

Further, the separate resistances can be incorporated into one, as shown in Fig. 4, economising in wire, or they may be separate as in Fig. 3 (*a*) and (*b*). The latter method is easier to calibrate, as each range is independent of the others.

Either method may be used, and the construction is a matter for the individual, as instruments vary in size and shape.

Moving Coil Ammeters.

Four methods of range changing are available, and are shown in Fig. 5 (*a*), (*b*), (*c*) and (*d*).

(*a*) Is the simplest, as each range is independent of the others. It has the disadvantage, however, of requiring extra terminals and a switch or plug and sockets, both of which must be altered when it is desired to change the range when in use.

The method of proceeding with the first arrangement is as follows: Calculate the resistance of each shunt as given earlier. Fit each shunt to the common terminal and one other. From each range terminal fix a lead to a socket or to a switch stud. The plug or switch arm is then connected to the swamp or the coil, if the swamp is in the other lead. The common terminal is then connected through to the other coil lead. For these connections flexible or wire of about 20 s.w.g. will do, but it is important to make good soldered connections, and to have a well-fitting switch or plug and sockets.

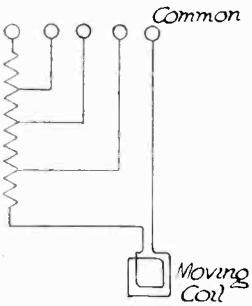


Fig. 4.

Arrangement (*b*) is simpler in use but more difficult to construct, especially when adjusting by trial. The largest shunt is across the common and the next terminal. When this range is in use the indicator is connected across the shunt through the smaller shunts in series. If, therefore, any of the shunts are subsequently adjusted the calibration of all ranges is upset. For this reason it is not recommended for conversion.

Arrangement (*c*) is very simple both to construct and to use, and is of use if the ranges are not widely different. For several ranges where the highest is many times the lowest it is not recommended. As there is only one shunt, this has to give the voltage drop required by the indicator when the smallest current range is in use. If the lowest range is, say, 1 ampère, and 50 millivolts drop are required the resistance must be ·05 ohm.

If, on the other hand, the highest range is 100 ampères the volt drop across the shunt is $100 \times \cdot 05 = 5$ volts, which is excessive, as well as requiring a much larger shunt. The purpose of the switch and series resistances is to limit the pressure applied to the indicator to that required for full scale deflection at each range. For two ranges of, say, 1 ampère and 2 ampères the procedure is as follows:—

Measure the potential required to produce full scale deflection by means of the millivoltmeter. This can be applied either across the indicator itself or across the complete shunted instrument, as it is the same value. Call this V_1. The resistance of the shunt must be such as to give the drop V_1 with 1 ampère passing.

This is $\frac{V_1}{1}$ ohms. Here no series resistance is used, the drop is applied directly to the indicator.

For the 2-ampère range there will be twice the volt drop across the shunt. The extra potential difference must be disposed of in the resistance, which must therefore be equal to the indicator resistance, so that the total resistance will be twice that of the 1-ampère circuit.

The construction may be with either a two-way switch or plug and two sockets. Good contact is essential. For the case of an instrument to which another range of double that of the present one it is possible to do the conversion without another instrument for calibration, but, if possible, another should be used as a check.

The procedure is this: Cut one lead from the shunt to the indicator. Attach the shunt lead to a socket or switch stud and connect the indicator lead to the plug or switch arm, whichever is used.

If this is done well the resistance added will be negligible, and the instrument will still read correctly. For the other range wire up a resistance as shown in Fig. 5 (*c*), and whilst a current equal to full scale deflection is passing, change over the switch. Adjust the resistance until the deflection is half-scale only. When this is correct, the instrument will then require double the current for full scale on this range. If the shunt is of ample proportions this will be satisfactory, but if the shunt gets warm on the higher range it will not be accurate. A greater range than double should not be used with the existing shunt, but another one fitted of the same resistance, but larger cross-sectional area. It should be noted that if the section of a shunt is doubled, the length must also be doubled to give the same resistance.

Fig. 5 (*d*) shows the simplest means of adding a higher range to an ammeter. The existing wiring is left intact and a link is arranged to put an extra shunt in parallel with the other.

It can be extended to two or more ranges, but then some form of switch or plug and socket arrangement is preferable. A milliammeter of two ranges on the line of the above idea is described in detail later. The calculation of the shunt required is simple, but, as before, the difficulty of measuring it accurately on a Wheatstone Bridge makes it preferable to adjust by calibration. If the original range is A_1, and the resistance between terminals is R_1, the required terminal resistance for a range A_2 is

$$\frac{A_1R_1}{A_2}$$

As part of this resistance is that existing, and is in parallel, the new shunt resistance must be

$$\left(\frac{A_1}{A_2-A_1}\right)R_1$$

This includes the resistance of the link or switch and the leads, and so the resistance at the contacts should be low and constant or trouble will occur. If the shunt is determined by calibration, and not by calculation, no error is involved due to the resistances mentioned, provided they remain constant.

Moving Coil Volt-Ammeters.

The next possibility is that of converting and Fig. 3 (*b*), or Fig. 4, can be used as a single-range voltmeter or ammeter into a multi-range volt-ammeter. This can always be done, providing the inside of the instrument is accessible, but it is not always economical. The usual current for a voltmeter is about 15mA, and the potential drop across an ammeter about 75mV. If these values apply to an instrument under

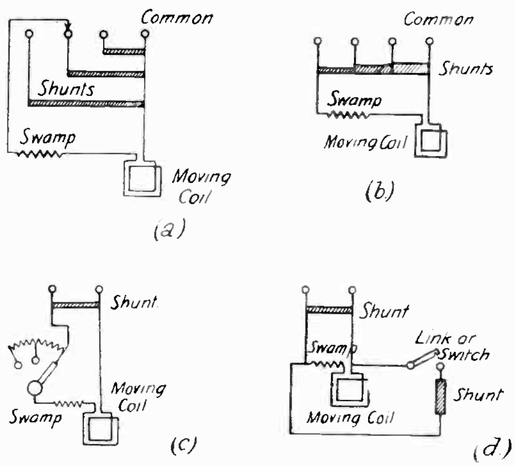


Fig. 5.

consideration a volt-ammeter is a practicability.

A voltmeter requiring only about 7mA instead of 15mA would naturally have a higher resistance. If this higher resistance necessitates a drop of more than about 100mV it is not economical to convert it to an ammeter. The writer has an instrument, which will be detailed later, which has a consumption of 7·3mA at full scale, and the indicator drop is 351mV. This is too much to use as ammeter, and so it is only used as a multi-range voltmeter. Another instrument, also described later, requires 50mV and about 18mA for full scale. This has been converted from its original purpose as a central-zero 5-ampère ammeter to a four-range volt-ammeter. The individual ranges of volts and ampères are calculated or fitted by trial exactly as before. The only addition is a switch for changing from volts to ampères. Fig. 6 shows the connections of the switch, (*a*) shows a single-range instrument, whilst (*b*) incorporates Fig. 6 (*a*) and Fig. 4 (*a*) to produce a multi-range instrument. The alternatives of Fig. 5 (*b*) and (*c*), stated before. Fig. 6 (*b*) is a three-range volt-ammeter, and is, of course, a much more useful instrument than the original single-range voltmeter or ammeter.

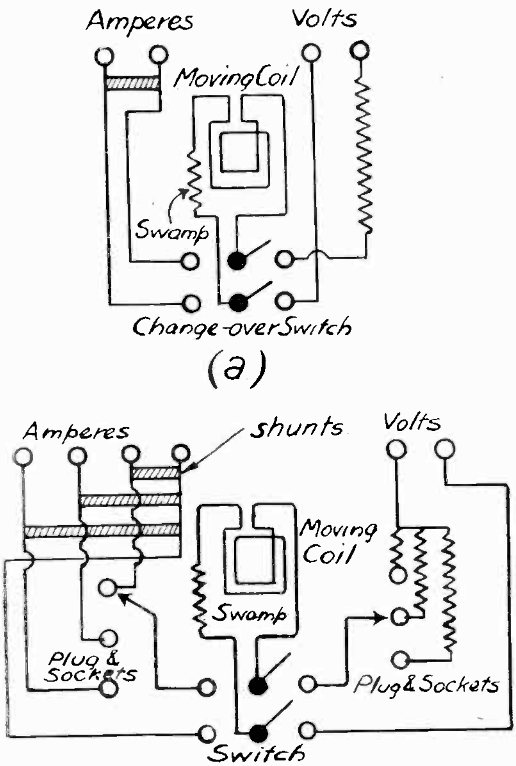


Fig. 6.

The number of ranges is unlimited, and left entirely to the reader.

Moving Iron Voltmeters.

The range of conversion for these instruments is not so wide as that of moving coil instruments, chiefly owing to the greater power consumption in the working coil. Several ranges, however, can be fitted, more especially if they are all higher than the original range. If the required lowest range is lower than the scale reading, some of the wire may be removed from the bobbin, if all the wire is on the working bobbin, or from the series resistance, if fitted. Removing the wire from the coil is not very good practice, for in order to produce full scale deflection, a certain number of ampère-turns are required. If, then, the turns are reduced in number, more current is required to excite the coil fully. The winding being designed for a given current, a higher rating than this will probably cause overheating, as well as greater power loss in the instrument. If higher ranges are required they can be calculated for and fitted exactly as for moving coil voltmeters, taking care to wind the resistances non-inductively in order to prevent their action on the working coil.

Moving Iron Ammeters.

These instruments are rarely shunted, and so, as the line current flows through the winding, the size of wire or strip used depends on the range. To increase the range of an ammeter, the best way is to re-wind, but if several ranges are required, it is usually simplest to arrange shunts, as shown, for the moving coil ammeter in Fig. 5 (*d*). If there is room on the working coil to wind more wire on, this may be done for a second range, using copper wire. The section of wire can be calculated from the range and the current density—4 ampères per square millimetre. Fig. 7 shows the connections. Three terminals only are required. Moving Iron volt-ammeters are not nearly so good as moving coil instruments, owing to the larger power consumption in the working coil. If a volt-ammeter is required, a moving coil instrument should be obtained.

Hot-Wire Instruments.

A second—higher—range may be fitted to a hot-wire ammeter if required. The shunt method with a link or plug as shown in Fig. 5 (*d*) is about the only method of

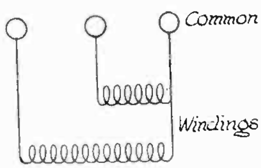


Fig. 7.

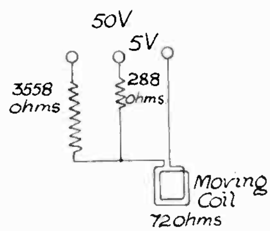


Fig. 8.

satisfactorily accomplishing this, and is quite satisfactory for one or two higher ranges.

The Limitations of Different Instruments.

As moving iron instruments can be purchased more cheaply than moving coil instruments, and as both will read on D.C., the usual circuit on which they are used, it is often the case that the moving iron instrument is bought. When accurate readings are required the cheap moving iron instrument is useless.

For indicating the approximate current they are of some use, but even then their high consumption often causes an appreciable waste of battery power. As an example, the anode battery circuit of a valve receiver will be considered. Assume that the voltage is nominally 50, and about 5 milliampères are required by the triodes. The ideal voltmeter for this purpose is an electrostatic instrument, but these are very expensive. A moving coil voltmeter can be used satisfactorily however. If the instrument requires about 15 milliampères for full deflection (and 50 volts) it is seen that the load on the battery is 5 + 15 milliampères, or only one quarter of the output is used on the set, and the rest wasted in the voltmeter.

Now, considering the moving iron voltmeter. This may require about 100 milliampères for full scale. The battery current is now 105 milliampères, which is not good for the battery, especially if not quite new. Also, the heavy current will reduce the potential difference at the battery terminals appreciably.

A moving iron instrument should not be employed on a low-power circuit therefore, and the above typical case should be thoroughly understood. It is possible that the prospective purchaser may not be able to recognise one from the other by inspection, and if ex-Army disposals instruments are under consideration, no real details of them are to hand. A moving coil instrument always has a uniform scale, and if wrongly connected in circuit, its pointer will tend to move the wrong way, *i.e.*, from right to left, except in the case of central zero instruments.

Moving iron instruments never have a truly linear scale. A number of them are proportional from the first 10 per cent. to the top of the scale, but the initial 10 per cent. is so cramped that it is usually omitted. If the instrument is known to be a moving iron one, and the scale is quite uniform, it should be left, as its scale is not true.

Hot-wire instruments are usually easy to distinguish. Their scales also are not uniform and usually commence cramped and continue to increase their divisions up to full scale. It will often be found that the pointer is not at zero. A screw is usually provided for adjusting this however. In use a hot-wire instrument is almost always "dead-beat," *i.e.*, it settles down to its reading without oscillations. Some are so much "damped" that they are sluggish in action. If the instrument is shaken, the pointer will not move, but with other instruments the pointer can be made to swing.

Converted Instruments.

A few cases of conversion of instruments performed by the writer will now be detailed.

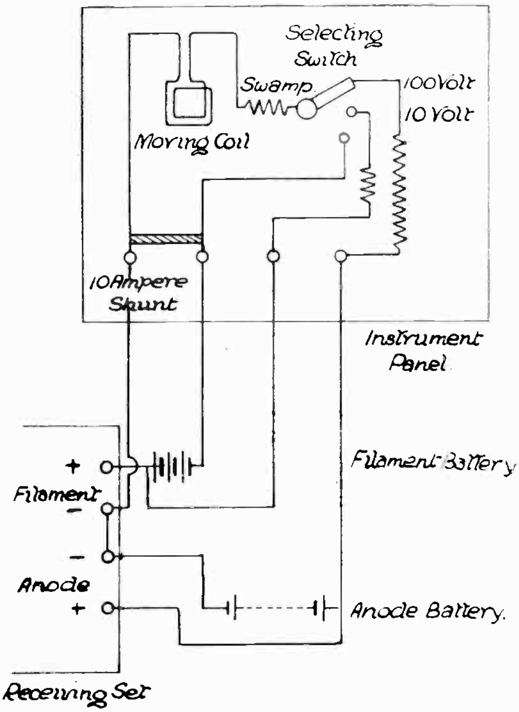


Fig. 9.

(1) N.C.S. 5-ampère moving coil ammeter, central zero, portable, in wood case, 5 in. by 4 in. This appeared to be a useful instrument for conversion, and the following ranges were fitted: 50mV, 1V, 2·5V, 10V, 25mA, 100mA, 1A, 5A. The low ranges were possible because the coil, when disconnected from its shunt, required 18mA at 50mV. The instrument was fitted complete in a larger wood case, with the original top and terminal block showing. Extra terminals were then fitted on each side of the others, a switch fitted in the centre of the top of the case, and two strips of four sockets with two plugs were affixed at

the sides. The photograph (Fig. 10) shows the completed instrument at the left.

(2) Roller-Smith (American) voltmeter. 50 volts. A tapping was made between the coil and the series resistance, and on applying a potential to the coil only, the deflection was full scale for 1 volt. This precluded its use as an ammeter, for an ammeter with a drop of 1 volt is hopeless. However, the resistance of the coil was measured, and found to be 72 ohms. A range of 5 volts, *i.e.*, one-tenth, was decided to be fitted, so that the instrument would do for a 4-volt accumulator circuit. As the resistance of the coil is 72 ohms per volt, the added resistance had to dissipate 4 volts, and so had four times the coil resistance. This was done, and an external resistance of 288 ohms added. The connections are as shown in Fig. 8.

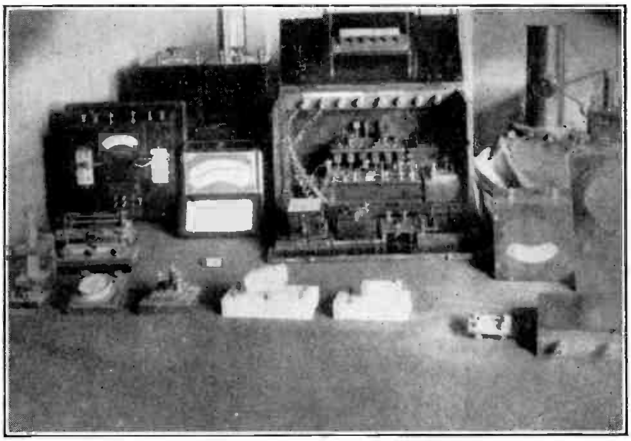


Fig. 10. *The completed instrument.*

(3) Park Royal. 80 milliampères. The present range was of no use to the writer, and the shunt was removed. The current now was almost exactly 15 milliampères for full scale, and so a new scale was made and the instrument calibrated for 15mA. A shunt was added with a link, as in Fig. 6 (*d*), to give a range of 150mA, ten times the first. The resistance on the 15mA range is 4·45 ohms, and on the higher it had obviously to be one-tenth of this, or ·445 ohm. The shunt, therefore, was made of 0·5 ohm, and was adjusted by trial. Manganin wire was used, as the current is quite small.

(4) Elliot sub-standard voltmeter. 25 volts moving coil. Portable. This is the best of the writer's instruments, and many of them are now on sale from dealers. They are well worth the money. It was hoped to include extra resistance in the case, but on inspection it was decided not to, for this reason: To get a number of ranges a great number of resistances would have to be made up and fitted. The writer has several standard resistance boxes (seen in the testing set in the right centre of the photograph), and it was decided that a terminal could be fixed to the junction of the coil and resistance so that any resistance could be connected externally to give any volt range required. Accordingly, one terminal was fitted between the other two, and the lead connected to the coil. On trial, the voltage necessary to produce full scale was 351mV. This was too high for an ammeter, except a low-range milliammeter, but quite satisfactory for volt ranges. The coil resistance is 49·5 ohms, and the following ranges can be obtained by connecting through the resistance stated, externally :—

		Ohms.
.5 volt range.	Series resistance	19·2
1·0 ,, ,,	,, ,,	87·8
2·5 ,, ,,	,, ,,	294·0
5·0 ,, ,,	,, ,,	636·5
12·5 ,, ,,	,, ,,	1 666·5

And for 100 volts a resistance equal to that of the instrument (3 432 ohms) is put in series with the original terminals. Higher ranges could be obtained if desired.

It is also used as a milliammeter, but as the range is 7·3mA, it does not fit the scale. A shunt could be fitted to give a higher range, and fit the scale, but as the lowest possible range was required, no shunt was fitted, but it is used on its low-voltage range (*i.e.*, coil only, no added resistance), and the current calculated by slide-rule. It is not, therefore, direct reading as a milliammeter.

(5) Siemen's 10-ampère ammeter. Moving coil. Switchboard type. It was required to make this instrument serve the following purposes: Accumulator volts, anode battery volts, and filament current.

After several plans had been considered it was finally accomplished, and the instrument wired permanently in circuit with a three-way switch to change from one to the other circuit and range (Fig. 9).

The Perfect Set.

Part V: The Last of L.F. Amplification. [R342·7

In this issue we complete, as far as we can in the space available, our treatment of L.F. work. We deal largely with tuned L.F. for telegraphy.

ALREADY two instalments of this series have been devoted to L.F. amplification, and still we have not completed a simple exposition of the bare beginnings of it. We have, however, dealt with (1) the valve, and (2) the coupling, on the basis of an attempt to amplify without distortion. Now we must devote a little space to amplifying *with* distortion, *i.e.*, tuned or part-tuned amplification for telegraphy.

We need not deal with it at length, partly because it is essentially an easier matter, partly because those interested in it have usually had rather more experience of wireless work than those who attempt the much more difficult task of broadcast reception—that is one of the topsy-turvy tricks of life !

For telegraphic work we can concentrate on the reception of one note. Not only is it easier to do so, but it is actually advantageous, for it helps to eliminate the unwanted notes of other stations. The first matter is to choose the note. It was probably accidental in the beginning that the usual telephone is most sensitive to a note round about 800-1 000 cycles, which is also the pitch to which the average ear is most sensitive. Modern telephones made for wireless telegraphy have this resonance accentuated as far as possible. Since, luckily, the use of C.W. for transmission enables us to choose our own note for reception, we shall obviously design our amplifier for a frequency within this range, and adjust the beat note to suit.

How then shall we design the receiver ? Since we want maximum amplification we shall obviously use transformers, and we shall try to tune these transformers. We say *try*, for it is not so easy to tune an L.F. transformer as an H.F. Sharpness of resonance (at any given frequency) depends on the ratio of inductance to resistance, and it is difficult to make this ratio large for an instrument like an inter-valve transformer. If sharpening is required special steps must be taken—luckily they are easy ones.

First, however, as to tuning. Each transformer can be tuned by a condenser across primary or secondary. It is unnecessary to tune both for *as far as tuning goes the two circuits behave as one.* This is quite an important point, and applies also to H.F. transformers if they are close-coupled : the proper condenser across *either* winding will tune the whole ; and the proper condenser across the small winding is S^2 times that across the large one, if S is the turns ratio. In actual practice many transformers naturally tune not far from 1 000 cycles : if they do not, a condenser of less than ·001μF across the secondary is usually sufficient. High ratios should be chosen (1 to 5 or 1 to 6, or even more), as they can easily be made to give their full step-up at one frequency by tuning.

Another point is, that of the total alternating voltage in the anode circuit of a valve, only part is applied to the transformer, part being absorbed in the valve. At its resonant frequency the transformer will probably have an apparent input impedance of 500 000 ohms or more (see the recent series by D. W. Dye, in E.W. & W.E. for September, October and November, 1924) compared with 20 000 ohms for the valve, so that there is not much in this : however, there will be an improvement by using valves of low impedance compared with their amplification—power valves, in fact. It seems foolish to suggest power valves for bringing faint distant signals to telephone strength, but sometimes there is a great gain by doing so. It depends largely, however, on the next point to be brought forward.

This is reaction. It does not seem to be generally realised that reaction is quite easily applied to audio-frequency amplifiers, resulting in a great increase of amplification combined with sharp note-tuning. It is, of course, difficult to use inductive reaction, although it can be done by a back-coupling transformer with a movable iron core. But it is by no means difficult to arrange capacity reaction. All that is necessary is to couple the grid of the last valve, through a condenser, to the grid of the first. The "tightness" of the coupling depends on the size of the condenser, and it is almost impossible to give this value, for it depends on the μ of the valves, the step-up of the transformers, and on all the transformer losses. In some cases a variable condenser of ·001 gives ample reaction, causing the set to howl if used all in. In other cases one must use something much larger.

Lastly, do not forget that though distortion is not important in this work, grid bias is as necessary as ever in order to get amplification.

Designing an Amplifier.

Perhaps we can now try and give some actual suggestions as to the design of an amplifier; and we shall confine these suggestions to broadcast work, for (as we have already said) those doing long-distance work in most cases know all about it.

Our amplifier will have its input connected either to a valve or a crystal, and the first transformer must be designed accordingly. A valve when used as detector is likely to be used at a low filament heat, and its impedance will probably be high. Therefore, the input transformer should be of low ratio—say, about 3 to 1. If we are using a special high μ detector valve, without grid condenser, an even lower ratio may be best.

But if we are using a crystal—especially a galena crystal—we may have a much lower input impedance, which means a higher ratio; 6 to 1 or 8 to 1 is called for here. In either case the primary will probably want a by-pass condenser. A value of ·0001 is really sufficient, and should not be greatly exceeded for the valve detector. But for the crystal-to-valve transformer with its high ratio there is no objection to using a larger one, up to ·001, although a condenser of this size may quite probably by-pass some of the audio-frequency energy.

Now as to the valves. For domestic work it can be given as our definite opinion (although we are shy of "definite opinions") that not more than two stages should be used. If they do not give sufficient volume the input to the detector must be small, and this leads to distortion. The remedy is H.F. amplification. If good tone is required, see that the rectifier is supplied with plenty of power, and then more than two stages will be unnecessary for work in even a large room.

Of course, if resistance or choke coupling is used with valves of low magnification, three stages might be necessary. But now that special high μ valves are made for such work we need not consider such an inefficient combination.

For loud-speaker work, the last valve must be chosen, before everything, for sufficiency of power output. Bearing in mind the points made in the discussion on valves (E.W. & W.E., December, 1924, p. 153), we can take it that 15 volts swing must be catered for. It is obvious that, with a constant input, the higher the magnification the bigger the output. With a μ of 8 it is probable that the valve must be capable of giving 40mA or so of maximum saturation current in order to get full power without distortion. With a μ of 5, a valve capable of about 25mA would do. There is little difficulty in picking a suitable type from among those we have described from time to time: it is probable that we can make our final choice so that the filament voltage required suits the battery used for other valves.

As to the first valve, we have a free hand. The input to it will probably not exceed 1 volt, and it will be found that practically any "general purpose" valve, with the usual saturation output of 6mA or more, will be sufficiently powerful.

It will usually be found that valves specially sold for L.F. work have a low μ and correspondingly low anode impedance ($\mu=5$, $R_a=15\,000$ are common values), while both these values are higher for "H.F." valves, which may give $\mu=10$, $R_a=25\,000$. As we have already explained, these changes often compensate each other, and either valve may give the better results *if it has a good "straight" characteristic.* On our own set, picking transformers to suit the valve to be used, we usually find "H.F." valves considerably better than L.F.! The L.F. valves, however, usually need less H.T. voltage with a given grid bias. But a power valve for the first stage, though unnecessary, may often give higher amplification owing to its high ratio of μ to R_a.

An important point in connection with the valves is to put the filament resistances on the positive side. The idea of using the odd volt lost across the filament resistance is a snare: every change of filament volts upsets the grid bias. No, put the rheostats on the + side, and provide bias batteries. It may not be necessary to provide filament rheostats at all, but we prefer it, for one often likes to use valves of rather higher rating than strictly necessary, in order to under-run them and thus secure long life. But remember that some dull-emitters do not like to be much under-run, and may even cease to "dull-emit" if this is done consistently.

Next, as to the provision of separate grid and anode supplies for the two amplifying valves. If the first valve is a dull-emitter it is not wise to apply much more than 100 volts to it, even if the output is kept down by biasing. The reasons seem to the writer so interesting that a digression will be made to give them.

A Digression.

If a valve is not *absolutely* hard, there will be positively-charged ions of gas in it. These will move in the opposite direction to the normal electron stream, and thus will strike the filament. This "ionic bombardment" in time disintegrates the filament. In the case of the thin filaments of dull-emitter valves there is no surplus of filament, and the life would be short under bombardment. Further, such bombardment dislodges the thorium coating of a dull filament, and, if excessive, will clear the filament of thorium more quickly than fresh supplies can be diffused from within the filament body, and so spoil the emission. Hence a very hard vacuum is an essential. But even if the valve is very hard, if electrons strike the glass of the bulb hard enough they will dislodge ions. Now the electrons are set in motion by the H.T. field, and those that pass the anode have a speed depending on the H.T. voltage. As they go on, they are moving away from the anode against the H.T. voltage; hence they are slowing up. The larger the bulb the slower they will be travelling when they hit the glass. Hence the chance of their striking out ions which damage the filament depends on the H.T. voltage and the size of the bulb. With the usual size of ".06" valves, voltages over 100 volts may shorten the life.

Returning to our main point—the question of grid and anode tappings—we shall probably need about 8 volts bias on the last valve, which with most valves will necessitate more than 100 volts of H.T. If then we are using a ·06 valve for the first, that means two anode voltages, and with most types of ·06 valve this in turn will need two grid bias values. But if we are willing to be at some pains to choose suitable valves, or if we care to sacrifice a little economy in filament current by using a power-valve for the first, we can almost certainly use *either* one grid bias or one anode voltage, and quite possibly only one value of each. Just as an indication of suitable values where separate supplies are used, the writer will quote those on his set at the moment:—

	1st Valve.	2nd Valve.
Type	Mullard D ·06 H.F.	M-O.D.E. 5
Filament Rating ..	2·5-3V, ·06A	5·5V, 2·5A
Actual Voltage on Filament	2·7	4·9
Actual Voltage on Grid	—3·0	—9·0
Actual Voltage on Anode	90	135
H.T. Current (mA) ..	1	4·5

Note the last item: this is read on a milliammeter permanently in the common return: the individual currents are read by lifting one H.T. plug for a moment.

Remember that a change of phone or loud-speaker resistance changes the actual anode volts. You can check this by reading the current.

Although there is much more to be said on the subject, we must leave L.F. work for a while. In our next instalment we will get on with H.F. amplification.

Ship's Orchestra Broadcast.

A "SHIP'S orchestra repeater" which will enable music played in the saloon to be heard throughout the ship has been installed by the Marconi Co. on the liner *Montclare* of the C.P.O.S. By means of the Marconiphone which has lately played a prominent part in large public gatherings and carried the voice of the Prince of Wales to thousands at the closing ceremony of the Wembley exhibition, orchestral music can be repeated in any part of the ship, including the crew's quarters. Dance music will be provided on various decks and also lectures and concerts.

The *Montclare* is the first ship to be equipped with this apparatus, and it is interesting to reflect that, but for the progress in wireless directly due to broadcasting, the loud-speaking telephone would have continued in the stage of arrested development in which it remained for so many years, and the possibilities of a public address system would never have been realised.

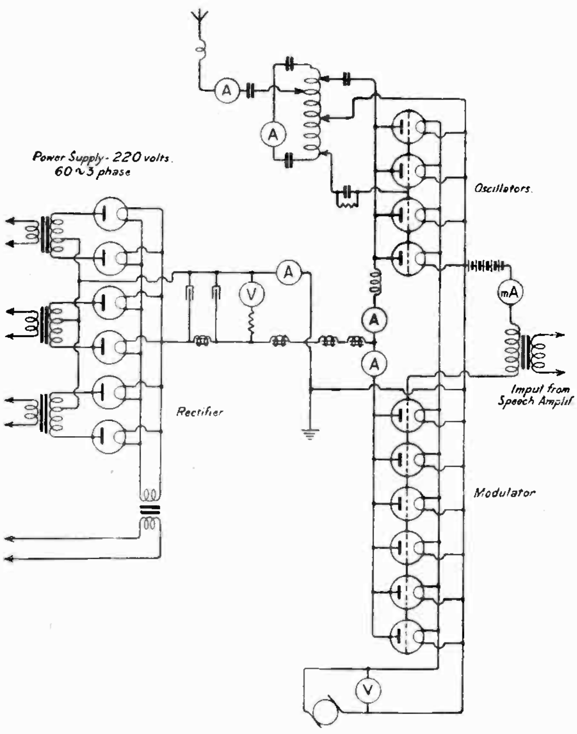
KDKA Short-Wave Station.

[R612

Some notes on the Westinghouse Company's station at Pittsburg.

THE new site of the short-wave station of KDKA is in direct contrast to its former location. When first installed, the short-wave transmitter was situated on the top of a nine-storey building in the heart of the Westinghouse Company's East Pittsburg Works and was then surrounded by steel buildings in addition to being in a valley almost surrounded by hills. The main transmission station of KDKA is still in the same position, and in spite of the many apparent drawbacks has accomplished many famous transmissions that will remain on record in the history of wireless.

The new building, a one-storey concrete and brick structure, has been erected on the Greensburgh Pike and is within a few feet of being the highest spot in Allegheny County. Particular attention has been given in the planning of the station to so arranging the apparatus that the whole installation shall be at once symmetrical and easy of inspection.



A schematic diagram of the transmitting apparatus used at KDKA.

The basement is divided into several rooms. The main basement chamber contains the high-power transformer plant, motor generator sets, filters, chokes and other apparatus. The remainder of the basement is occupied by the battery room, furnace room, and storage space. Power is brought into the basement through underground conduits from two separate sources, both of which are 4 000-volt, three-phase, 60 cycles. This current supply may be stepped up or down as required. The available power supply is approximately 250 kilowatts, which can, however, be increased should it be necessary.

The main apparatus room on the first floor of the building, which contains the oscillator, modulator and rectifier panels, is of ample area, and having windows on all four sides is well-lit by day.

The rectifier which furnishes high voltage to the anodes of the water-cooled valves is mounted on a specially designed frame, so that every part of the apparatus is accessible. Replacements and observations can be made conveniently, as every part of the unit is in full view of the supervisor. The rectifier has a capacity which can be pushed to 150 kilowatts, if necessary, and is the outcome of several years of experimental work by the Westinghouse Company in short-wave broadcasting.

The oscillator panel is of the same general construction as the rectifier panel; and Westinghouse high - power, water - cooled, copper - anode transmitting valves are mounted on it. They are not ordinarily subjected to maximum capacity, but are usually paralleled. Thus each valve is subjected to about half its rated capacity and an unusually long life in valves results. As in the case oi the rectifier, every part of the oscillator panel can be observed and replacements made without difficulty. The modulator panel, using the same general type of valves, has a switching arrangement whereby the number of valves and the amount of power used can be regulated.

Adjoining the main room and extending a few feet into it is the control room. The front and extended sides of the room have glass windows so that every part of the apparatus room may be constantly seen by the operator. This room is equipped with amplifying apparatus consisting of two units, one using 5-watt valves, the other using 50-watt valves. The start and stop control switches, line terminals, amplifying connections, etc., are all located in this room. The engineer at his desk, therefore, can control everything in the station and can also listen and hear the signals, thus judging them for quality.

The aerial is a copper tube erected vertically, supported rigidly from a pole about 50 feet high. Extremely fine results have been obtained from this perpendicular type of antenna, and although only one is now installed, several others will be erected at various points about the station in order that directional experiments may be made.

The Exhibition of the Physical Society.

A Fine Display of Wireless Apparatus. [R064

THE Annual Exhibition of the Physical Society of London always makes a strong appeal to the student of physics, and the fifteenth exhibition, which was held on January 7 and 8 at the Imperial College of Science, was well up to the high standard that the visitor is now accustomed to expect.

It was interesting to note the increase in the number of well-known instrument manufacturers who are now devoting great attention to wireless, and both research and construction were adequately represented. It is impossible in a brief account to do full justice to all the firms exhibiting, but if any are omitted it is not for lack of merit, but of space.

An improved design of the Duddell Oscillograph was shown by the Cambridge Instrument Co. The outstanding feature of this instrument is that simultaneous records may be obtained from three vibrators, which may be any combination of the electromagnetic and electrostatic types, only one camera and one source of light being required.

Both fixed and variable air condensers, constructed in accordance with the Lawes modification of the Kelvin system, were also shown.

The Zamboni H.T. disc batteries which have been developed by Major Phillips were another interesting exhibit. These consist of a number of paper discs coated on either side with metal foil, each disc giving approximately 0·5 volts. The standard battery gives a voltage of 500 and is easily portable.

A fine display of bright and dull emitter valves exhibited by Messrs. Cossor included a large model illustrating the special features of the valve, and a large selection of valves was shown by the M.O. and Mullard Valve Companies. The latter also showed the Holweck molecular pump.

Condensers of every description, ranging from the laboratory standard down to small types familiar in wireless sets, were naturally the chief feature of Messrs. Dubilier's stand, but they also had many other instruments including a short-wave heterodyne wavemeter

Two very interesting wireless instruments were exhibited by Messrs. Evershed & Vignoles. The first was the Evershed 1000-volt generator for the supply of H.T. current in transmitting circuits. This has been designed for use in amateur stations, and has proved highly successful in a number of special tests, including transatlantic transmission of morse and the transmission of speech from a motor vehicle while travelling at high speed. The other wireless exhibit was the Frost emergency wireless signal apparatus, a remarkably compact transmitter that can be operated by an unskilled person. As it measures only 11 by 12 by 9 inches it occupies but little space in a lifeboat, and a point in its favour is that it can be placed quickly in the boat most likely to be lowered first. Turning a handle sends out the S.O.S. signal automatically by means of the Frost transmitting drum on either I.C.W. or C.W., but the I.C.W. set is considered the best for marine work. There is only one switch on the set, and this provides a means of lighting a mast-head lamp so that the boats may keep in touch, the power for both wireless and lighting being provided by the hand operated Evershed generator. The C.W. set is only a trifle larger and is well suited to aeroplane work. Both types have a range of 60 miles in emergency conditions.

The stand of Messrs. Gambrell Bros. exhibited a complete range of instruments for all classes of laboratory and commercial work. Bridges of the Wheatstone and Kelvin type occupied a prominent place in the display.

A novelty in the form of variometers figured in the comprehensive exhibit of the Igranic Co., which covered a very wide field. This consisted of their B and BL types which have not been exhibited hitherto and are of interest both electrically and mechanically, as the windings of both rotor and stator are self-supporting, the use of moulded material being eliminated, thus justifying the claim that they are "wound on air."

The Silvertown Co., in addition to an interesting show of testing sets and measuring instruments, had a good assembly of L.F. transformers, headphones, condensers and loud-speakers and also many examples of the telegraph instruments that are now used in high speed wireless telegraphy.

Both the Marconi Co. and Marconiphone Co. had interesting stands, the former exhibiting a new and convenient public speech microphone with amplifier and loud-speaker, while among the instruments shown by the latter was a series-parallel variometer. By means of a simple switch this component may be used on a band of wave-lengths from 300 to 1 800 metres.

A standard multivibrator wavemeter was demonstrated by Messrs. H. W. Sullivan. This instrument is due to Mr. Dye of the N.P.L., and depends for its action upon the control of the fundamental frequency of an Abraham-Bloch Multivibrator, auxiliary apparatus for the selection and selective amplification of the desired harmonics from the multivibrator being provided. A group of instruments specially designed for the precision measurement of alternating currents of frequencies up to several thousand cycles per second was also shown.

The Interior of the Control Room at KDKA (see p. 304.)

The many fine examples of the instrument maker's art shown by Messrs. H. Tinsley and Co. included a wave meter designed by Mr. Dye of the N.P.L., having a range of from 600 to 5 000 metres. The variable air condenser of the meter is similar to their standard air condenser and amber is used throughout for insulation.

The laboratory and commercial instruments of the Weston Company are too well known to need description, but an attractive new item was provided in their miniature precision D.C. instruments. The moving system of these beautiful little instruments weighs only 5 grains and the quality of workmanship is equal to that of their standard instruments.

Altogether a most interesting and valuable exhibition, and an excellent exposition of British workmanship.

A Short Esperanto-English Dictionary of Radio Terms.

[399(R800)

This dictionary has been specially compiled for E.W. & W.E., and is companion to that which appeared in the January issue. For a few of the terms synonymous expressions have been given pending international standardisation.

Abbreviations.

- separates the *root* word from its ending; it also represents the repetition of the *root*.
— represents the repetition of the whole word in Esperanto.

n. .. noun.
adj. .. adjective.

A

Aer-o, air; **-a,** of air, air (*adj.*); **-a dielektriko,** air dielectric; **-a kondensatoro,** a. condenser; **-a kerno,** a. core; **-kerna transformatoro,** a. core transformer.

agord-i, to tune; **for-i, mal-i,** to detune, tune out; **re-i,** to retune; **-a,** tuning (*adj.*); **-a bobeno,** t. coil; **-a kondensatoro,** t. condenser; **-o,** tuning (*n.*); **akuta -o,** sharp t.; **delikata (subtila) -o,** fine t.; **kruda -o,** coarse t.; **neakuta -o,** flat t.; **-ilo,** tuner; **multopa -ilo,** multiple t.; **-ita,** tuned; **akute -ita,** sharply t.; **ne-ita,** untuned.

akumulator-o, accumulator, storage battery (*see* **Sintoniz-i.**)

akut-a, sharp, acute; **—agordo,** s. tuning; **ne-a agordo,** flat tuning.

alĝustig-i, to adjust; **-ebla,** adjustable.

alt-a, high; **—frekvenco,** high (radio) frequency (H.F.); **—tensio,** high tension (H.T.); **mal-a,** low.

altern-a, alternating; **-a kurento,** a. current (A.C.); **-ilo,** alternator (*see* **Alternatoro**).

alternator-o, alternator; **altfrekvenca—,** high frequency a.; **dufaza—** two-phase a.; **— kun turna fero,** induction a.; **motoralternatora grupo kun diska sparkilo,** motor a. disc set; **multfaza—** multiphase (polyphase) a.; **turbo- —** turbine a.

alumini-o, aluminium.

amator-o, amateur; **radio- (senfadena)—,** radio (wireless) a.

amortiz-o, damping; **antena—,** damping of antenna; **granda—,** high d.; **-aj ondoj,** damped waves.

amper-o, ampere; **-turnoj,** ampere turns; **mili-o,** milliampere; **-metro,** ammeter; **alternkurenta-metro,** A.C. a.; **kontinukurenta-metro,** D.C. a.; **movbobena-metro,** moving coil a.; **varmfadena-metro,** hot-wire a.

amplif-i, to amplify; **-a,** amplifying; **-a valvo,** a. valve; **-o, -ado,** amplification (*action of amplifying*); **-eco,** amplification (*state*); **altfrekvenca -ado,** H.F. a.; **duala -ado,** dual a.; **malaltfrekvenca -ado,** L.F. a.; **-ilo,** amplifier (*see* **Amplifikatoro**).

amplifikator-o, amplifier; **altfrekvenca—,** H.F. a.; **malaltfrekvenca—,** L.F. a.; **magneta—,** magnetic a.; **rezistanca—,** resistance a.; **transformatora—,** transformer a.

amplitud-o, amplitude.

anod-o, anode, plate; **agordita—,** tuned a.

anten-o, aerial, antenna; **artefarita—,** artificial a.; **direktebla—,** directional (*moveable*) a.; **direktita—,** directional (*fixed*) a.; **funela—,** funnel-shaped a.; **horizonta—,** horizontal a.; **kadra— (kadro),** frame, loop, a.; **kaĝa—,** cage a.; **kolbasa—,** sausage a.; **L-forma—,** L-shaped a.; **nefermita—,** open a.; **ombrela—,** umbrella a.; **pendanta—,** trailing a.; **radianta—,** radiating a.; **riceva—,** receiving a.; **senda—,** transmitting a.; **T-forma—,** T-shaped a.; **vertikala—,** vertical a.; **-a amortizo,** damping of antenna; **-a portilo,** antenna support.

aperiod-a, aperiodic.

aparat-o, apparatus.

apuda kupleco, close (tight) coupling.

aranĝ-o, device, arrangement.

ark-o, arc.

asinkron-a, asynchronous; **—sparkilo,** a. discharger.

atmosfer-o, atmosphere; **-aĵoj (atmosferaj perturboj),** atmospherics, strays, static, X-s.

aŭd-i, to hear; **-ebla,** audible; **-ebleco,** audibility; **dis-igi,** to broadcast (*see* **Brodkasti**).

aŭdion-o, audion.

aŭtodin-o, autodyne, endodyne, self-heterodyne.

aŭtomat-a, automatic.

B

Bakelit-o, bakelite.

bateri-o, battery; **alt-tensia—,** H.T. b.; **anoda—,** anode b.; **filamenta—,** filament b.; **malalt-tensia—,** L.T. b.

bat-oj, beats.

boben-o, coil; **aerkerna reaktanca—,** air core protecting choke coil; **aldona (longiga)—,** loading c.; **anoda—,** anode c.; **araneaĵa—,** spiderweb c.; **cilindra—,** cylindrical c.; **ĉelara—,** honeycomb c.; **enŝtopa—,** plug-in c.; **indukta—,** choking c.; **induktanca—,** inductance c; **korba—,** basket c.; **kupla—,** coupling c.; **mezura—,** measuring c.; **solenoida—,** solenoid c.; **Tesla—,** Tesla c.; **reaktanca—,** **ŝok—,** choke c.; **-ujo, -tenilo,** c.-holder, -stand; **fiks-o,** stator (*see* **Statoro**); **turn-o,** rotor (*see* **Rotoro**).

born-o, terminal.

braz-i, to solder (*see* **Soldi**).

brodkast-i, to broadcast; **-a,** broadcasting (*adj.*); **-a stacio,** b. station; **-o, -ado,** broadcasting (*n.*).

C

Ciferplat-o, dial.
cikl-o, cycle.
cirkuit-o, circuit, hook-up ; **fermita—,** closed c. ; **krada—,** grid c. ; **intera (pera)—,** intermediate c. ; **mallonga—,** short c. ; **nefermita—,** open c. ; **oscila—,** oscillating c. ; **radianta—,** radiating c. ; **refleksa—,** reflex c. ; **reĵeta—,** rejector c. ; **rekta—,** straight c. ; **-a,** circuit (*adj.*) ; **-a interuptoro,** c. breaker.
ĉapo, cap (*of telephone earpiece*).

D

Dekoheror-o, decoherer.
dekrement-o, decrement.
dekremetro, decremeter.
detekt-i, to detect ; **-ilo,** detector (*see* **Detektoro**).
detektor-o, detector ; **kompensita kristala—,** balanced crystal d. ; **kristala—,** crystal d. ; **magneta—,** magnetic d. ; **perikona—,** perikon d. ; **valva—,** valve d. ; **termo-—,** thermo-d. ; **termo-elektra—,** thermo-electric d.
dielektrik-o, dielectric ; **-a,** dielectric (*adj.*) ; **-a konstanto,** d. constant, specific inductive capacity; **-a firmeco,** d. strength ; **-a streĉo,** d. stress.
dinam-o, dynamo, continuous current generator ; **kompunda—,** compound d. ; **mem-ekscita—,** self-excited d. ; **ŝunta (deriva)—,** shunt d. ; **—kun sendependa ekscito,** separately excited d.
diod-o, diode, two-electrode valve.
dipleks-a, diplex.
direkt-o, direction ; **-o-trovilo,** d.-finder ; **-ebla anteno,** directional (*moveable*) aerial ; **-ita anteno,** directional (*fixed*) aerial.
disk-o, disc.
distord-i, to distort ; **-o,** distortion.
drat-o, wire (*see* **Fadeno**).
dual-a, dual ; **—amplifado,** d. amplification.
dupleks-a, duplex.

E

Ebonit-o, ebonite.
efektiv-a, effective.
efik-a (valoro), root mean square (value).
efik-eco, efficiency
ekscit-i, to excite ; **-ilo,** exciter (*see* **Ekscitatoro**) ; **mem-a,** self-excited
ekscitatoro, exciter.
eksperiment-o, experiment ; **-i,** to experiment ; **-isto,** experimenter.
ekvilibritaj signaloj, balancing signals.
elektr-o, electricity ; **—mova forto,** electromotive force ; **termo-a,** thermo-electric ; **—magneta,** electro-magnetic ; **—statika,** electro-static.
elektrod-o, electrode.
elektroliz-a, electrolytic.
elektron-o, electron ; **-a elsendo,** electronic emission
elimin-i, to eliminate ; **subondeta -o,** ripple elimination.
elmet-o, output.
elsend-o, emission (*see* **Emisio**).
emisi-i, to emit ; **-o,** emission.
energi-o, energy.
enira (fadeno), lead-in (wire).
enmet-o, input.
esting-i, to quench, extinguish ; **-ita,** quenched ; **-ita sparko,** q. spark ; **-a sparkilo,** q. spark gap.
eter-o, ether, æther.

F

Faden-o, wire ; **dividita—,** stranded w. ; **enira—,** lead-in w. ; **fleksebla—,** flexible w. ; **izolita—,** insulated w. ; **nuda—,** bare w. ; **solida—,** solid w. ; **-i,** to wire ; **-ado,** wiring (*action*) ; **-aro,** wiring (*collection of wires*) ; **-aranĝo,** wiring (*method of wiring*) ; **sen-a,** wireless.
fajl-i, to file ; **-aĵo,** filings.
faktor-o, factor ; **—de potenco,** power f.
farad-o, farad ; **mikro-o,** microfarad.
faz-o, phase ; **mult-a,** multiphase, polyphase.
ferm-i, to close ; **-ita,** closed ; **-ita cirkuito,** c. circuit.
fibr-o, fibre.
fiksboben-o, stator (*see* **Statoro**).
filament-o, filament ; **hela—,** bright f. ; **malhela—,** dull f.
filtr-i, to filter ; **-ilo,** filter.
fleks-ebla, flexible.
flu-o, flow (*see* **Kurento**).
formul-o, formula ; **—de Thomson,** Thomson's f.
frap-ilo, tapper.
frekvenc-o, frequency ; **alta—,** high (radio) f. ; **malalta—,** low f. ; **onda—,** wave f. ; **ondara—,** group f.
fulm-o, lightning ; **-ŝirmilo,** l. arrester.
fundament-a, fundamental, natural.
funkci-i, to function, work ; **-igi,** to operate, cause to function.

G

Galen-o, galena.
galvanometr-o, galvanometer.
gener-i, to generate ; **-o, -ado,** generation ; **-ilo,** generator (*see* **Generatoro**) ; **re-i,** to regenerate ; **re-o,** regeneration, reaction.
generator-o, generator ; **—de kontinua kurento,** continuous current g.
glat-a, smooth ; **-igi,** to smooth.
glim-o, mica.
grad-o, degree, co-efficient (*see* **Koeficiento**) ; **kupla—,** coupling c.
grajna koheroro, granular coherer.
grajna mikrofono, granular microphone.

Ĝ

Ĝiger-o, Jigger, oscillation transformer.

H

Harmonik-o harmonic.
hel-a, bright ; **—valvo,** bright (emitter) valve ; **mal-a,** dull (emitter) valve.
heliks-o, helix.
henri-o, henry ; **mikro-o,** microhenry.
Hertza ondo, Hertzian wave, electromagnetic wave.
heterodin-o, heterodyne ; **mem-o,** self-h. ; **super-o,** super-h.
hidrarg-o, mercury.

I

Impedanc-o, impedance.
indukt-o, induction ; **mem-o,** self-induction ; **-a,** inductive ; **-a motoro,** induction motor ; **ne-a, sen-a, ŝunto,** non-inductive shunt.
induktanc-o, inductance ; **antena—,** aerial i. ; **antenagorda—,** aerial tuning i. (A.T.I.) ; **primaria—,** primary i. ; **sekundaria—,** secondary i.
inert-a, inert ; **-eco,** inertia.

inkandeska katodo, incandescent cathode.
inter, amongst, between; **-a,** intermediate; **-a cirkuito,** i. circuit; **-valva,** intervalve.
interfer-o, interference (*see* **Ĵami**).
interupt-i, to cut out, switch off; **-ilo,** interrupter (*see* **Interuptoro**).
interuptor-o, interrupter, cut out switch, make-and-break; **aŭtomata—,** automatic cut-out; **cirkuita—,** circuit breaker; **elektroliza—,** electrolytic interrupter; **hidrarga—,** mercury i.; **hidrarga turbo-o,** mercury turbine i.; **martela—,** hammer break, trembler; **ŝarĝa—,** charging switch; **—de indukta bobeno,** induction i.; **—de kampo,** field break switch; **—de kurento,** current i.; **-a tabulo,** switchboard (*see* **Ŝalto, Komutatoro**).
izol-i, to insulate; **-ita,** insulated; **-eco,** insulation (*state*); **-ilo,** insulator (*see* **Izolatoro**).
izolator-o, insulator; **fleksebla—,** flexible i.; **—de eniro,** leading-in i.

Ĵ

Ĵako, jack.
ĵam-i, to jam; **-o, -ado,** jamming.
ĵul-o, joule.

K

Kadr-o, -a anteno, frame aerial, loop antenna.
kalibr-i, to calibrate; **-o, -ado,** calibration.
kamp-o, field; **elektra—,** electric f.; **magneta—,** magnetic f.; **interuptoro de—,** f. break switch; **reostato de—,** regulating resistance.
kapacit-o, capacity; **antena—,** aerial c.; **mem-—,** self-c.; **rezistanca—,** resistance c.; **superfluaj -oj,** stray capacities.
kapacitanc-o, capacitance.
karbon-o, carbon; **-diska mikrofono,** c. disc microphone; **-cilindra mikrofono,** c. rod microphone.
karborund-o, carborundum.
kaskad-o, cascade; **-a formo,** c. formation; **-e,** in cascade.
"katlipharo," "cat-whisker."
katod-o, cathode; **inkandeska—,** incandescent c.
kern-o, core; **aera—,** air-c.; **fera—,** iron-c.
klav-o, key; **senda—,** sending k. (*see* **Manipulatoro**).
klem-o, terminal (*see* **Borno**).
kod-o, code; **Morsa—,** Morse c.
koeficient-o, coefficient; **kupla—,** coupling c.
koher-i, to cohere; **mal-i,** to decohere; **-ilo,** coherer (*see* **Koheroro**); **mal-ilo,** decoherer (*see* **Dekoheroro**).
koheror-o, coherer; **fajlaĵa—,** filings c.; **grajna—,** granular c.
kompens-i, to compensate, to balance; **-ita,** balanced; **-ita ricevilo,** b. receiver; **-itaj signaloj,** balancing signals; **-ita kristala detektoro,** balanced crystal detector; **-ilo,** compensator (*see* **Kompensatoro**).
kompensator-o, compensator.
kompon-i, to compose; **-aĵo,** component, part.
kompund-a, compound.
komun-a, mutual, common; **—konduktanco,** m. conductance.
komut-i, to change over, to switch over; **-o,** changing over, switching over; **-o por ricevo,** change of connections for receiving; **-o por sendo,** change of connections for transmitting, **ilo,** change-over switch (*see* **Komutatoro**).
komutator-o, change-over switch, commutator; **dupolusa—,** double-pole switch; **duvoja—,** two-way s.; **turna—,** rotary s.; **—a tabulo,** s.-board.
kondens-i, to condense; **-ilo,** condenser (*see* **Kondensatoro**).
kondensator-o, condenser; **alĝustigebla—,** adjustable c.; **antenagorda—,** A.T.C.; **bloka—,** blocking c.; **fermita cirkuita—,** C.C.C.; **sekundaria cirkuita—,** secondary circuit c.; **duopa—,** twin-coupled c.; **varia (variigebla)—,** variable c.; **verniera—,** vernier c.; **—kun malgranda perdo,** low-loss c.
konduk-i, to conduct; **-ilo,** conductor, lead (*see* **Konduktoro**); **-iva,** conductive.
konduktanc-o, conductance; **komuna—,** mutual c.
konduktor-o, conductor, lead.
konekt-i, to connect; **-o,** connection (*action*); **-aĵo,** connection (*thing*).
konstant-o, constant; **dielektrika—,** dielectric c.
kontakt-o, contact; **ŝova—,** sliding c.; **-a fadeneto por kristalo,** contact wire for crystal, cat-whisker (*see* **Katlipharo**); **-a mikrofono,** c. microphone.
kontinu-a, continuous, direct; **—kurento,** direct current; **—ondo,** continuous (sustained, undamped) wave.
kontraŭpez-o, counterpoise, capacity earth.
kontrol-i, to control; **-panelo,** control-panel.
konvert-i, to convert; **-ilo,** converter (*see* **Konvertitoro**).
konvertitor-o, converter.
krad-o, grid; **-a cirkuito,** g. circuit; **-a rezistanco,** g. resistance (leak); **-a tensio,** g. bias, potential
kristal-o, crystal; **-a detektoro,** c. detector.
krud-a, coarse.
kulombo, coulomb.
kupl-i, to couple; **-o, -ado,** coupling (*action*); **-eco,** coupling (*state*); **apuda -o,** close (tight) c.; **elektromagneta, elektrostatika, -o,** electromagnetic, electrostatic, c.; **fiksa -o,** fixed c.; **indukta -o,** inductive c.; **reakcia -o,** reaction c.; **rezistanca -o,** resistance c.; **termo-o,** thermocouple; **transformatora -o,** transformer c.; **varia (variigebla) -o,** variable c.; **-ilo,** coupler; **vario-ilo,** vario-coupler; **-ita,** coupled; **induktive -ita,** inductively coupled.
kupr-o, copper; **stanita -o,** tinned c.; **-a pirito,** copper pyrites.
kurent-o, current; **alterna—,** alternating c.; **altfrekvenca—,** high frequency c.; **kontinua,—** direct c.; **malaltfrekvenca—,** low frequency c.; **primaria alterna—,** primary alternating c.; **-a interuptoro,** c. interrupter.
kurv-o, curve (graph); **karakteriza—,** characteristic c.

L

Lamen-i, to laminate; **-ita,** laminated; **-aĵoj,** laminations.
lamp-o, valve (*see* **Valvo**).
laŭt-a, loud; **-igilo, -parolilo,** loud-speaker.
Lejdena botelo, Leyden jar.

M

Magnet-o, magnet; **elektro-a,** electromagnetic.
maksimum-o, maximum.
malalt-a, low; **—frekvenco,** low frequency; **—tensio,** low tension.
manipulatoro, sending key (*see* **Klavo**).

martela interuptoro, hammer break, trembler.
mast-o, mast ; **dismuntebla—,** compound m. ; **portebla—,** portable m.
mem-ekscita dinamo, self-excited dynamo.
mem-indukt-o, self-induction.
mem-kapacit-o, self-capacity.
mem-oscil-o, self-oscillation.
mem-skribilo, mem-skribanta aparato, recorder, recording apparatus.
metr-o, meter ; **amper-o,** ammeter ; **dekre-o,** decremeter ; **frekvenc-o,** frequency m. ; **galvano-o,** galvanometer ; **mikro-o,** micrometer ; **miliamper-o,** milliammeter ; **ondo-o,** wavemeter ; **potencio-o,** potentiometer ; **radiogono-o,** radio-i goniometer ; **volt-o,** voltmeter.
mezura bobeno, measuring coil.
mikro-, micro- ; **-farado,** microfarad ; **-henrio,** microhenry ; **-metro,** micrometer.
mikrofon-o, microphone ; **grajna—,** granular m. ; **karbondiska—,** carbon disc m. ; **karboncilindra—,** carbon rod m. ; **kontakta—,** contact m. ; **pulvora—,** powder m.
miliamper-o, milliampere ; **-metro,** milliammeter.
minimum-o, minimum.
modul-i, to modulate ; **-o, -ado, -eco,** modulation.
Mors-o, Morse ; **-a kodo,** M. code.
motor-o, motor ; **alternkurenta—,** A.C. m. ; **asinkrona—,** asynchronous m. ; **indukta—,** induction m. ; **-alternatora grupo kun diska sparkilo,** motor-alternator disc set.
mobvobena ampermetro, moving-coil ammeter.
multetaĝ-a, multi-stage (*see* **Multopa**).
multfaz-a, multiphase, polyphase ; **—alternatoro,** m. alternator.
mult-opa, multiple, multi-stage ; **—agordilo,** m. tuner ; **—sendo kaj ricevo,** m. transmission and reception ; **—sparkilo,** m. spark gap.
multvibr-ilo, multi-vibrator.
munt-i, to mount ; **dis-i,** to dismount.

N

Neakut, flat ; **—agordo,** f. tuning.
nefermit-a, open ; **—anteno,** o. aerial ; **—cirkuito** o. circuit.
negativ-a, negative.
neon-o, neon ; **-a tubo,** n. tube.
neŭtrodin-o, neutrodyne.
nod-o, node ; **—de intenseco,** current n. ; **—de tensio,** potential n.
norm-o, standard, norm ; **-igi,** to standardise.

O

Om-o, ohm ; **meg-o,** megohm.
ond-o, wave ; **amortiza—,** damped w. ; **elektromagneta—,** electromagnetic w. ; **Hertza—,** Hertzian w. ; **kontinua—,** continuous (sustained, undamped) w. ; **portanta—,** carrier w. ; **propagado de -oj,** propagation of waves ; **-metro,** wavemeter ; **-a frekvenco,** wave frequency ; **sub-eto,** ripple ; **sub-eta elimino,** ripple elimination ; **-ŝanĝa komutatoro,** wave-changing switch.
orelpec-o, earpiece (*of telephone receiver*) ; **ĉapo de—,** e. cap.
oscil-i, to oscillate ; **ek-i,** to break into oscillation ; **-o,** oscillation ; **fundamenta -o,** fundamental (natural) o. ; **mem-o,** self-oscillation ; **-a,** oscillating, oscillation (*adj.*) ; **-a transformatoro,** oscillation transformer, jigger ; **fermita -a cirkuito,** closed oscillating circuit ; **nefermita -a cirkuito,** open oscillating circuit ; **-ilo,** oscillator (*see* **Oscilatoro**).
oscilator-o, oscillator.

P

Panel-o, panel ; **kontrol-o,** control-p.
paralel-a, parallel ; **konektita -e,** connected in p.
perikon-o, perikon ; **-a detektoro,** p. detector.
permes-o, permission, licence ; **riceva, senda—** receiving, transmitting l.
perturb-oj, disturbances.
pil-o, cell ; **seka -o,** dry c. ; **-aro,** battery.
pirit-o, pyrites ; **fera—,** iron p. ; **kupra—,** copper p.
plat-o, plate ; **—de telefonilo,** diaphragm of telephone receiver ; **-a cirkuito,** plate circuit.
polus-o, pole ; **-a,** polar, pole (*adj.*) ; **du-a,** double-pole ; **unu-a,** single-pole.
porcelan-o, porcelain.
potenc-o, power ; **faktoro de—,** power factor.
potenciometro, potentiometer.
pozitiv-a, positive.
primari-o, primary ; **eliro de—,** outer p. ; **eniro de—,** inner p.
propagado de ondoj, propagation of waves.
proporci-o, proportion, ratio.
pulvora mikrofono, powder microphone.

R

Radi-o, radio ; **-amanto,** r. lover, " fan " ; **-amatoro,** r.-amateur ; **-ejo, -o-stacio,** r. station ; **-isto,** r. professional ; **-ulo,** r. user ; **-o-frekvenco,** r. (high) frequency ; **-o-telefonio,** r.-telephony ; **-o-telegrafio,** r. telegraphy ; **-i, -adi,** to radiate ; **-ado,** radiation ; **-anta,** radiating.
radiogoniometr-o, radiogoniometer.
rapid-eco, velocity.
reakci-o, reaction, regeneration, feed-back (*see* **Regenero**) ; **-a kuplo,** r. coupling ; **super-o,** super-regeneration.
reaktanc-o, reactance.
refleks-a, reflex.
regener-i, to regenerate ; **-o,** regeneration, reaction, feed-back ; **super-o,** super-regeneration (*see* **Reakcio**).
registr-i, to log, to register ; **-o-libro,** log-book.
reĵet-i, to reject ; **-a,** rejector (*adj.*).
rektif-i, to rectify ; **-o, -ado,** rectification ; **-ilo,** rectifier (*see* **Rektifikatoro**).
rektifikator-o, rectifier.
relaj-o, relay ; **alt-tensia—,** high tension r. ; **—de la manipulatoro (senda klavo),** key r. ; **-i,** to relay.
rendiment-o, efficiency.
reostat-o, rheostat, variable resistance ; **filamenta—,** filament r. ; **starta—,** starting resistance ; **—de kampo,** regulating resistance.
resonanc-o, resonance ; **-a kurvo,** r. curve.
resonator-o, resonator.
rezistanc-o, resistance ; **alta—,** high r. ; **izola—,** insulation r. ; **krada—,** grid r. (leak) ; **malalta—,** low r. ; **varia (variigebla)—,** variable r. ; **-a amplifikatoro,** r. amplifier ; **-a kapacito,** r. capacity ; **-a kuplo,** r. coupling.
ricev-i, to receive ; **-o, -ado,** reception ; **-anto, -isto,** receiver (*person*) ; **-ilo, -aparato,** receiver, receiving apparatus, r. set ; **kompensita -ilo,** balanced receiver ; **-ilo por kontinuaj ondoj,**

continuous wave receiver ; **-ila aranĝo,** receiver arrangement.
rotor-o, rotor.

S

Satur-eco, saturation.
sekundari-o, secondary ; **eliro de—,** outer s. ; **eniro de—,** inner s.
selekt-i, to select ; **-iva,** selective ; **-iveco,** selectivity.
send-i, to transmit, to send ; **-a,** transmitting (*adj.*) ; **-a klavo,** sending key ; **-o, -ado,** transmission ; **-anto, -isto,** transmitter (*person*) ; **-ilo, -aparato,** transmitter, transmitting apparatus, t. set ; **dis-i,** to broadcast (*see* **Brodkasti**) ; **el-i,** to emit ; **el-o,** emission (*see* **Emisio**).
senfaden-a, wireless ; **—telegrafio, telefonio,** w. telegraphy, telephony ; **-isto,** w. operator.
seri-a, series (*adj.*) ; **konektita -e,** connected in s.
signal-o, signal ; **vok-o,** call-sign ; **kompensitaj (ekvilibritaj) -oj,** balancing signals.
silent-igilo, damper.
sinkron-a, synchronous ; **—sparkilo,** s. discharger.
sintez-a, synthetic.
sintoni-o, syntony.
sintoniz-i, to syntonise, to tune (*see* **Agordi**) ; **-o,** syntonisation ; **-ita sistemo,** tuned system.
skrib-i, to write ; **-ilo, -anta aparato,** writing apparatus ; **mem-ilo, mem-anta aparato,** self-recorder, self-recording apparatus.
sold-i, to solder.
sonfort-igilo, note magnifier, L.F. amplifier.
spark-o, spark ; **estingita—,** quenched s. ; **—de rompo,** break s. ; **-a distanco,** sparking distance ; **-ilo,** spark gap, discharger ; **asinkrona -ilo,** asynchronous d. ; **estinga -ilo,** quenched s.g. ; **multopa -ilo,** multiple s.g. ; **turna -ilo,** rotary s.g.
spil-i, to tap, to draw from (*see* **Tapi**) ; **-aĵoj,** tappings.
spindel-o, spindle.
spul-o, coil (*see* **Bobeno**).
stabil-a, stable, firm ; **-eco,** stability ; **-igilo,** stabiliser.
staci-o, station.
stang-o, pole, staff ; **apartiga—,** spreader.
start-i, to start ; **-a reostato,** starting resistance ; **-ilo,** starter.
stator-o, stator.
streĉ-o, stress ; **dielektrika—,** dielectric s.
super, above, super ; **-heterodino,** super-heterodyne ; **-regenero,** super-regeneration ; **-sona,** supersonic.

Ŝ

Ŝalt-i, to switch (*general term*) ; **-ilo,** switch ; **-a tabulo,** switch-board.
ŝarĝ-i, to charge ; **-a interuptoro,** charging switch ; **-o,** charge ; **-tro-o,** overload.
ŝelak-o, shellac.
ŝirm-i, to screen ; **-ita,** screened.
ŝova kontakto, sliding contact.
ŝtopi-, to plug ; **-ilo,** plug ; **bobena -ilo,** coil plug ; **en-i,** to plug-in ; **en-a bobeno,** plug-in coil.
ŝunt-o, shunt ; **altindukta—,** highly inductive s. ; **neindukta—,** non-inductive s.

T

Tap-i, to tap, to take a tapping ; **-aĵoj,** tappings.
telaŭtograf-o, telautograph.
telefon-o, telephone ; **-ilo, -ricevilo,** t. receiver.
telefoni-o, telephony.
telegraf-o, telegraph.
telegrafi-o, telegraphy.
tensi-o, tension, voltage, potential ; **alta—,** high t. ; **malalta—,** low t. ; **nodo de—,** potential node ; **ventro de—,** potential loop ; **alt -a relajo,** H.T. relay.
ter-o, earth, ground ; **-a konektaĵo,** e. connection.
termion-a, thermionic ; **—valvo,** t. valve.
termoelektr-a, thermoelectric.
termokupl-o, thermo-couple.
Tesla bobeno, Tesla coil.
tetrad-o, tetrode, four-electrode valve.
tikl-ilo, tickler.
trafpov-o, range.
transform-i, to transform ; **-ilo,** transformer (*see* **Transformatoro**).
transformator-o, transformer ; **altfrekvenca—,** H.F. t. ; **malaltfrekvenca—,** L.F. t. ; **aerkerna—,** air core t. ; **altproporcia—,** high ratio t. ; **malaltproporcia—,** low ratio t. ; **enŝtopa—,** plug-in t. ; **oscila—,** oscillation t. ; **-a kuplo,** t. coupling.
triod-o, triode, three-electrode valve.
troŝarĝ-o, overload.
tub-o, tube (*see* **Valvo**).
turbo-alternatoro, turbo-alternator.
turbo-interuptoro, turbo interrupter.
turna spark-ilo, rotary spark gap.
turnboben-o, rotor (*see* **Rotoro**).

U

Ulul-i, to howl ; **-ado,** howling.

V

Vaku-o, vacuum ; **-a tubo,** v. tube.
valor-o, value ; **efika—,** root mean square (value).
valv-o, valve ; **amplifa—,** amplifying v. ; **detekta—,** detecting v. ; **du-, tri-, kvar-elektroda—,** two-, three-, four-electrode v. ; **hela—,** bright (emitter) v. ; **malhela—,** dull (emitter) v. ; **-a detektoro,** v. detector ; **-a amplifikatoro,** v. amplifier.
vari-i, to vary ; **-a, -iga,** variable ; **-o-kuplilo,** vario-coupler.
variometr-o, variometer.
varmfaden-a, hot-wire (*adj.*) ; **—ampermetro,** h.w. ammeter ; **—voltmetro,** h.w. voltmeter.
vat-o, watt ; **kilo-o,** kilowatt.
velk-i, to fade ; **-o,** fading.
ventro de intenseco, current loop.
ventro de tensio, potential loop.
vernier-a, vernier.
vibr-i, to vibrate ; **-ilo,** vibrator ; **mult-ilo,** multi-vibrator.
voj-o, way ; **du-a,** double-way, double-throw ; **unu-a,** single-way, single-throw.
vok-i, to call ; **-signalo,** call-sign.
volt-o, volt ; **-metro,** voltmeter ; **varmfadena -metro,** hot-wire voltmeter ; **alternkurenta -metro,** A.C. voltmeter ; **kontinukurenta -metro,** D.C. voltmeter.

Z

Zum-i, to buzz ; **-ilo,** buzzer.

Correspondence

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

Rectification—A Reply.

The Editor, E.W. & W.E.

DEAR SIR,—I should like to reply to the two correspondents who commented upon my article on "Rectification," published in the December issue. The low anode current is naturally due to the relatively low filament current employed in the Ora valve. The suggestion of substituting a broadcast station would not, I am afraid, give the satisfactory results anticipated by Mr. H. Emmons, but I hope to extend these experiments in the near future by employing ordinary, interrupted C.W. and specially-modulated C.W., when I trust the results will be made public and comparisons be made.

With reference to the cases quoted by Mr. Emmons, I should be glad to know if the better results were judged qualitatively or quantitatively, and if grid-leak resistance values were measured before and after the experiment, and also whether account was taken of the insulation resistance between valve-holder electrodes, as mentioned in my article of the January issue?

I would refer Mr. Smith to my remarks above, but fail to appreciate his sentence concerning the obvious effect of the wave-length on grid-leak values. The wave-length employed was above broadcast values—between 600 and 700—but the determination of optimum resistance values depends on the grid characteristic, as ably illustrated in the article "The Perfect Set," in the November issue of E.W. & W.E.

H. J. BARTON CHAPPLE.

Bradford Technical College.

Grid and Anode Rectification.

The Editor, E.W. & W.E.

DEAR SIR,—The disparagement of the valve as an "anode" detector on the score of inefficiency reaches its climax in Mr. H. J. Barton Chapple's article in your December issue. It is to be noted, however, that his conclusions are based on the use of the same valve for both methods. The Ora is quite suited to the cumulative grid-detecting system, but of all the hundred or so types on the British market it would be a problem indeed to choose one less suited to anode rectification. The 5—1 signal strength ratio would be much nearer the 3—2 mark if the valves were chosen for their work. Of course, the output instrument (transformer primary, etc.) must be suited to the comparatively high impedance of the anode detecting valves—comparative, that is, to that of grid detectors. L.F. transformers with primaries of 60 and more henries are easily obtainable, and under the best conditions in each case, anode detecting does not fall very far behind the grid method in strength (of little importance, after all), and the tonal superiority of the former is unquestioned in the case of telephony.

Your note at the foot of p. 186 seems to imply that the R.S.G.B. is more or less to blame. Now I wonder what *would* be the reply of either of the Services if the R.S.G.B. offered such assistance as that accepted from the American amateurs? An iceberg would probably arrive at 53, Victoria Street, carefully packed! Besides, the Post Office would probably demand a deposit of £103 for licences before opening a prolonged and abortive discussion, extending long after the period required had elapsed.

L. J. VOSS.

Plymouth.

H.F. and L.F. Amplification.

The Editor, E.W. & W.E.

DEAR SIR,—Your remarks concerning the choice of H.F. and L.F. for short-wave DX work in your "Editorial Views" in a recent issue of E.W. & W.E. are somewhat misleading. To the inexperienced amateur it would appear that for efficient two-way DX working an H.F. amplifier should be used, and that for reception purposes only one is able to dispense with the H.F. amplifier and to use L.F.

Now let us consider what is required by the transmitting amateur and the receiving amateur. In the first case the receiver must be sensitive, selective and capable of quick searching; and in the second case it must have precisely the same properties.

There is no reason why the receiver should be different in these two cases. The transmitting experimenter must have a receiver capable of quick searching, since the fellow at the other end may wish to change his wave-length. When the operator closes down to one station, he always listens to see if any other stations are calling him, and quick searching is again necessary.

One type of receiver is needed. The supersonic heterodyne is too expensive for most of us, and the ordinary H.F. amplifier is dismissed as being incapable of quick searching.

We are left with the detector and L.F. set. Examples of the sensitivity and selectivity obtainable in this type are met with daily, and it cannot be said that it is difficult to control.

Incidentally, Mr. Hogg informs me that he is now using a detector and one L.F. in place of his old H.F. and detector. For the past two months I have been doing two-way DX work of the usual standard, and have not experienced even the slightest trouble with the receiver.

These facts, together with the other evidence, help to prove that for either two-way communication or reception only the detector and L.F. type of receiver is the best, from the experimenter's point of view, for short-wave, DX work.

S. K. LEWER.

West Hampstead.

[These arguments seem to us quite unconvincing. In our opinion, the "best" type of receiver for logging call signs will be of quite a different type from the "best" for two-way working. This correspondence is now closed.—ED., E.W. & W.E.]

Efficiency of the Counterpoise.

The Editor, E.W. & W.E.

DEAR SIR,—I was much interested in Mr. M. C. Ellison's article, "The Efficiency of the Counterpoise," appearing in your January issue. May I point out one little fallacy? Throughout the article Mr. Ellison states that his radiation was so-and-so many ampères. A high-frequency generating system connected to an aerial does not radiate ampères; it radiates watts.

Not for one moment do I imagine Mr. Ellison is ignorant of this simple fact, but there is a great tendency by experimenters to express their radiation in ampères. It is a very minor point, but one finds it so constantly being used that I feel this is an excellent opportunity "to drop a gentle hint."

Mr. Ellison says he thinks the only apparent advantage of the counterpoise is to reduce the fundamental wave-length of the aerial. Besides this important fact, surely one of the greatest advantages of the counterpoise, from an amateur point of view, is to reduce the ground loss resistance of the whole radiating system?

Hove. DALLAS G. BOWER.

The Editor, E.W. & W.E.

DEAR SIR,—In the January issue of E.W. & W.E. there is an article by Mr. M. C. Ellison about "The Efficiency of the Counterpoise," in which he makes the curious statement that the counterpoise system is less efficient than the earth system.

Of course, this cannot be the fact, especially if the counterpoise is well designed. Not only is the fundamental wave-length reduced, as mentioned by the author, but—and here the gain lies—the total loss-resistance of the aerial system is reduced. At the same time, the radiation resistance is very little (if at all) decreased; it may even be greater than before. Thus the aerial efficiency, *i.e.*, the ratio between the radiation resistance and the total resistance, will be increased.

If we wish to compare the efficiencies of the systems mentioned above we have to supply them with the same amount of power, and that so as to give different ammeter readings, for if we do not know the maximum points of aerial current, the ammeter tells us nothing.

Finally, the author's way of comparing the systems by measuring the voltage induced in a tuned coil in the vicinity of the aerial is wrong. Near the aerial the fields may have any direction and any value; it may even happen, as in the author's case, that the earth system will give larger readings on the voltmeter. But make the same measurements, say, 15 wave-lengths from the aerial, where the geometric dimensions of the aerial can be neglected!

Some months ago I was experimenting on these lines and fully proved the quite enormous gain in efficiency by the use of a counterpoise instead of the normal earth. Wave-lengths, 80-150 metres

Stockholm. GUSTAV LAMM (Swedish SM27).

"Poaching."

The Editor, E.W. & W.E.

DEAR SIR,—I should be obliged if your valuable columns could be used to draw attention to the fact that from reports received some person is making illicit use of our call 2AW.

This station has not operated since March last, and will not do so for a month yet.

From the regularity of reports the Birmingham area would be indicated, but reports have also been received from the Department of Moselle, France.

Wakefield. H. H. BURBURY.
Crigglestone, Wakefield.

Some Suggestions.

The Editor, E.W. & W.E

SIR,—In the issue of your magazine for October last and at the conclusion of the first "instalment" of "The Perfect Set" series appeared a very wise remark that, "In our opinion there is too much written about detailed construction these days, and not enough about principles, and we have endeavoured to fill in some of the gaps in the latter division." This seems to me to be the crux of the matter in so far as I myself am concerned and, I should imagine, as far as a good number of your readers are likewise concerned. Now, the article, "An Easy Way to Calculate Circuits," by P. K. Turner in your November number is a step, or perhaps two steps, in the right direction; however, I am only fit, mentally, to take my "maths" in small doses, and would appreciate a series of articles on the same subject, not quite so condensed, perhaps, but a little extended in scope, both upwards and downwards. What beginners must have, if they are to learn anything, is the reason why for everything they do, and the reason why they should not do a lot of the things they do. I am very much obliged to you for bringing to my knowledge the workings of the Dewey system.

Again, it seems to me that amateurs will never be able to do any serious work unless they are in the possession of measuring instruments; you have very nobly stepped into the breach with your calibration scheme; most of us have only the money to purchase one decent measuring instrument, if that.

Now, is it practicable for you to publish a series of articles on the measurement of various quantities, not the condensed type of article that only the initiated can understand, but starting with one fairly accurate instrument, such as a sensitive galvanometer, to show us *in detail* how, by admixture of various condensers, resistances, etc., to make a series of fairly accurate measurements of useful quantities, teaching us to check our results somehow or other, and not forgetting to constantly din into our fuddled brains the deductions we should draw. Please do not think that I am trying to teach you your business; but I am simply trying to ask you to do something to help the advancement of Science and to do something for us that no other radio journal in this country has yet done or ever will do. Text-books always assume that one lives in a well-ordered laboratory, and do not show us how to allow for the errors that are always present when amateurs use measuring instruments.

Thanking you for your excellent magazine.

"BEGINNER."

Monmouthshire.

[We welcome letters such as the above, for they indicate a means by which we can serve best the interests of our readers. All suggestions receive careful consideration and, whenever sufficient interest is shown, we endeavour to publish articles dealing with the subjects desired.—ED., E.W. & W.E.]

Esperanto *versus* Others.

The Editor, E.W. & W.E.

DEAR SIR,—In describing the new high-power transmitter at CKAC (Montreal) in your January issue, mention is made of the use by this widely-heard broadcasting station, of an auxiliary language that is other than "Esperanto."

As for some years I too supported Esperanto, but like CKAC am now of the opinion that the alterations effected in its newer form are of the greatest importance, it may be of interest to enumerate the basis of such claims, so far as a short letter will permit.

The first appears in its name: Registered as "The International Language of the Delegation," because it was unanimously adopted and launched by "The International Delegation (of Linguistic Savants) for the Adoption of an Auxiliary Language" and because it is in fact "International" in the sense that all roots used are international ones. "Ido" is used as an abbreviation much as "Espo" is for Esperanto. The word "Ido" is merely an Esperanto suffix serving to indicate a newer form of Esperanto.

"Ilo" is another short name that stands for "International Language (Official)." meaning: "of the Delegation."

[Here followed some detailed comparisions of Ido and Esperanto, which we have omitted. See our note below.—ED., E.W. & W.E.]

The "International Language of the Delegation" is not the product of a single individual or the property of a commercial concern, but claims to be a scientific auxiliary evolved by linguistic savants from the six leading languages, simple, euphonious, regular, having the exactitude of mathematics yet speedy in transmission, and applicable to radio without alteration.

E. H. TURLE, A.M.I.E.E.

London.

[We regret to have to "cut" the letter of a correspondent, but for reasons given in our "Editorial Views," we do not propose to open our columns to any discussion on the comparative, merits from the philological point of view of various international languages —Ed. E.W. & W E.]

More "Effective Transmission."

The Editor, E.W. & W.E.

SIR,—In your issue of December last you published a letter from Mr. E. H. Robinson dealing with my "Effective Transmission" articles. I will reply to his criticisms in the order in which he made them.

A high resistance H.F. circuit will not, and cannot, flatten tuning if both plate and filament supplies are quite pure, but will do so, for the reasons Mr. Robinson gives amongst others, if any modulation is present, as is nearly always the case to some extent in practice. But, in any case, no one, I suppose, will advocate high-resistance coils.

On the question of the side-bands of raw A.C. Mr. Robinson is quite right. I had forgotten, at the moment of writing, the fact that the valve must stop oscillating every other half-cycle. The side-bands produced would, I should imagine, be infinite.

As to the question of harmonics, Mr. Robinson has mis-read the article. He will find that I only condemned harmonics which could be heard by a remote receiver, and are therefore present in the aerial. Harmonics must, of course, be produced in the closed circuit if any sort of efficiency is to be obtained (another reason, by the way, for a low-resistance closed circuit, since we want to keep these components wattless).

Finally, I hope Mr. Robinson does not class me with the "many amateurs who despise theory as not in agreement with practice," as he seems to suggest! If so, he's wrong—both in theory and practice! By the way, the letter below Mr. Robinson's accuses me of a statement (about condensers) which was actually made by another contributor. Sorry, wrong number! Try 2DX!

Wimbledon Park. HUGH H. RYAN.

A New Call Sign.

The Editor, E.W. & W.E.

DEAR SIR,—Please allow me to advise you that the transmitting call sign 2IH was allotted to me some time ago, and I should be pleased if you could publish this fact and also alter your list of call signs.

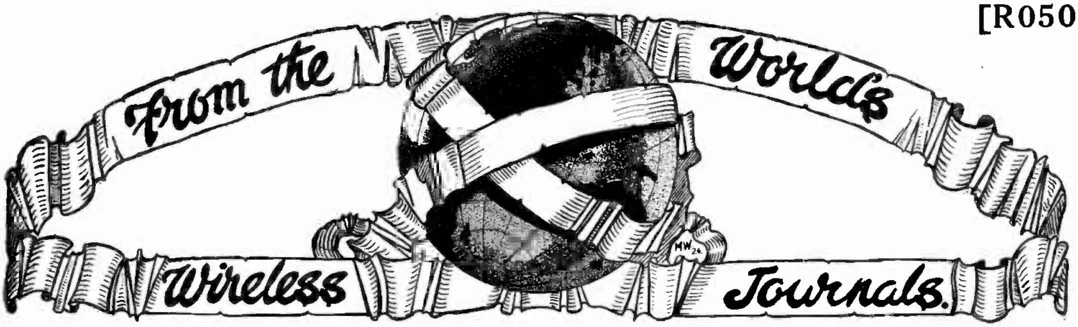
I might add that I shall be at all times pleased to receive reports on my transmissions.

Wishing your periodical every success.

Riddlesden, H. HILEY.

Nr. Keighley.

[R050



R100.—GENERAL PRINCIPLES AND THEORY.

R112·1.—On the Radiation Resistance of a Simple Vertical Antenna at Wave-Lengths Below the Fundamental.—Stuart Ballantine (*Proc. I.R.E.*, Dec., 1924).

R113·4.—Sir Joseph Larmor's Theory: Why Wireless Electric Rays Can Bend Round the Earth.—G. W. de Tunzelman (*Electn.*, Jan. 9, 1925).

Summary of a theory which has been recently developed by Sir Joseph Larmor to explain the bending of radio waves round the surface of the earth. The theory, in some respects, is similar to that suggested earlier by Eccles—inasmuch as an ionised upper atmosphere is involved—but also attempts to put the matter on a tangible scientific basis. The chief feature of the theory is the refraction which may occur in an ionised atmosphere owing to the different velocity of electromagnetic waves in ionised and un-ionised atmospheres.

R121.—On the Optimum Transmitting Wave-length for a Vertical Antenna Over a Perfect Earth.—Stuart Ballantine (*Proc. I.R.E.*, Dec., 1924).

R131.—The Inter-Electrode Capacities of a Valve.—H. J. Barton Chapple, Wh.Sch., B.Sc. (Hons.) (*Exp. W.*, Jan., 1925).

Some measurements on the actual inter-electrode capacities of various types of valve.

R200.—MEASUREMENTS AND STANDARDS.

R210.—Ondamètre d'Absorption Pour Poste Récepteur.—M. Claveux (*Onde Elec.*, Dec., 1924).

The wave-meter described comprises simply a variable tuned circuit, and is intended to work in conjunction with a receiving set. The means of indicating resonance between the wave meter and the receiver are described in the article.

R210.—Standing Waves.—Gustav Lamm and Edward Graham (*W. World*, Dec. 31 and Jan. 7, 1924).

Description of the Lecher wire arrangement for making absolute determinations of wave-length on waves of the order of 10 metres or less. A practical method of laboratory procedure is given.

R210.—Correction Factor for the Parallel Wire System Used in Absolute Radio Frequency Standardisation.—August Hund (*Proc. I.R.E.*, Dec., 1924).

Errors which may occur in Lecher wire measurements and a correction factor to apply.

R210.—Wave-meters.—L. B. Turner, M.A., M.I.E.E. (*W. World*, Dec. 17 and 24, 1924.)

A paper read before the Radio Society of Great Britain dealing with various methods of arriving at frequency and wave-length in radio work. The different methods of absolute measurement are summarised: namely, natural frequency of oscillatory circuits, oscillograph records, generation by H.F. alternator, Lecher wires and multivibrator methods.

Comparison of frequencies and forms of practical calibrated instruments are next dealt with. This involves a detailed discussion on heterodyne, buzzer and detector wave-meters, and means of indicating resonance. The paper concludes with some practical points on the design of wave-meters and wave-length standards for everyday use. It is of interest to note that the author of the paper prefers a variometer and fixed condenser to the usual combination of a variable condenser and fixed inductance for wave-meter purposes.

R240.—Sur l'Absorption des Ondes Courtes J. Granier (*Onde Elec.*, Dec., 1924).

Experiments to determine the resistances and dielectric losses of various substances on oscillatory currents of frequencies of the order of 10^{-8} (3 metres wave-length). A 3-metre oscillator is loosely-coupled to a closed oscillatory circuit containing a fixed inductance, a variable condenser, a known variable resistance and an H.F. current-indicator. The measurement of resistance of a conductor is effected by first inserting the conductor in the circuit and bringing the circuit into exact resonance with the oscillator by means of the variable condenser. Next the conductor under measurement is replaced by the known resistance, which is adjusted until the same current is obtained at resonance as before. For dielectrics these are made to replace the condenser, by again replacing the dielectric under measurement by an air condenser of low losses and re-adjusting the resistance to give the same current, one arrives at the equivalent series resistance corresponding to the dielectric loss.

The H.F. currents being small require an indicating instrument of greater sensitivity than the usual hot-wire ammeter, and the instrument actually used is interesting for its cheapness and ingenuity. An ordinary low consumption 1 c.p. pocket lamp bulb is included in the H.F. circuit so that its filament becomes heated to a greater or less extent by the H.F. currents flowing through it; this causes a change in the D.C. resistance of the bulb which is recorded in a Wheatstone Bridge balanced for D.C., of which the bulb forms one arm. The arrangement is, in effect, a simple bolometer bridge.

The results of measurements made at the above ultra high frequency are interesting. The skin effect of iron is materially exaggerated by the permeability of this metal, and its hysteresis provides a further source of loss. An iron wire 1 mm. in diameter was found to have a resistance of 20 ohms per metre. Tinned copper wire was found to have a resistance 2·8 times that of the bare wire, as the pronounced skin effect causes the major part of the current to flow through the surface layer of tin and not through the body of the copper. Galvanised iron would be a better conductor than tinned copper, since zinc is a better conductor than tin.

The conductivity of a wire immersed in electrolytes of various strengths showed some interesting effects. If the wire was surrounded by electrolyte of only slight conductivity, most of the current was carried by the wire. As the conductivity of the electrolyte was increased, a greater proportion of the current travelled via the electrolyte, while the net resistance of the system was increased. Thus the resistance of a wire 3 cm. long and 0·1 cm. in diameter, immersed in 0·9 per cent. sulphuric acid, showed a resistance of 2·2 ohms, but when immersed in 20 per cent. sulphuric acid, showed a resistance of 4·8 ohms.

The power factor of water as a dielectric in a condenser was measured using distilled water, river water and sea water respectively. With the latter condenser action disappeared as far as the tuned circuit was concerned. Power factor measurements were also made for a number of common dielectrics, and although the figures obtained are not claimed as being accurate absolute values, it has been possible to arrange a number of these substances in a distinct order of merit. Paraffin and mica are easily the best, while dry brick and dry earth come next. These are followed by glass and waxed paper, while below these in the list ebonite ties with ordinary brick! Moist things, like leaves and damp earth, are the worst dielectrics. The author of the article discusses the possible bearing of his observations on ultra-short wave transmission and explains the serious effect of the presence of poor dielectrics in short wave apparatus.

R250.—Measuring very small R.F. Currents.—J. H. Turnbull (*Q.S.T.*, Jan., 1925).

The arrangement described suffices for the measurement of high-frequency currents of the order of one-tenth of a milliampère. It consists of a hard, two-electrode valve (or an ordinary triode with grid and anode connected together), in the anode circuit of which is included a milliammeter and a source of fixed potential.

An ammeter is also provided in the filament circuit, and a curve is plotted showing anode current against various heating currents through the filament. The small H.F. currents to be measured are passed through the filament (which has been previously adjusted to a convenient brightness), and the change in emission as indicated by the plate milliammeter is noted. From the calibration curve the superimposed H.F. current through the filament is deduced. Of course, suitable chokes have to be provided to prevent the H.F. currents passing through the filament heating battery.

R281.012.5.—Electrical Constants of Dielectrics for Radio-Frequency Currents.—R. V. Guthrie, Jr. (*Proc. I.R.E.*, Dec., 1924).

We hope to publish an abstract of this in our next issue.

R300.—APPARATUS AND EQUIPMENT.

R321 : R326.—Some Experiments with Aerial and Earth Systems for Reception.—R. L. Smith-Rose, Ph.D. and F. M. Colebrook, B.Sc. (*Exp. W.*, Jan., 1925).

The results of some long-needed precise experiments on the relative merits of various aerial earth and counterpoise systems for reception on wave-lengths in the region of 300 metres.

R330.—Moderne Empfängröhre.—H. Rukop (*Telefunken-Zeitung*, Oct., 1924.)

A general and historical article on German valve technology with particular reference to the Telefunken range of products. Conditions governing the optimum size of filaments, dull-emitting filaments, etc., are discussed.

R334.—La Lampe à Quatre Electrodes.—H. Nozières and P. Giroud (*Onde Elec.*, Dec., 1924).

The purpose and properties of the use of an auxiliary grid in a thermionic valve are explained. The idea is that of Langmuir who took out a patent in 1913. The action by means of which the auxiliary (internal) grid reduces the space charge, and the practical advantages accruing therefrom, are explained with the aid of curves and diagrams.

R355.52.—Mercury Arc Rectifiers.—Earl D. Smith (*Q.S.T.*, Jan., 1925).

Short account of some experiments on the use of a mercury arc to produce H.T. plate supply for a valve transmitter. Results were obtained but were not altogether satisfactory because the power required to keep the mercury arc alight was large compared with the power required for the transmitter. It is not worth attempting to use an ordinary mercury arc rectifier for inputs of anything less than 100 watts to the transmitter.

R374.—A TEST FOR CRYSTALS.—P. K. Turner (*Exp. W.*, Jan., 1925).

Details of a method of making quantitative measurements on a crystal receiver for the purpose of specifying the merits of various crystals. The means by which the difficult problem of measuring H.F. power of a few microwatts has been solved are of particular interest.

R374—375.—BEITRÄGE ZUR KENNTNIS DER DETEKTORWIRKUNG (CONTRIBUTION TO THE KNOWLEDGE OF DETECTOR-ACTION).—Georg Hilpert (*Telefunken-Zeitung*, Oct., 1924).

This article describes some observations on the thermoelectric and detecting properties of loose contacts between metallic wires. Rectification falls into two distinct classes, namely, that due to pure valve action and that which is occasioned by curvature in the voltage-current characteristic of some system. An interesting fact is pointed out; that if a condenser be inserted in series with an ordinary detector signals are still audible in a pair of telephones, although all D.C. current, except that required for the initial charging of the condenser, is stopped. This is due to the difference in wave-form produced on the positive and negative half-cycles of the H.F. voltage across the condenser, which causes alternate half-cycles to affect the telephones to a different degree. The chief interest of the article lies in the experiments with junctions of two pieces of the same metal. If the ends of two platinum wires are allowed to touch and the junction thus formed symmetrically heated in a flame no thermoelectric current can be detected in any circuit of which the junction forms part. This, of course, is to be expected. If, however, the flame is shifted to one side of the junction so that the temperatures either side of the point of contact are not symmetrical, then a distinct thermoelectric current may be registered. This effect is much more pronounced if copper wires are used instead of platinum. In this case a film of copper oxide between the contact points is supposed to account for the observed phenomenon; the junction actually consisting of two copper to copper oxide junctions in opposition. If placed symmetrically in a flame both junctions will attain the same temperature and will, therefore, generate equal and opposite thermo-E.M.F.'s. By holding flame to one side the temperature conditions in the two junctions are different, different thermo-E.M.F.'s are produced and a resultant current flows. Now the thermoelectric E.M.F. of a couple is seldom a linear function of the temperature over any large range of temperature, so that junctions of the kind under consideration may have conductivity characteristics similar to those exhibited by crystal detectors.

Experiments were made using asymmetrically-heated junctions as detectors for wireless signals. For convenience the heating was effected by means of an auxiliary spiral carrying an electric current. It was found that with several different substance for the junction signals from a neighbouring transmitting station could be distinctly heard in a pair of telephones. For any one combination there was a definite temperature which gave the best results. The outputs on a presumably constant signal are reproduced below, the figure for a good pyrites detector being included as a standard for comparison.

Metal point—Pyrites	1 000
Copper—Copper	190
Constantan—Constantan ..	105
Platinum—Platinum	9
Iron—Iron	2
Carbon—Carbon	2
Copper—Flame—Copper ..	1

It is pointed out that one of the conditions for detection with such couples is that the contact resistance must not be too low. Also, the contact pressure must not be too heavy or the oxide film may be pierced. We are rather left in doubt however as to what intermediate film can exist in the case of the carbon-carbon contact, but still the writer does not guarantee the purity of his materials further than they are ordinary commercial samples.

R376.—LOUD-SPEAKERS.—Capt. H. J. Round, M.I.E.E. (*W. World*, Dec. 17, 1924).

Description of a loud-speaker designed on analogous lines to the Sykes-Round magnetophone. The speech-currents energise a light coil of wire held by a special diaphragm in a powerful magnetic field, the diaphragm having a natural period of vibration of about 1/250 of a second. It is stated that this type of loud-speaker may be constructed for very loud reproduction. Some of the difficulties experienced in operating public address systems are briefly mentioned.

R600.—STATIONS: DESIGN, OPERATION AND MANAGEMENT.

R610.—THE HIGH POWER STATION AT MALABAR, JAVA.—Dr. C. J. de Groot (*Proc. I.R.E.*, Dec., 1924).

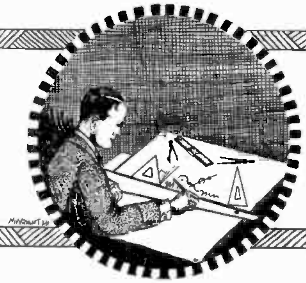
A most interesting technical description of one of the world's great high-power arc stations. A good example of modern high-power radio-engineering practice.

R610.—SHORT-WAVE RADIO BROADCASTING.—Frank Conrad (*Proc. I.R.E.*, Dec., 1924).

The technical history of the KDKA short-wave transmitter, which, it may be recalled, began its career under the amateur call-sign of 8XK.

R610.—BROADCAST TRANSMITTING STATIONS OF THE RADIO CORPORATION OF AMERICA.—Julius Weinberger (*Proc. I.R.E.*, Dec., 1924.)

Technical description. The reader is referred to the original paper for details.



Some Recent Patents

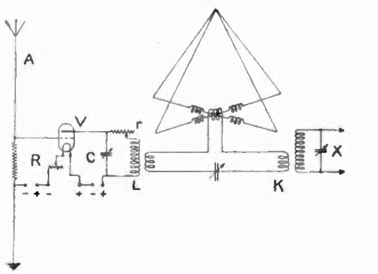
(The following notes are based on information supplied by Mr. Eric Potter Patent Agent, Lonsdale Chambers, 27, Chancery Lane, W.C.2.)

[R800

DIRECTIONAL RECEPTION.

(*Application date, May* 18, 1923. *No.* 220,392.)

British Patent No. 220,392 granted to G. M. Wright and L. D. Hill, describes a directional reception scheme shown in the accompanying diagram. It will be seen to consist in combining a non-directional aerial with a directional aerial in the following manner. A non-directional aerial A is damped by means of a resistance R, which is adjusted to give the aerial its critical damping. This resistance is connected across the grid and filament of a valve V, in the anode circuit of which there is an inductance L, the impedance of which is small compared with that of the valve. This impedance can be varied by means of a resistance *r* and a capacity C. This inductance L is coupled magnetically to the search coil of the goniometer. The search coil circuit contains an inductance K which is coupled to a receiving circuit X.

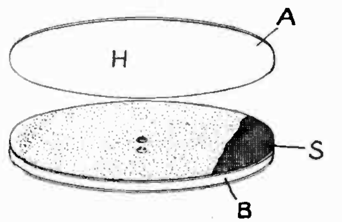


The valve V must have a straight characteristic, and the use of a small transmitting valve is recommended with a resistance in the anode circuit. The operation of the scheme is as follows: Arriving signals set up E.M.F.'s in the aerial A, which are in phase with the field. As the aerial is damped the potentials set up across the resistance R are also in phase. Now as the impedance of the anode coil is small compared with that of the valve the current in the coil is in phase with the potentials across R, so that the induced E.M.F. is 90 degrees out of phase with the field of the arriving signal. Turning now to the frame aerial the E.M.F. is 90 degrees out of phase with the field and as the impedance of the loop circuit is substantially inductive the current is 180 degrees out of phase with the E.M.F., and hence the phase difference between the E.M.F. in the search coil circuit and the field of the arriving signal is 90 degrees. It will therefore be seen that it is possible to obtain a balance between the open and loop aerials, the usual cardioid diagram being obtainable. An advantage of the system is that a heart-shape can be obtained for long wave-lengths on small aerials.

A BUILT-UP DIAPHRAGM.

(*Application date, June* 20, 1923. *No.* 222,180.)

The Radiotive Corporation describe in the above patent a method of diaphragm construction. The diaphragm is built up from two celluloid discs A and B, together with a silk centre S. The silk is spread with a mixture of powdered shellac and mica and the whole is placed under pressure and heated.

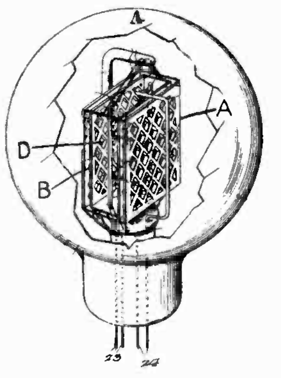


This causes the shellac to melt and forms with the mica a plastic mass which hardens on cooling. The discs are provided with a hole H, to which a lever connected to an armature is attached. The specification describes several modifications and provides for the corrugation of the diaphragm.

ELECTRODE CONSTRUCTION.

(*Application date, August* 17, 1923. *No.* 219,823.)

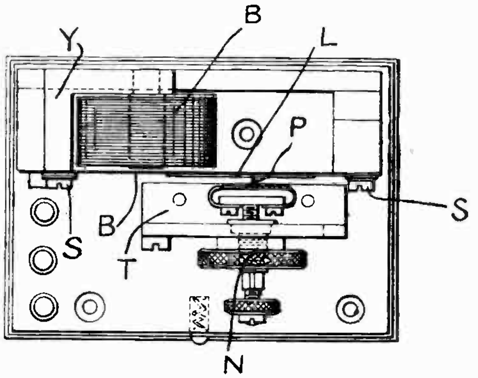
G. la Vere Geisley and F. W. Brown claim in the above patent a form of electrode construction shown in the accompanying diagram. The chief feature of the invention lies in the type of anode and grid which are employed. It will be noticed that the grid B has in it a number of diamond-shaped openings D. These openings coincide with diamond-shaped indentations in the anode A. The grid and anode are assembled so that the indentations in the anode project inwards and are exactly opposite the openings in the control electrode. The object of the invention is to provide a valve which shall be perfectly rigid and as free as possible from microphonic or mechanical noise. It is also stated that this method of construction enables a valve to be produced which can have a high voltage and current output.



A TUNED INTERRUPTER.

(*Application date, May* 30, 1923. *No.* 220,996.)

W. F. Bubb describes in British Patent No. 220,996, a form of interrupter or tunable buzzer illustrated by the accompanying diagram. Across the yoke Y of an electro-magnet a thin blade B is fixed by means of two screws S. This blade carries a contact strip L, which extends for about half the length of the blade. A vertical angle member T carries an adjustable screw N, fitted

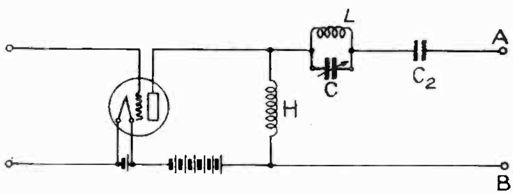


with a contact point P, which can be arranged to touch the strip L on the blade B. The vertical member T is provided with a horizontal slot in which the contact screw and its associated locking nuts and knobs can move. By altering the position of the screw in the slot the frequency at which the reed or blade will vibrate can be altered within very wide limits. An instrument of this type should prove very useful for laboratory measurements and experiments.

AN INTERESTING RADIO-FREQUENCY AMPLIFIER.

(*Application date, October* 22, 1923. *No.* 222,331.)

A very interesting radio-frequency amplifier is described in British Patent No. 222,331, granted to the Western Electric Co., Ltd., and G. H. Nash. The scheme is intended for radio-frequency

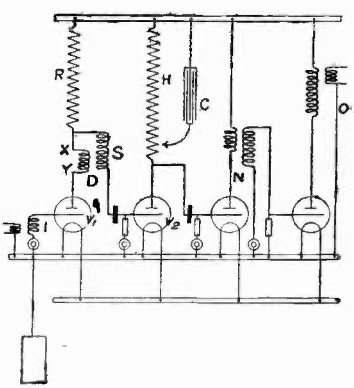


amplification on the broadcast band of wave-lengths. The anode circuit of the first valve contains a radio-frequency choke coil H, which has approximately an inductance of one henry. The output from this valve is shown as A and B, and these leads go respectively to the grid and filament circuit of the next valve. The grid lead, however, contains a tuned circuit LC, and a capacity C2. It is stated that for the present broadcasting range of 300 to 400 metres the coil L should have an inductance of 300 microhenries, while the capacity of the condenser should be 0·000 2 microfarads. The value of the fixed condenser C_2 is given as 0·000 1 microfarads. The object of the invention is to provide very great selectivity and to enable various broadcasting stations to be tuned in without mutual interference. The manner in which the arrangement operates should be obvious. There are really two tuned circuits. The first circuit is constituted by LC—C2, which is really a series acceptor circuit for the desired wave-length. The other circuit is simply LC and constitutes a rejector circuit for other wave-lengths, allowing only a very small potential to be applied to the grid of the next valve by undesired signals. The specification states that it is found possible to receive distant broadcasting stations in London while the London station is in operation. The choke H, of course, provides for the H.T. supply to the anode.

A DIFFERENTIATING AMPLIFIER.

(*Appointed date, June* 28, 1923. *No.* 222,413.)

A. F. Sykes describes in the above patent an amplifying system which is shown in the accompanying illustration and will be seen to consist of an amplifier containing both resistance and transformer coupled valves. The object of the invention is to provide an amplifying system which will differentiate between various frequencies so that almost any desired resulting characteristic can be obtained. The scheme is intended, of course, for speech frequencies, and the

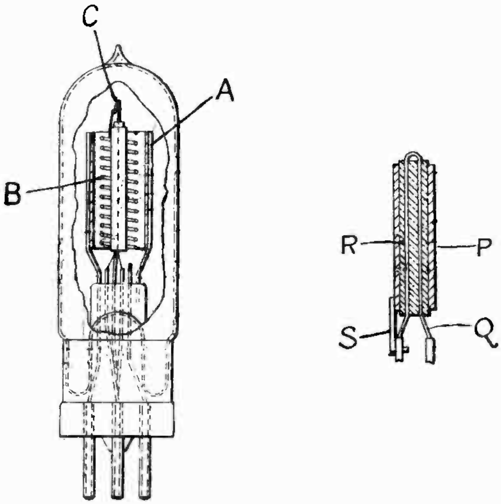


amplifier is suitable for use with the well-known Sykes magnetophone or loud-speaker. The first valve is rendered operative by means of an ordinary input transformer I. The anode circuit of this valve contains a resistance R and the primary winding X Y of the first differentiating transformer D. The secondary S of this transformer is connected to the grid of the next valve by means of a condenser, and the winding is so adapted as to enable it to be connected either to the point X or the point Y of the primary winding. According to the direction in which it is wound it will either diminish or assist the combined effect of the resistance R and the inductance X Y. In the anode of the second valve there is a resistance H, which can be shunted at any point by a condenser C. The potentials derived from this valve are transferred to the next valve which also contains another differentiating transformer N. The general effect of the circuits associated with the valve V1, is to amplify uniformly for low frequencies, but to diminish or increase the values of the higher harmonics according to the connections of the transformers. The effect of the circuits associated with the second valve V2, is to amplify to a greater extent for the bass than for the treble. The claims of the invention seem to indicate that the amplifier is intended primarily for operating a loud-speaker. The idea of differentiating between frequencies is, of course, not new, but this particular method would seem to provide much subject matter for amateur experimental work.

CATHODE CONSTRUCTION.

(*Convention date, January* 8, 1923. *No.* 209,415.)

British Patent No. 209,415, granted to the Westinghouse Electric and Manufacturing Co., describes a type of equi-potential cathode shown in the accompanying diagram, which illustrates the actual construction of the cathode

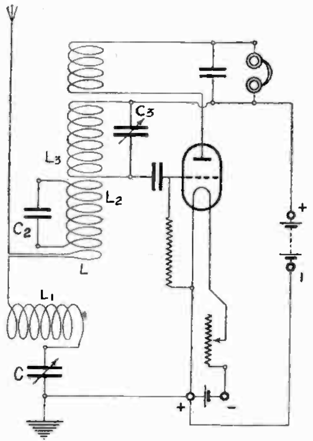


itself and also the method of incorporating it into a valve. It will be seen that it consists of a metal tube P, in the middle of which there is a heater wire Q. The space between the heater wire and the cylinder is filled with a material R, which is thermally conductive, but is at the same time electrically non-conductive. The second part of the diagram shows the electrode fixed into an ordinary valve, in which A is the anode, B the grid, and C the cathode. Electrical connection is made to the cathode surface by means of a link S, joined to one side of the heater wire. The claims of the invention are rather interesting and appear to be exceedingly broad. The essence of the invention lies in the use of some substance such as zircon between the heater filament and the cathode itself.

A PECULIAR RECEIVING CIRCUIT.

(*Application date, September* 18, 1923. *No.* 221,951.)

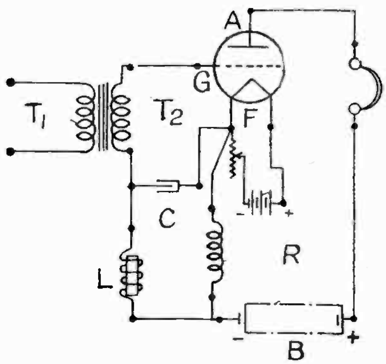
Cooke and Whitfield Wireless, Limited, claim in British Patent No. 221,951, a peculiar receiving arrangement which it is stated gives improved results over the circuits normally employed. Referring to the diagram it will be seen that the aerial circuit L L_1 C comprises two inductances and a capacity all connected in series. The first inductance L, consists of only one turn and this is tightly coupled to a tuned circuit L_2 C_2. This in turn is coupled to the grid circuit L_3 C_3 of the valve V. The grid circuit it will be observed happens to be shown connected to the grid condenser and the positive terminal of the high tension battery. The latter feature alone is, of course, quite old. Reaction is obtained between the grid and anode circuits in the normal manner. From the data provided in the specification it is rather hard to see why the arrangement gives ". . . the maximum clarity and tone," as it is stated to do in the first paragraph. The circuit reminds us of the Cockaday Four-Circuit Tuner.



A GRID BIAS SCHEME.

(*Application date, May* 25, 1923. *No.* 220,727.)

The accompanying illustration shows a grid biasing scheme which is described in British Patent No. 220,727, by E. A. Graham and W. J. Rickets. The object of the invention is to obviate the necessity of a grid bias battery by making use of the fall of potential along a resistance inserted in the anode circuit. This, of course, is not new, but the particular feature of the invention constitutes a modification of the method. Referring to the illustration, it will be seen that the anode circuit of the valve amplifier is completed through a non-inductive resistance R. The secondary winding of the transformer T1 T2, is connected to



the filament through a condenser C. The peculiar feature lies in the use of a choke L, which is connected across the resistance and the condenser. The arrangement is also claimed for an aerial or radio-frequency circuit, the one illustrated being intended, of course, for low frequency work.