EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorial Views.

The Radio Society of Great Britain.

WE have pleasure in informing our readers that commencing with this issue E.W. & W.E. will become the Official Organ of the Radio Society of Great Britain, a position which up to the present has been held by our weekly Sister Journal, *The Wireless World*.

The Radio Society of Great Britain, as most of our readers will be aware, is the headquarters in this country of amateur wireless technical exposition and discussion, and it seems fitting therefore that this Society should have as its organ the premier technical wireless journal of the country.

Developments which have taken place in *The Wireless World* under its new proprietorship have perhaps rendered that journal less fitted to undertake this work, for while the proceedings of the Society in question cannot but be of interest to every reader of a technical paper such as E.W. & W.E., the same can hardly now be said of *The Wireless World*, which under its new proprietorship has now broadened its circle of readers as to embrace a very large number, who, while interested in wireless as a means of entertainment, have not yet made such a technical hobby of it as to be deeply interested in the proceedings of the Society.

E.W. & W.E. is essentially a technical paper, and we feel sure all our readers will benefit by the publication of a full report, not only of the papers which are read before the members of the Radio Society, but also of the discussions at meetings. These full reports will appear first in the pages of E.W. & W.E., and we feel sure that our readers will look forward with pleasure to their publication.

Elementary Articles.

In an incautious moment last month we wrote in "Editorial Views" that we should like the opinions of readers as to whether they desired (*a*) an elementary series on circuit calculations, (*b*) one on setting up a wireless "lab."

We have suffered from excessive correspondence as a result, and the one salient fact that emerges is that half our correspondents want (*a*) and half want (*b*), and that each group beg us not to waste space on the other subject !

Incidentally, quite a large number lament that "much of the material in E.W. & W.E. is above our heads." I must thank these correspondents for the high compliment they pay us, in refraining from any suggestion that we should lower the general quality of our contents : they beg, on the other hand, for a series which will help them to raise their own knowledge to the required level.

But is it really a fact that the highly-technical articles which we often publish are beyond ordinary comprehension ? Remember that as a rule the author of such an article is trying to prove a point to his fellow "high-brows," and it is for this reason that he puts down in full his mathematical reasoning. In nearly every case the non-mathematical reader, *if he is content to take the author's correctness for granted*, can skip the proofs, and devote his energy to studying the conclusions reached and what they mean.

Just as an instance, take the recent extremely valuable article on L.F. Transformers, by Mr. D. W. Dye. This contained much mathematics which, though not advanced, was complicated. But the final conclusions reached (E.W. & W.E., Nov., 1924, pp. 80-83) re expressed in the simplest of language.

It seems appro riate to restate here the main lines of ou policy, which have not changed since our acquisition of E.W. & W.E. We try to cater for the three following classes of reader (their order here is not necessarily their order of importance in our eyes) :—

(*a*) The professional wireless engineer, research student, and laboratory worker ;

(*b*) The advanced amateur experimenters especially those interested in transmission;

(*c*) Those who have taken up wireless, without much previous scientific training, but are really anxious to get some real knowledge of it.

It has been our endeavour, and we believe a successful endeavour, to provide in every issue some matter for each of the above classes of reader. But we have not space to repeat what is already known to all : to those who have written to us that they have to think very hard over our simplest articles we would reply that it was with that object we inserted them !

Now as to practical matters. We are satisfied that there is a call for both the series we suggested, and we have had some requests for a third series, on Mathematics for Wireless. The latter, we fear, must wait for a while. For many purposes, simple algebra and trigonometry are all that is needed, and we could not devote space to this. The other main necessity is an acquaintance with Calculus—by no means so difficult as supposed. This is admirably catered for already by such books as Perry's *Calculus for Engineers*, which can be studied with only the sketchiest previous mathematical knowledge, and should be on every wireless man's bookshelf. Special mathematical subjects needed in wireless, such as numerical computation, least squares, imaginaries, and so forth, will be dealt with from time to time.

The other two series we will tackle as soon as possible. But we must beg the indulgence of our readers, for these articles are difficult to write if they are to be easy to read. The writer must be absolutely at ease and abreast of his subject, and must have a special talent for explanation if he is to combine the scientific spirit with simple presentation.

Lastly, although, as stated above, we can hardly at present run a series on mathematics, we are convinced that a *real* knowledge of wireless cannot be got by those who are afraid to face and deal with figures, x's, and y's. Elaborate mathematics can often be dodged or taken for granted : but calculations such as those in "An Easy Way to Calculate Circuits (E.W & W.E., Nov., 1924, p. 69) will always be cropping up, and there is no real excuse for shirking them.

Simple algebra, simple trigonometry, and the use of logs or slide-rule are all of them easy to learn if not already known, and in our view real progress in any branch of engineering is impossible without them.

The Problem of Rectification. [R149

Below we give a short non-technical abstract of the important article on this subject which commences in this issue.

ON p. 330 of this issue we commence the publication of a very important article by Mr. F. M. Colebrook, B.Sc., D.I.C., A.C.G.I., on Rectification. This subject is, undoubtedly, one of the most difficult of the many branches of wireless work which have hitherto lacked a detailed and thorough investigation.

Unfortunately the very nature of the subject precludes a complete treatment on very simple lines; and although Mr. Colebrook's article does not contain any highly advanced mathematics, it may yet be found fairly heavy by many of our readers; also it is fairly long. We therefore propose to give as shortly as possible, a non-technical abstract which will (as far as possible) present the conclusions reached in a simple form.

Throughout the greater part of the article, Mr. Colebrook is dealing with crystal rectification, although at the end he adds some notes on heterodyne and supersonic working. The main subject of valve detection, however, is reserved to a future article already in preparation.

The author of the article begins by showing examples of the "static characteristics" of the galena and perikon crystals with which the paper deals. Perikon, it will be remembered, is the trade name of the well-known Zincite-Bornite or Zincite-Pyrites combination. Next, he discusses what he refers to as the "rectification characteristic"—otherwise known as the "dynamic characteristic." The first of these two curves is the one got by applying a known D.C. voltage to the crystal—first in one direction and then in the other—and measuring the resulting currents. The result is the familiar curve shown in Fig. 1, p. 330. The second could be got, in theory, by measurement and calculation from the first: it shows the relation between any applied H.F. voltage and the resulting D.C. current. Such a curve is marked O in Fig. 9, p. 336. It is a curious point that in actual fact there are distinct differences between a dynamic curve got by calculation from a static one, on the one hand, and a dynamic curve obtained direct. In other words there is a real difference in the behaviour of a crystal at high and low frequencies.

A curve which will appear in a later part of the paper shows a drop of about 20 per cent. in output between 300 and 2 000 metres, but an almost constant result from 2 000 to 9 000. At what frequency the important changes take place we are not told. The cause of the change is not yet known. Whether it is due to the capacity of the crystal, or whether it is due to some actual lag in the electronic changes at the contact is a nice point for the physicist.

An important point brought out is that, whenever there is—as is usual—a high-resistance load in series with the crystal, the passage of the D.C. output current through this load causes a D.C. voltage which comes across the crystal itself. Unfortunately this voltage is always in such a direction as to hinder rather than help rectification, which indicates that a potentiometer will be of assistance for *any* crystal, though only necessary with some. It will be of even greater use for telephony, where we have a steady carrier wave, large compared with the modulation. There is a chance here for some experimenter to try measuring the output of the same crystal with and without potentiometer.

An important point next dealt with is that the apparent input resistance of the crystal, which governs the sharpness of tuning, increases with the resistance of the phones or other load, even if these are by-passed, as usual, by a condenser. This condenser, it should be noted, is of considerable assistance in getting large output.

The next point brought out—and a most important one—is the behaviour of the crystal from the point of view of its output circuit. Here the author of the article handles the theoretical side very ingeniously, getting the final result that the crystal in operation should behave as a generator—D.C. for a pure carrier wave, audio-frequency for a modulated wave—having a definite internal resistance. The voltage apparently generated varies directly with the input H.F. voltage, as one would expect, but also varies somewhat with the load. The apparent internal resistance also varies with load and input. The values obtained are given in detail in Section 6 of the article, but we give some rough idea here. The apparent internal resistance of Perikon is likely to vary from 1 000 ohms for weak input (·1 volt of H.F.) to 400 for strong signals (1·0 volt). Corresponding values for galena are 500 to 100 ohms. The apparent output E.M.F. is likely to be about ·5 the input for both.

Mr. Colebrook next takes up the question of efficiency, especially in regard to the best resistance for the load. At the outset, one is confronted with the question of defining just what "efficiency" is to mean. If the crystal is being used in the usual way, we want power in the output. If now the input power is constant, our "efficiency" will be the ratio of output to input power. If, however, the input *voltage* is constant, however much power we take from the circuit, then we want simply maximum power output. It has been said that we may regard the input power as constant in the case of an ordinary crystal receiver, the voltage across the aerial inductance dropping as the current taken increases. If, however, we have an H.F. valve with reaction, the input volts may be maintained constant even if the current increases. However, we have some information in our possession which inclines us to believe that under some circumstances the aerial may take more power from the ether as required, so that the voltage is maintained even without reaction.

The point is quite important, for the best load resistance is quite different in the two cases.

It is shown, both in theory and practice, that the maximum output power is got with a comparatively low resistance load, especially for large input. It would appear that in such cases phones of much lower resistance would be an advantage. But where the input power is constant instead of the voltage, a load of much higher resistance, more like the usual, is best.

In calculating the efficiency, it became necessary to work out the H.F. resistance of the crystal. As it happens, we ourselves have been doing some actual measurements on this point, and it is pleasing to note that the results agree well. The apparent H.F. resistance is a very variable factor, even with one crystal contact, depending on both the input volts and the output load. It can be as low as 100 ohms for no load and as high as 10 000 ohms with a high-resistance D.C. output load, with 1 volt of input, the values being larger for smaller input voltages.

It is interesting to note the actual output power and efficiency under various conditions. With the best load for maximum power, and 1 volt input, a galena took about ·002 watt and gave ·001; with ·5 volt input it took ·000 25 watt and gave ·000 12; with ·1 volt it took 5 microwatts and gave ·09; and with ·05 volt it took ·1 microwatt and gave ·004.

These figures do not, however, show the best efficiencies: the load was adjusted for maximum output power. With a much higher load, the efficiencies are, at large inputs, of the order of 90 per cent.; at small inputs say 2 or 3 per cent. This falling off emphasises a point which has long been our own belief: that the proper place for a crystal is in a valve set, where, by H.F. amplification, we can make it work at high efficiency. Further, as will be explained later, a crystal may be practically distortionless at high input, and is, in fact, the nearest thing to a distortionless rectifier. These, however, are the present writer's personal opinions. We will leave them and return to the article itself.

The author of the article discusses the use of the crystal as a "potential" rectifier, *i.e.*, used direct in the grid circuit of a valve, and shows that it may be very efficient. He points out, however, that the coupling from crystal to valve may be safely done by a transformer, as there is much less chance of distortion from a transformer in this position than in one between two valves.

Hitherto the author has been dealing entirely with the rectification of C.W. into D.C.—the simplest case. We have not laid stress on the point, because the investigation of modulated input, which he next undertakes, leads to results of essentially similar nature. The first point which he makes is that, where we are working with sufficient input to work on a more or less straight part of the "rectification characteristic," the modulation does not appreciably interfere with the straightforward rectification of the carrier wave. The important point here, from the non-technical point of view, is that hitherto most theoretical workers who have investigated rectification have assumed a "parabolic" characteristic—one that always gets steeper and steeper. This must result in distortion if used for telephony. But it has not generally been realised that within a quite useful working range the usual crystal does *not* have this sort of curve. After the first bend at the bottom it is often practically straight for a considerable range, and will then give distortionless rectification. It is only for weak signals that we have distortion.

Mr. Colebrook shows from his mathematical investigation that for modulated input just as for steady C.W., the detector has, from the output point of view, an apparent internal resistance and "generates" an apparent voltage—andio-frequency this time instead of D.C. as before.

The author's own summary of conclusions on the crystal detector, which will appear in a later instalment, is so clear and simple that we will not abstract it here. We will, however, go on to note one or two of the other points investigated.

Experiments were made with various metals as the contact wire, and resulted in the conclusion that there was no important difference. Varied pressure of contact also made little difference to the efficiency, though it caused great changes in the detector resistance, which needed changes in the circuit constants to maintain the same efficiency. Thus for a definite given circuit A.T.I. and telephones, there will be a best contact pressure.

The mathematical analysis developed for the above investigation is also used to investigate heterodyne and supersonic reception. The great sensitivity of beat reception is accounted for, and (an important point) it is shown that, under proper conditions, the change of frequency in the supersonic is, like crystal detection, distortionless.

Insulating Materials for H.F.

We have known for some time, and have advised our readers privately, that many insulating materials, excellent for ordinary purposes, are by no means satisfactory in connection with H.F. circuits on account of dielectric losses.

Hitherto we have had no accurate experimental results to give our readers, but some are now available.

In an article in the December issue of the "Proceedings of the Institute of Radio Engineers" of America—would we had such an institute here !—Mr. R. V. Guthrie, jun., gives the results of some tests at the State University of Iowa; and in an article in *QST* for February, Messrs. Preston and Hall, of the Bureau of Standards, give some further figures. The tests were all carried out at radio-frequencies.

We have expressed the results as power factors. The power losses involved in using these insulators instead of air will be proportional to these power factors, and we give in the following table the actual power factors: the proportional losses in terms of ebonite as 1 can be got by multiplying these by 100. Our table is abridged, for in some cases the authors tested several samples of the same material, in which cases we give the average :—

Material.	Power Factor.	
	Guthrie.	Preston and Hall.
Asbestos and binders ..	—	>*
Bakelite	·046	—
Celeron	·057	—
Celluloid	·042	·03
Ebonite	·010	—
Fibre	·059	·04
Fibroc	·041	—
Formica	·050	—
Glass	·008	·008
,, (pyrex)	—	·006
Leatheroid	·048	—
Marble	—	>*
Mica	·000 4	·000 7
,, built up with binder	—	·016
Paper, waxed	—	·02
Petrite	>*	—
Radion	·017	—
Slate	—	>*
Sulphur	·006	—
Varnish	—	·003—·005
Vulcabeston	·044	—
Waxes :		
Beeswax	—	·015
Ceresin	—	·000 3
Condenser compound	—	·005
Paraffin	—	·000 16
Wood, dry..	·05	·03—·1
,, baked and then boiled in wax ..	—	·015—·03

*> Indicates that the losses are so large as to make the material undesirable for wireless work.

We add a few notes on these insulators, from our own experience :—

ASBESTOS.—It seems quite likely that asbestos itself may be quite efficient; but, as in the case of mica, its losses are greatly increased when it is worked up with binding materials.

BAKELITE.—A good material mechanically. Much superior to ebonite for power work at low frequencies and used to a very large extent on American sets.

CELERON.—Exact composition not known, but believed to be more or less like formica.

CELLULOID.—A very tempting material, being so easy to work by softening in hot water. But a snare for H.F. work. Remember that celluloid varnish, so often advised for coils, etc., is just as bad. No figures are given for shellac, but it is believed to be much superior.

EBONITE.—We all know it. Bad mechanically, being brittle and yet inclined to warp; also it spoils by exposure to light and air. None the less, the only panel and former material for efficiency in H.F. circuits.

FIBRE.—High losses. Also suffers the defect of absorbing moisture. The latter trouble may be minimised by boiling in wax.

FIBROC.—Not known.

FORMICA.—One of the laminated series, composed of thin layers of various materials (usually cellulose, *i.e.* paper, etc.) bound by a synthetic resin. Good mechanically, and superior to ebonite *except* for H.F. work.

GLASS.—Both the experimenters got good results; probably their samples were a special glass made for insulation. Ordinary glass often has very high losses.

LEATHEROID.—Not known, but very probably allied to pegamoid, which is canvas with celluloid varnish.

MARBLE.—Comment is needless. Luckily it is not a favourite panel material for wireless sets!

MICA.—This shows up splendidly—unfortunately mica panels are hardly practicable. But beware of built-up mica products, which often have a power factor of ·05 or more.

PAPER.—This is very variable. Special paper with first-class wax is often used in condensers, but losses must always be faced, and for radio-frequency circuits it should not be used.

PETRITE.—Nothing known of this.

RADION.—This is a type of ebonite, and gives results very similar.

SLATE.—See note on marble.

SULPHUR.—A much neglected material. Has magnificent insulating properties. Can often be used very well for bushings, being easily melted and cast in position.

VARNISH.—This is not shellac, which is usually used for insulation, but high-class varnish for wood.

VULCABESTON.—Believed to be a rubber-asbestos product.

WAXES.—*Beeswax*, of course, is not greatly used; in any case it is not a satisfactory material.

Ceresin is, we believe, a special variety of paraffin wax, though we are not certain.

Compound condenser wax is usually an adulterated paraffin.

Paraffin wax shows up as one of the outstanding good insulators. Contrary to the usual belief it is often better practice to use wax (sparingly, of course) than shellac for coils and the like.

WOOD.—This shows high losses, but we have reason to believe that some samples of well-dried timber are much better. We know that many high-power transmitting stations use it in preference to anything else.

ERRATA.

We regret that two printer's errors crept into Mr. Banner's article on "Increasing the Range of D.C. Measuring Instruments" in our last issue.

The formula at the bottom of p. 294, given as

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

should read

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

and the dimensions of the shunt given on line 9 of first column of p. 295 as 1 cm. × 5 mm., should be 1 cm. × 0·5 mm.

The Arrangement of Wireless Books and Information.

Part VI: R600 and R700. [025·4

This series draws to a close: these are the last purely wireless sections, and the next instalment will be the concluding one

Before proceeding to the classes R600 and R700, we should like to call our readers' attention to a slip in our last issue. Under R510 we stated that ship traffic would be dealt with under R531. This should have been R530: further, we omitted a new heading which we had prepared for the purpose, and we should therefore be glad if readers will insert, after R537, the four following headings :—

*R538	Ordinary Commercial Services.
* ·1	Work on board ship.
* ·3	Coastal work.
* ·5	Long-range " fixed station " service.

R600 Station Equipment, Management, and Operation.

In this section, as in the next, we have been obliged to strike out a new line to a considerable extent, for, as will be seen on examining the tables, the B.S. extension has not gone very deeply into them.

As usual, the numbers between R600 and R610 are for general matters, arranged according to the "form division"; but one should beware of including therein items which should more properly be placed under R610 or later.

R610 Descriptions of stations and their equipment.

R611 Long-wave stations.

R612 Extra-short-wave stations.

In the B.S. extension, there followed here two numbers :—

R613 Ship stations.
R614 D.F. stations.

But this seems hardly sufficient for classifying a series of station descriptions, so we propose that the two above numbers be not used; a place will be found for such items in the suggested extension below.

*R615 Station descriptions, classified by systems of working.

These items are classified in exact correspondence with R400 "Systems of Working," the figure 4 being omitted and the remaining figures placed after R615. We therefore only give a skeleton list: fuller details can be found under R400.

*R615·1	Modulated-wave stations.
* ·11	Spark.
* ·12	Telephony.
* ·2	C.W. stations.
* ·23	Valve stations.
* ·35	Stations for secret work.
* ·4	Remote control stations.
* ·45	Relay stations.
* ·46	Duplex and multiplex stations.
* ·47	" Wired Wireless " stations.
* ·48	Recording and high-speed stations.

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

*R616 Station descriptions classified according to use or purpose.

Here again we take advantage of a previous extension; this section is divided according to R500 "Applications and Uses of Wireless." As in the case of R615, we only give a skeleton; further details can be filled in from R500, by dropping the "5," and placing the figures which follow it after R616.

*R616·1	Stations for assisting navigation.
* ·2	Aircraft stations.
* ·3	Commercial stations generally.
* ·4	Private stations.
* ·45	Amateur stations.
* ·5	Broadcasting stations (in the wide sense).
* ·57	"Entertainment" Broadcasting stations.
* ·6	War service stations.
* ·9	Stations classified simply by location.

R620 Operation and management.

In the B.S. extension, the whole subdivision of this section is carried out by means of the "Form Division," the class numbers extending only from R620·01 to R620·09. This is, of course, an entirely legitimate method which is always open. But we feel that further division is called for in this case. Now upon seeing the endings ·001, etc., the inquirer will probably look straight to the "form division" list, which is not so closely sub-divided as would be useful.

We therefore do not repeat the B.S. extension here, as it will be found in Part I. of this series: we have divided the class R620 on the same lines, but in a manner which leaves the way open for further extension.

*R621	Construction and installation.
*R621·1	Choice of site.
* ·2	Design and Construction of buildings.
* ·3	Erection of masts, installation of aerial and earth or counterpoise.
* ·4	Installation of apparatus.
*R622	Regulation and control.
*R622·1	Special wireless laws and regulations.
* ·2	Other statutory regulations (Factory and Workshop Acts).
* ·3	Licences.
* ·4	Official inspections
*R623	Operation.
*R623·1	Personnel.
* ·11	Engineering staff.
* ·111	Training.
* ·112	Qualifications.
* ·113	Conditions of service.
* ·12	Operating staff (Sub-divide as above.)
* ·2	Routine of traffic.
* ·21	Official regulations and forms.
* ·22	Local and special traffic methods.
* ·23	Logs and records.
*R624	Testing and maintenance.
*R624·1	Routine tests.
* ·11	Tests for radiation.
* ·12	Tests for wave-length.
* ·13	Tests for modulation or keying.
* ·2	Maintenance and running repair: workshops, etc.
*R625	Administration.
*R625·1	General management, staff personnel
* ·2	Accounts.
* ·21	Costs, supply of materials, etc.
* ·26	Revenue: charges, inter-station accounts, etc.

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

R700 The Manufacture and Sale of Wireless Apparatus.

Here we have actually a modification of the "form division." The class ·01 is essentially a general one, and in Dewey's original scheme it was specially extended for engineering, to take account of the most general things in all engineering work: Materials and their Properties. We borrow some items direct: many other items under R700 are also from Dewey.

R701 Wireless materials: tests and properties.

R701·1 General properties.
* ·12 Testing.
* ·2 Timber.
* ·7 Iron and steel.
* ·8 Other Metals.
* ·9 Other Materials.

R710 Factories.

Again we are provided for in the original Dewey. We could class such matter under "Non-wireless" in R800, giving the simple Dewey numbers, but it seems best to find room here for as much as we want.

R710·05 (Form Division) works administration, etc., is especially useful here.

R711 Drawing office.
*R711·1 General.
* ·2 Arrangement.
* ·3 Equipment and tools.
* ·4 Supplies and stores.
* ·5 Methods and processes.

R712 Wood-working shops.
Divide as R711.

*R713 Smithy.
*R714 Foundry.
*R715 Machine shops.
*R719 Assembly and finishing.
} All to be divided as R711 above.

R730 Office Organisation.

*R731 Buildings, &c.
*R732 Equipment.
*R733 Personnel.
*R734 Administration and management.
*R735 Files and records.
*R737 Correspondence.

R740 Sales Organisation.
*R750 Publicity Organisation.
} Both divided as R730 above.

At this point our special extension, as such, comes to an end, for R900 is not classified. But we propose to give, in our next issue, some extracts from the main Dewey tables, to assist in the classification of items on non-wireless subjects, which as already explained, are grouped under R800.

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

The Rectifying Detector.

By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.

Part I. [R149

An exhaustive investigation, theoretical and experimental, into one of the most difficult problems of the Wireless Engineer.

IN the early days of wireless telegraphy the subject of rectification, or, as it was more usually termed, detection, was one of very great practical importance, and received a correspondingly large amount of attention. The advent of the two-electrode and, later, the three-electrode valve, however, greatly reduced the difficulties attendant on this part of the radio-telegraphic process and, at the same time, opened up a wide field of unexplored ground, with the result that attention was transferred to other branches of wireless technique.

More recently still, the popularisation of wireless telegraphy and telephony and the revival of crystal reception have given a renewed interest to the subject of rectification. It still remains however in a comparatively elementary state. Very little work of an exact character has been published on the subject, and the basis of its technique is still largely empirical. The chief reasons for this are probably the difficulty of the measurements involved (particularly at the high radio frequencies used in broadcasting) and the apparent intractability of the mathematical side of the subject.

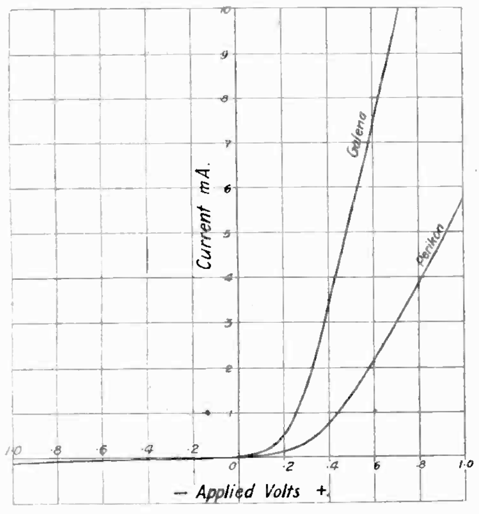


Fig. 1. *The characteristics of two typical rectifying crystals.*

The writer has recently been engaged on some work which required a fairly detailed understanding of the process of rectification, and has taken the opportunity to carry out a fairly extensive investigation of this matter. Since the results obtained are likely to be of general interest, they are embodied in as compact a manner as possible in the following paper.

The treatment of the subject will be divided approximately as follows :—

1. The Description of a Rectifying Conductor.
   Determination and analysis of the static characteristic.
   (*a*) Small amplitudes.
   (*b*) Large amplitudes.
2. The Rectification Effect.
3. Some Particular Cases.
   (*a*) Parabolic characteristic.
   (*b*) Exponential characteristic.
   (*c*) Perfect rectifier.
   (*d*) Practical case.
4. Loaded Rectifier Circuit.
   Determination of rectification characteristic.
   Analysis of rectification characteristic.
   (*a*) Large amplitudes.
      i. General.
      ii. Apparent internal resistance (no load).
      iii. Apparent rectified E.M.F. (no load).

(*b*) Small amplitudes.
5. Continuous Wave Rectification Efficiency.
Experimental results on C.W. efficiency.
6. Potential Rectification (Infinite load).
Experimental results on potential rectification.
7. The Rectification of a Modulated E.M.F.
8. The Effect of a Modulation Load.
9. Efficiency in the Rectification of a Modulated E.M.F.
Experimental results with modulation loads.
The choice of telephones.
10. Distortion in the Rectification of Modulated Currents.
11. The Influence of Contact Conditions.
(*a*) Galena.
(*b*) Perikon.
12. The Variation of the Sensitivity with Wave-length.
13. Summary of Results with simple Crystal Rectifiers.
14. Crystal-Valve Combinations.
15. Heterodyne Reception.
16. The Supersonic Heterodyne.

In order to illustrate and confirm the principles deduced from the general theoretical considerations, a large number of measurements were carried out with representative specimens of the two crystal detectors in most general use, namely, galena and perikon.

1. The Description of a Rectifying Conductor.

For any ordinary non-inductive conductor the relation between the instantaneous value of the current and that of the E.M.F. which produces it is given by

$$i=ae, \quad .. \quad .. \quad (1\cdot 1)$$

where i and e are the instantaneous values of voltage and current. The coefficient a is known as the conductance of the conductor, its reciprocal being known as the resistance.

The distinctive property of a rectifying conductor is that the relation between i and e is of a less simple character, the relation being expressible in the general case by

$$i=f(e) \quad .. \quad .. \quad (1\cdot 2)$$

i.e., the current, instead of being a simple multiple of the E.M.F. is some other finite, and in all practical cases continuous, function of the E.M.F.

Assuming the function to be capable of expansion in positive integral powers of e, we have

$$i=a_0+a_1e+a_2e^2+ \ . \ . \ . \ +a_ne^n + \ . \ . \ . \ . (1\cdot 3)$$

This functional relationship, under specified conditions of time variation of the

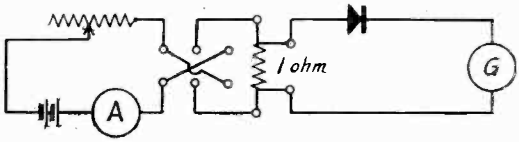


Fig. 2. *Circuit for obtaining curves such as those in Figs. 1 and 3.*

E.M.F., is termed the characteristic of the rectifier under the given conditions. Examples of such conductors are :—

(*a*) The grid or anode circuits of a thermionic valve ;

(*b*) Various arrangements of inorganic crystalline substances, i.e., "crystal detectors" ;

(*c*) Certain electrolytic conductors, etc., etc.

The curves shown in Fig. 1 may be taken as representative of rectifying characteristics. They are, in fact, the static or continuous current characteristics of two crystal detectors.

In all cases, except certain valve circuits, the coefficient a_0 in equation (1·3) is zero. In all that follows it will be assumed to be zero unless otherwise stated.

Determination and Analysis of the Static Characteristic.

The measurement of the continuous current or static characteristics of the various detectors examined was made by means of the circuit illustrated in Fig. 2. The arrangement is a convenient one for applying accurately known voltages to the terminals of the detector. It was found that in every case the current required an appreciable time, about a minute or so, to become steady in value, there being generally a positive "creep" in the pass direction, and a negative in the reverse direction. Typical results are shown in Fig. 1.

It was found that in every case the static characteristics would admit of fairly simple description over the regions (*a*) applied voltage less than 100 millivolts, and (*b*) applied voltage greater than 0·3 to 0·5 volts. For convenience these regions will be referred to as corresponding with small signal amplitudes and large signal amplitudes respectively.

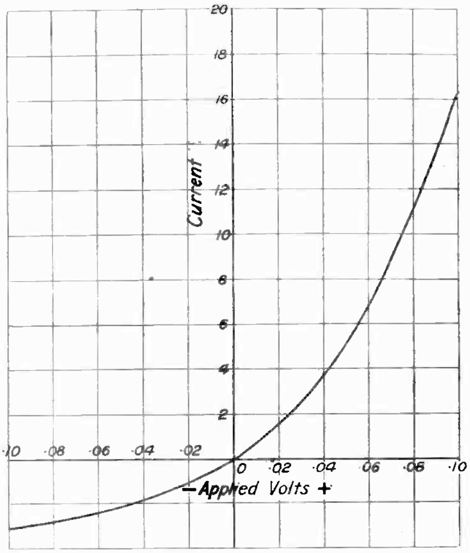


Fig. 3. *A characteristic for very small input; the current is in microamps.*

(*a*) *Small amplitudes.*

A suitable enlargement of the region ± 100 millivolts gives a curve such as that shown in Fig. 3, which actually refers to one of the perikon detectors examined. In general an equation

$$i_e = a_1 e + a_2 e^2 + a_3 e^3 + a_4 e^4$$

can be made to fit such a curve fairly closely. A simple method of determining the coefficients is worthy of note. For an E.M.F. e we shall have the equation given above. For an equal E.M.F. of opposite sign the current will be

$$i_{-e} = -a_1 e + a_2 e^2 - a_3 e^3 + a_4 e^4$$

Therefore

$$\frac{i_e + i_{-e}}{2e^2} = a_2 + a_4 e^2$$

and

$$\frac{i_e - i_{-e}}{2e} = a_1 + a_3 e^2.$$

Thus a_2 and a_4 can be found by dividing the algebraic sum of i_e and i_{-e} by $2e^2$ and plotting the result against e^2, which will give an approximately straight line. The coefficients a_1 and a_3 can be found in a similar manner by plotting the algebraic difference of i_e and i_{-e} divided by $2e$ against e^2.

(*b*) *Large amplitudes.*

It was found that for applied voltages greater than about ·3 to ·5 volts the characteristics approximated very closely to a straight line of the form

$$i = a_1(e - e_0) \text{ (See Fig. 4).}$$

The constants a_1 and e_0 can obviously be measured directly from the actual curve.

§2. The Rectification Effect.

If the E.M.F. e be a pure sine wave alternation represented by

$$e = E \sin \omega t \quad .. \quad .. \quad (2{\cdot}1)$$

the current i will in general be an alternating one of the same periodicity as e, but of some irregular wave form. By Fourier's theorem, therefore,

$$i = f(e) = f(E \sin \omega t) \quad .. \quad (2{\cdot}2)$$

$$= i_0 + i_1 + i_2 + \ . \ . \ . + i_n + \ . \ . \ . \ ... \quad (2{\cdot}3)$$

i_0 being a continuous current and i_n being a current of sine wave form and of frequency $\frac{n\omega}{2\pi}$. By the same theorem the amplitudes of these various currents will be given by

$$i_1 = \frac{1}{T}\int_0^T f(e).dt \quad .. \quad (2{\cdot}4)$$

$$I_1 = \frac{2}{T}\int_0^T f(e) \sin \omega t.dt \quad .. \quad (2{\cdot}5)$$

and in general

$$I_n = \frac{2}{T}\int_0^T f(e) \sin n\omega t.dt \quad .. \quad (2{\cdot}6)$$

where

$$\omega = \frac{2\pi}{T} \quad .. \quad .. \quad (2{\cdot}7)$$

(It is here assumed that the series 2·3 will contain no cosine terms, these will exist among the higher terms, but not in the fundamental with which we are concerned.)

We see from the above that the application of an alternating E.M.F. to a conductor of the type under consideration will produce a continuous current represented by

$$i_0 = \frac{1}{T}\int_0^T f(e).dt \quad .. \quad (2\cdot 8)$$

together with an alternating current of the fundamental frequency and, in general, a whole series of harmonics. The first of these, which will hereafter be termed the "rectified current," is, of course, the objective in the practical applications of rectifiers in wireless telegraphy and telephony.

If, as in equation 1·3

$$i = a_1 E \sin \omega t + a_2 E^2 \sin^2 \omega i + \ldots$$
$$+ a_n E^n \sin^n \omega t + \ldots \quad .. \quad (2\cdot 9)$$

plus cosine terms,

then general expressions can be found for i_0, i_1, etc., in terms of the coefficients a_1, a_2, etc., by the application of the integrals

$$\frac{1}{T}\int_0^T \sin^{2p} \omega t.dt = \frac{1.3.5 \ldots (2p-1)}{2.4.6 \ldots (2p)} \quad (2\cdot 10)$$

$$\frac{1}{T}\int_0^T \sin^{(2p+1)} \omega t.dt = 0 \quad .. \quad .. \quad (2\cdot 11)$$

from which it can easily be shown that

$$i_0 = \frac{1}{2} a_2 E^2 + \frac{1\cdot 3}{2\cdot 4} a_4 E^4 + \frac{1\cdot 3\cdot 5}{2.4.6} a_6 E^6 + \ldots \quad (2\cdot 12)$$

and

$$I_1 = 2\left[\frac{1}{2} a_1 E + \frac{1\cdot 3}{2.4} a_3 E^3 + \frac{1\cdot 3\cdot 5}{2.4.6} a_5 E^5 + \ldots\right] \quad .. \quad (2\cdot 13)$$

where I_1 is the amplitude of i_1.

Similar expressions could be found for the other harmonics, but they are not of any practical importance.

It is of interest to note at this point that of the various alternating components of the total current only that of the fundamental frequency will be associated with the consumption of any energy from the source of the E.M.F., since, for all values of n, except $n=1$, the mean value of ei_n over a period is zero. Other points to note are that the expression for i_0 contains only the coefficients of even powers of e, while the expression for I_1 contains the coefficients of the odd powers of e; also that for very small values of e the expressions will approximate to the simple forms :—

$$i_0 = \frac{1}{2} a_2 E^2 \quad .. \quad .. \quad .. \quad (2\cdot 14)$$

$$I_1 = a_1 E \quad .. \quad .. \quad .. \quad (2\cdot 15)$$

3. Some Particular Cases.

It will be as well to illustrate the form taken by the above general expressions in certain particular cases of some practical importance.

(*a*) *Parabolic characteristic.*
If

$$i = a_1 e + a_2 e^2 \quad .. \quad .. \quad (3\cdot 1)$$

then

$$i_0 = \frac{1}{2} a_2 E^2 \quad .. \quad .. \quad (3\cdot 2)$$

and

$$I_1 = a_1 E \quad .. \quad .. \quad (3\cdot 3)$$

while for $n > 2$

$$I_n = 0 \quad .. \quad .. \quad (3\cdot 4)$$

(*b*) *Exponential characteristic.*
If

$$i = a\epsilon^{be} \quad .. \quad .. \quad (3\cdot 5)$$

and

$$e = e_0 + E \sin \omega t \quad .. \quad (3\cdot 6)$$

then

$$i_0 = a\epsilon^{be_0}\left[1 + \left(\frac{bE}{2}\right)^2 + \frac{1}{2!}\left(\frac{bE}{2}\right)^4 + \frac{1}{3!}\left(\frac{bE}{2}\right)^6 + \ldots\right] \quad .. \quad (3\cdot 7)$$

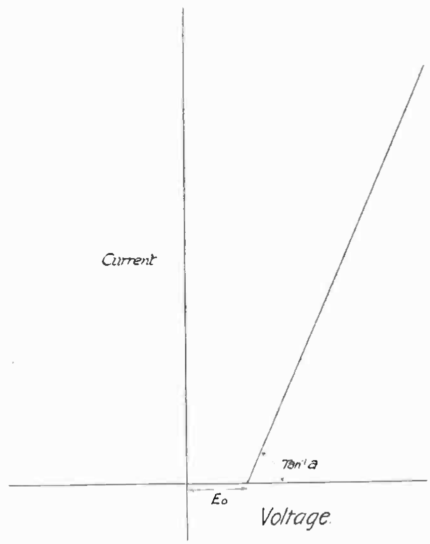


Fig. 4. *At large amplitudes, the crystal characteristic approximates to a straight line.*

and

$$I_1 = 2a\epsilon^{be}\left[\frac{bE}{2} + \frac{2}{2!}\left(\frac{bE}{2}\right)^3 + \frac{3}{3!}\left(\frac{bE}{2}\right)^5 + \dots\right] \quad \dots \quad (3\cdot8)$$

This will be found to have a very important practical application.

(*c*) *Perfect rectifier.*

An interesting special case is that of the theoretically perfect rectifier specified by

$$i = a_1 e \text{ for positive values of } e \quad (3\cdot9)$$

$$= 0 \text{ for negative values of } e \quad (3\cdot10)$$

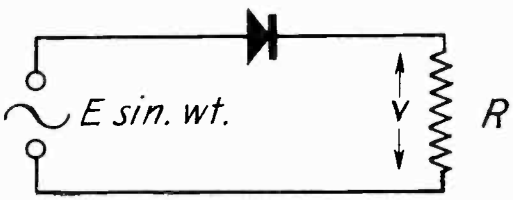


Fig. 5. *The simplest output load.*

For this case

$$i_0 = \frac{1}{T}\int_0^{\frac{T}{2}} a_1 E \sin \omega t.dt = a_1 \frac{E}{\pi} \quad \dots \quad (3\cdot11)$$

and

$$I_1 = \frac{2}{T}\int_0^{\frac{T}{2}} a_1 E \sin^2 \omega t.dt \quad \dots \quad \dots \quad (3\cdot12)$$

$$= a_1 \frac{E}{2} \quad \dots \quad \dots \quad \dots \quad (3\cdot13)$$

(*d*) *Practical case.*

A case similar to the above, but of greater practical interest, since it will be found to be related to crystal reception, is that illustrated in Fig. 4 :—

$$i = a_1 (e - e_0) \text{ for } e > e_0 \quad \dots \quad (3\cdot14)$$

$$= 0 \qquad \text{for } e < e_0 \quad \dots \quad (3\cdot15)$$

Putting

$$e_0 = E \sin \omega t_1 \quad \dots \quad \dots \quad (3\cdot16)$$

then

$$i_0 = \frac{1}{T}\int_{t_1}^{(\frac{T}{2}-t_1)} a_1(e-e_0).dt \dots \quad \dots \quad (3\cdot17)$$

$$= \frac{a_1 E}{\pi}\left[\sqrt{1-\frac{e_0^2}{E^2}} - \frac{e_0}{E}\left(\frac{\pi}{2} - \text{arc}\sin\frac{e_0}{E}\right)\right] \quad (3\cdot18)$$

which, for small values of e_0/E approximates to

$$i_0 = \frac{a_1 E}{\pi} - \frac{a_1 e_0}{2} \quad \dots \quad \dots \quad (3\cdot19)$$

Similarly

$$I_1 = a_1 E\left[\left(\frac{\pi}{2} - \text{arc}\sin\frac{e_0}{E}\right) - \frac{e_0}{E}\sqrt{1-\frac{e_0^2}{E^2}}\right] \quad (3\cdot20)$$

which for small values of e_0/E approximates to

$$I_1 = \frac{a_1 E}{2} - \frac{a_1 e_0}{\pi} \quad \dots \quad \dots \quad (3\cdot21)$$

4. Loaded Rectifier Circuit.

In the practical applications of rectification there will invariably be some form of load in the detector circuit, in which the energy represented by the rectified component of the current is converted into heat or mechanical energy. To make the above analysis applicable to practical conditions, therefore, it will be necessary to consider how the equations will be modified by the presence of a load in series with the rectifier. The first arrangement to be considered will be that illustrated in Fig. 5.

The currents represented by i, flowing in the load, will give rise to a back E.M.F. v which will, in general, consist of a continuous component and an infinite series of high-frequency harmonics, *i.e.*,

$$v = v_0 + v_1 + v_2 + \dots + v_n + \dots \dots \quad (4\cdot1)$$

The E.M.F. acting across the detector will now be $(e-v)$, so that equation 1·2 becomes

$$i = f(e-v) \quad \dots \quad \dots \quad (4\cdot2)$$

A little consideration will make clear that in the general case the mathematical analysis of the effect of a load in the detector circuit will be impossibly complex. It would, moreover, be of very little value, since in all practical cases steps are taken to ensure that all the components of v except v_0 are made negligibly small. This result is obtained by connecting across the load a condenser of sufficiently large magnitude to provide a path of low impedance for the high-frequency components of the current. The arrangement will then be as shown in Fig. 6, and we have

$$v = v_0, \quad \dots \quad \dots \quad (4\cdot3)$$

so that

$$i = f(e - v_0) \quad \dots \quad \dots \quad (4\cdot4)$$

This is illustrated in Fig. 7. The effect of the load is seen to be a shifting back of the centre point of the oscillation by an amount v_0, the actual amplitude of the oscillation being unaffected.

If the load were not short-circuited by the condenser it is clear that in addition to the shifting back of the centre point of the oscillation there would also be a reduction in the amplitude of the oscillation on account of the high-frequency components of the back E.M.F., the net result being not only a greater reduction of i_0 than in the first case, but also a useless consumption of energy on account of the passage of the high-frequency components of the current through the load.

The above diagram also makes clear another important feature of rectification of the type under consideration, i.e., that for any given amplitude of e, the current of the fundamental frequency (which

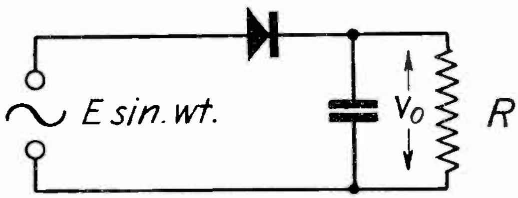


Fig. 6. *As a rule the output load has a condenser to by-pass the high-frequency components.*

determines the effective high-frequency resistance of the detector) will depend very considerably on v_0, i.e., on the magnitude of the **D.C.** load. In general the effective high-frequency resistance of the detector will increase with the load. Further reference will be made to this point later.

In all that follows it will be assumed that the back E.M.F. due to the load can be represented by the single term v_0, so that equation (4·4) applies. Expanding this equation by Taylor's theorem, we have

$$i=f(e)-v_0 f'(e)+\frac{v_0^2}{2!}f''(e)-\dots$$
$$\dots+(-1)^n\frac{v_0^n}{n!}f^n(e)+\dots \quad (4·5)$$

where

$$f^n(e)=\frac{d^n}{de^n}f(e) \qquad .. \quad (4·6)$$

The rectified current i_0 will then be given by

$$i_0=\frac{1}{T}\int_0^T f(e).dt-v_0\frac{1}{T}\int_0^T f'(e).dt+\dots$$
$$\dots+\frac{v_0^2}{2!}\frac{1}{T}\int_0^T f''(e).dt-\dots$$
$$\dots+(-1)^n\frac{v_0^n}{n!}\frac{1}{T}\int_0^T f^n(e).dt+\dots \quad (4·7)$$

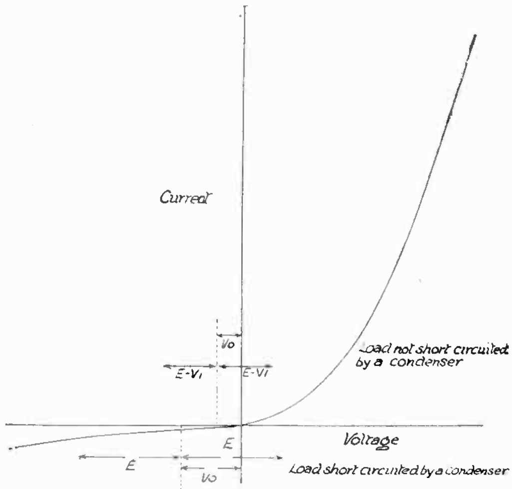


Fig. 7. *Illustrating the effect of the load in diminishing the output.*

The first term is the value of i_0 corresponding to zero load. Its value in terms of the characteristic has already been determined. For abbreviation we will put

$$\frac{1}{T}\int_0^T f(e)dt=F(E) \qquad .. \quad (4·8)$$

Similarly, putting

$$\frac{1}{T}\int_0^T f'(e)dt=F_1(E),\ etc. \qquad (4·9)$$

equation 4·8 becomes

$$i_0=F(E)-v_0F_1(E)+\frac{v_0^2}{2!}F_2(E)-\dots$$
$$\dots+(-1)^n\frac{v_0^n}{n!}F_n(E)+\dots \quad (4·10)$$
$$=F(E)-Ri_0F_1(E)+\frac{R^2i_0^2}{2!}F_2(E)-$$
$$\dots+(-1)^n\frac{R^ni_0^n}{n!}F_n(E)+\dots \quad (4·11)$$

R being the D.C. resistance of the load.

The general expressions for $F(E)$, $F_1(E)$, etc., in terms of the characteristic of the detector could easily be obtained in precisely the same manner as for $F(E)$. The expressions will not, however, be of much practical value. It is clear that whereas $F(E)$, $F_2(E)$, etc., will contain only the even coefficients a_2, a_4, etc., $F_1(E)$, $F_3(E)$, etc., will contain only the odd coefficients a_1, a_3, a_5, etc.

The expression for I_1, the amplitude of the fundamental high-frequency component, can be obtained in an exactly similar manner. Putting, for abbreviation,

$$\frac{2}{T}\int_0^T f(e)\sin\omega t.dt=\phi(E) \qquad (4\cdot12)$$

and

$$\frac{2}{T}\int_0^T f'(e)\sin\omega t.dt=\phi_1(E) \qquad (4\cdot13)$$

etc., etc.

then I_1 is given by

$$I_1=\phi(E)-v_0\phi_1(E)+\frac{v_0^2}{2!}\phi_2(E)- \ldots +(-1)^n\frac{v_0^n}{n!}\phi_n(E)-\ldots \qquad (4\cdot14)$$

Theoretically, equation 4·11 is capable of solution for i_0. It will be seen, however, that if n terms on the right hand side are significant, the determination of i_0 will involve the solution of an $(n-1)$th power equation, which would be a very difficult matter. It will be of interest to point out the general features of the solution in the case where only the first two terms of the series are significant. This will apply when R is very small or when $F_2(E)$, etc., are very small. Fortunately the two most generally used crystal detectors conform approximately to this latter requirement for relatively large amplitudes of e. Equation 4·11 now becomes

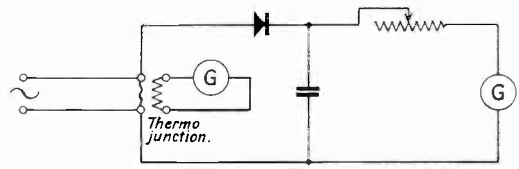


Fig. 8. *The circuit used for measuring the "Rectification Characteristic" (D.C. output compared with H.F. input).*

$$i_0=F(E)-Ri_0F_1(E) \quad .. \ (4\cdot15)$$

giving

$$i_0=\frac{F(E)}{1+RF_1(E)}=\frac{F(E)/F_1(E)}{1/F_1(E)+R} \qquad (4\cdot16)$$

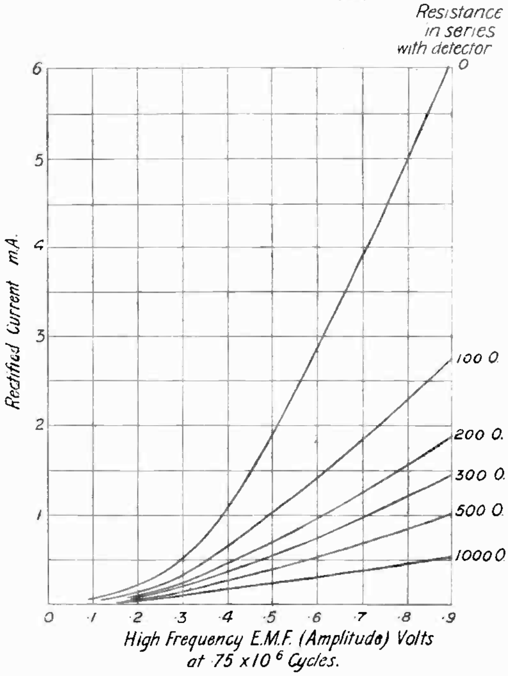


Fig. 9. *Rectification characteristics for Galena with various loads.*

Under these conditions it appears that the internal resistance of the crystal or detector to the rectified current is $1/F_1(E)$, the rectified E.M.F. producing the current being $F(E)/F_1(E)$. If the load is zero, the current will be the rectified E.M.F. divided by the internal resistance, i.e.,

$$i_0=\frac{F(E)/F_1(E)}{1/F_1(E)}=F(E) \qquad (4\cdot17)$$

as already shown.

Even in the general case, where $F_2(E)$, etc., are not negligibly small, the above equation (4·16) will be true for a small value of R, and it will therefore be true to say that $1/F_1(E)$ and $F(E)/F_1(E)$ are respectively the internal resistance and the rectified E.M.F. at "no load."

The next approximation to equation (4·16), taking account of v_0^2, but neglecting higher powers, will be

$$i_0 = \frac{\dfrac{F(E)}{F_1(E)} + \dfrac{v_0^2}{2}\,\dfrac{F_2(E)}{F_1(E)}}{R + \dfrac{1}{F_1(E)}} \quad \ldots \quad \ldots (4{\cdot}18)$$

This is equivalent to an increase of the rectified E.M.F. by an amount $\frac{v_0^2}{2}.\frac{F_2(E)}{F_1(E)}$, a term dependent on R. Thus as the load increases the rectified E.M.F. will also appear to increase slightly. It is probable, therefore, that if R is increased to infinity the ultimate value of v_0 will be greater than the value of the rectified E.M.F. determined by the change of current due to a small load R. These conclusions are illustrated by the experimental results described further on.

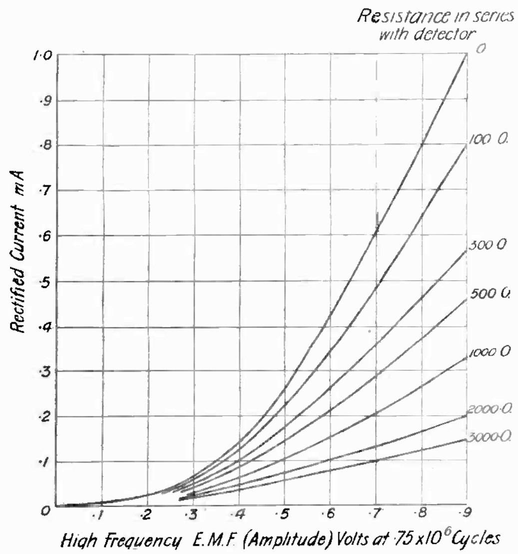


Fig. 10. *Rectification characteristics for Perikon with various loads.*

The above discussion may be summarised as follows: Under all conditions of signal amplitude and load the rectified current can be expressed in the form

$$i_0 = \frac{E_c}{R_c + R} \quad \ldots \quad \ldots \quad \ldots (4{\cdot}19)$$

where E_c is an apparent rectified E.M.F., and R_c an apparent internal resistance. In general R_c will depend on the amplitude of the signal E.M.F. Both E_c and R_c may vary to some extent with the load resistance R. In the limit, when $R = \infty$,

$$v_0 = Ri_0 = \frac{RE_c}{R_c + R} = E_c \quad \ldots (4{\cdot}20)$$

but, as already explained, the value of E_c in equation (4·20) will probably be somewhat greater than its value in equation (4·19).

The quantities E_c and R_c are clearly the important practical characteristics of a detector. The means of determining these quantities will now be described.

Determination of Rectification Characteristic.

The above term is used to designate the curve obtained by plotting the continuous component of the rectified current against the signal amplitude, with no load in series with the detector. The circuit used for this purpose is shown in Fig. 8. The first series of measurements was made at a frequency corresponding to a wave-length of 400 metres. To avoid uncertainty in the measurement of the signal E.M.F., the

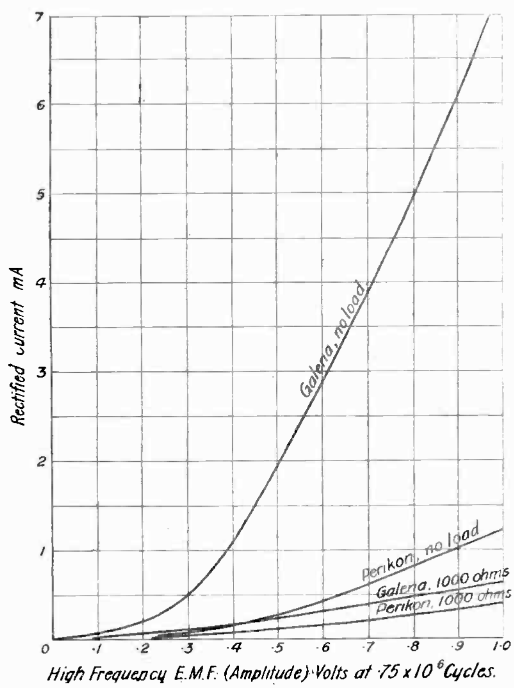


Fig. 11. *Curves from Figs. 9 and 10 to the same scale, for comparison.*

heater of a non-contact type of thermo-junction ammeter was used as the source

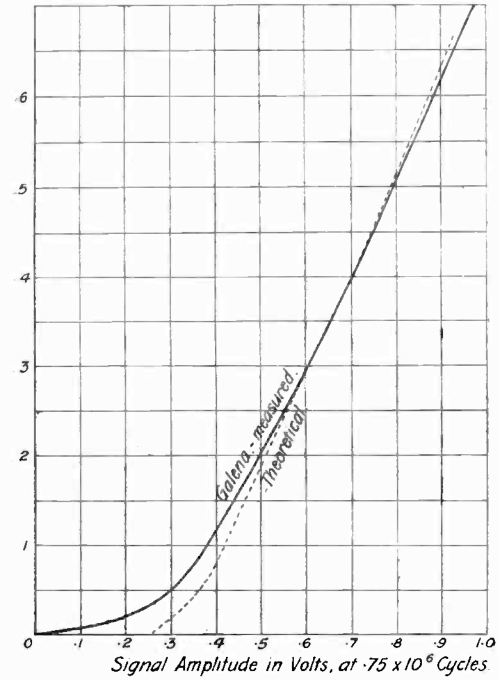


Fig. 12. *The measured curve for large amplitudes approximates to that calculated on the basis of a simple straight-line law for* i *and* e.

of potential. Proper precautions were taken to ensure that the whole of the high-frequency E.M.F. acting in the detector circuit was that derived from the fall of potential in the heater resistance.

Typical results are illustrated in Figs. 9 and 10, which also show the curves obtained with various D.C. loads. One distinction between the two detectors is clear from these curves, and is further emphasised in the comparative lines in Fig. 11. At no load, galena appears to be much more sensitive than perikon. This apparent superiority is very greatly diminished with a fairly high load in series, showing that it is mainly due, not to a higher rectified E.M.F., but to a lower apparent internal resistance.

Analysis of Rectification Characteristic.

(a) Large amplitudes.

(i) *General.*—It has been stated that for large amplitudes the static characteristics would approximate to

$$i = a_1 (e - e_0) \text{ for } e > e_0$$
$$= 0 \quad \text{for } e < e_0$$

This is confirmed in Fig. 12, which shows the actual performance of a galena detector compared with that deduced from a characteristic of the above type. (See para. 3.) It is found that the constants a_1 and e_0 deduced from the rectification characteristic are different from those given by the static characteristic. The following table gives the comparison for two typical specimens :—

	Galena.		Perikon.	
	Static.	Dynamic.	Static.	Dynamic.
a_1	$2{\cdot}13 \times 10^{-2}$	$3{\cdot}53 \times 10^{-2}$	$\cdot 96 \times 10^{-2}$	$\cdot 56 \times 10^{-2}$
e_0	·25	·25	·4	·22

It will be seen that the deviation of the dynamic from the static characteristic is in opposite directions for the above two specimens.

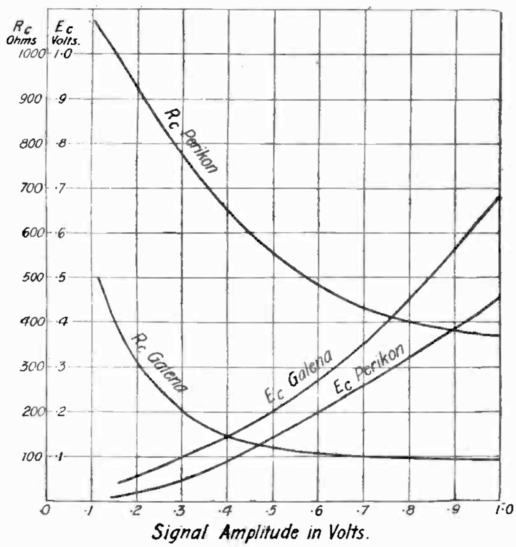


Fig. 13. *Variation of E_c and R_c (apparent E.M.F. and internal resistance) for varying input voltage (large input).*

(ii) *Apparent internal resistance at no-load.*—It has been shown above that the apparent internal resistance of a rectifier at zero load could be determined by inserting a small resistance (short-circuited by a condenser) in series with the rectifier and measuring the consequent change in the rectified current. If i_0 be the current corresponding to no load, and i_0' the current corresponding to a load R, then (equation 4·19)

$$i_0 = \frac{E_c}{R_c} \text{ and } i'_0 = \frac{E_c}{R_c + R}$$

therefore

$$R_c = \frac{Ri'_0}{i_0 - i'_0}$$

The variation of R_c with E was determined in this manner for the two specimen detectors described above. The results are shown in the curves of Fig. 13.

It should be noted that in each case the value of R_c approaches $\frac{2}{a_1}$ at its lower limit. (See equation 3·19.) The value of R_c determined as above applies only to zero load: with increasing load it will in general increase, but for large amplitudes the change of R_c will not be very great, and the zero load value can certainly be taken as approximately the value of the load which will

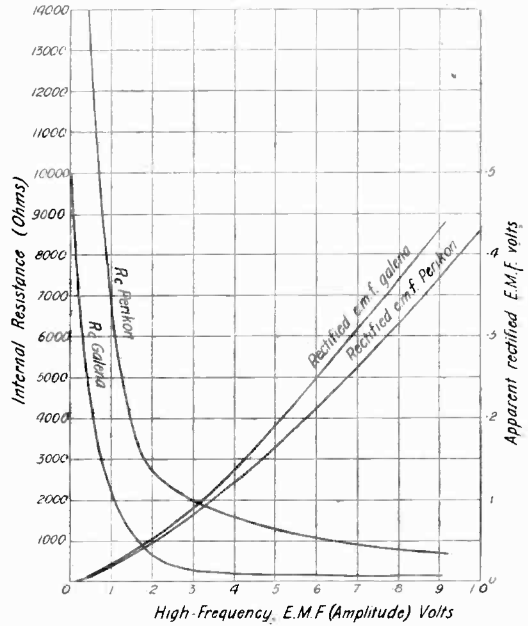


Fig. 15. *Combined curves showing R_c and E_c for both large and small inputs.*

give the maximum D.C. power with a constant potential input.

(iii) *Apparent rectified E.M.F. at no load.*—Since, at no load,

$$i_0 = \frac{E_c}{R_c}; \text{ it is obvious that } E_c = R_c i_0$$

The variation of E_c with E is shown in Fig. 13. It will be seen that as far as E_c is concerned, there is far less difference between the two detectors than the no-load sensitivity would appear to indicate.

(b) Small amplitudes.

Fig. 14 shows the no-load characteristics for the representative specimens of galena and perikon plotted against the square of the r.m.s. value of the high-frequency E.M.F. Expressing the lines in the form

$$i_0 = \frac{1}{2}a_2E^2 + \frac{3}{8}a_4E^4 = a_2E_s^2 + \frac{3}{2}a_4E_s^4,$$

(where E_s=r.m.s. volts)

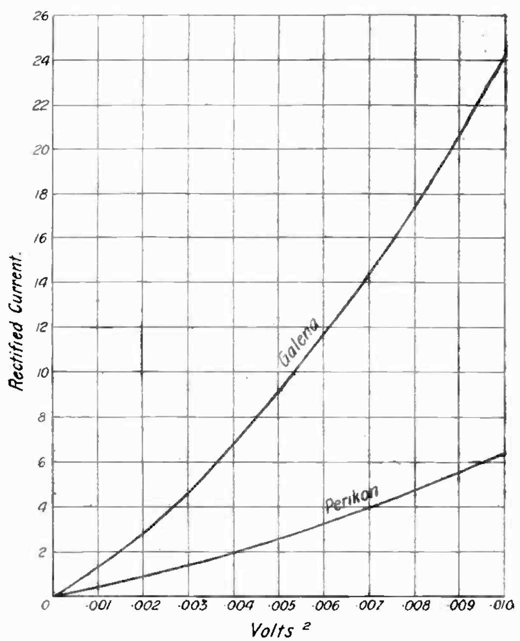


Fig. 14. *D.C. output against square of H.F. input, for small inputs.*

we see that the values of a_2 and a_4 can be obtained by plotting i_0/E_s^2 against E_s^2, since

$$\frac{i_0}{E_s^2} = a_2 + \frac{3}{2}a_4 E_s^2$$

The no-load values of R_c and E_c can be determined as already described. Since (equations 4·15 and 4·19)

$$\frac{1}{R_c} = F_1(E) = a_1 + \frac{3}{2}a_3 E^2$$

a_1 and a_3 can be determined by plotting $1/R_c$ against E^2. The following table gives the comparison between the static and dynamic characteristics of the two specimens examined :—

	Perikon.		Galena.	
	Static.	Dynamic.	Static.	Dynamic.
a_1	$6{\cdot}4 \times 10^{-5}$	$5{\cdot}0 \times 10^{-5}$	$8{\cdot}75 \times 10^{-5}$	$8{\cdot}5 \times 10^{-5}$
a_2	$5{\cdot}3 \times 10^{-4}$	$4{\cdot}0 \times 10^{-4}$	$9{\cdot}5 \times 10^{-4}$	13×10^{-4}
a_3	$2{\cdot}8 \times 10^{-3}$	$2{\cdot}2 \times 10^{-3}$	$1{\cdot}05 \times 10^{-2}$	$1{\cdot}5 \times 10^{-2}$
a_4	$2{\cdot}4 \times 10^{-2}$	$1{\cdot}6 \times 10^{-2}$	$5{\cdot}5 \times 10^{-2}$	$7{\cdot}5 \times 10^{-2}$

For the sake of completeness the values of E_c and R_c were determined both for large and small amplitudes for the contact points having the above characteristics. The curves of Fig. 15 show the results obtained.

(To be continued.)

Principles and Methods of Obtaining High-Tension Supply from Direct Current Mains.

By L. C. Grant (2QP). **[R355**

How to run transmitters cheaply from the public supply.

THIS short article is intended to give the broad principles which must be observed if the direct current mains are to be used as a source of supply for feeding valve oscillators, and as most small transmitting valves operate on a maximum anode potential of 500-600 volts, it will be found that observance of the following remarks will enable most small power transmitters to be successfully operated from the public supply, at a purely nominal cost for energy. In passing, it may be useful to mention that to get the most out of a transmitter valve, does not by any means mean piling on anode voltage, but rather to pay a little more attention to the high frequency circuits to reduce their impedance and to tune accurately and carefully all tuned circuits. The writer, in his own experience with both

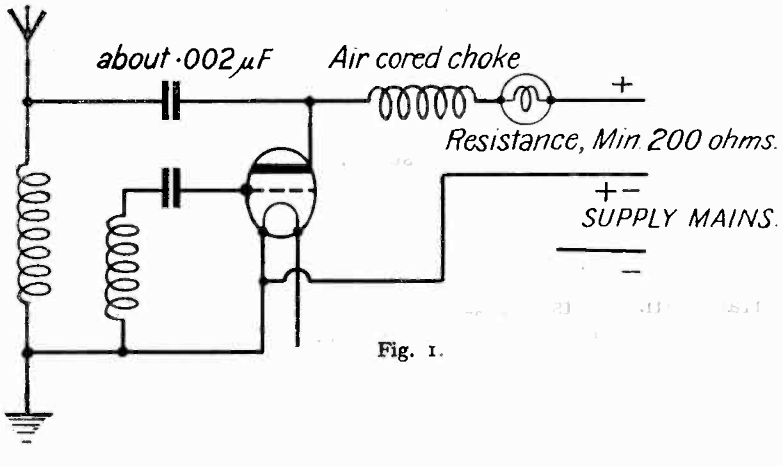


Fig. 1.

large and small transmitters, has found that very often after tuning and adjusting a circuit, the addition of further anode voltage either has no effect on the output, or may even reduce it, in both instances causing additional heating of the anodes.

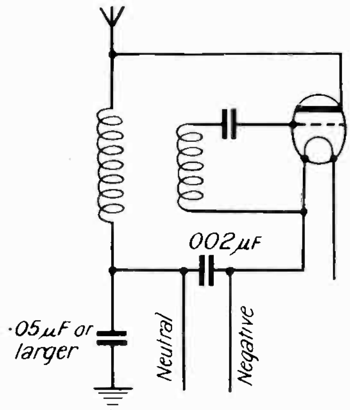


Fig. 2.

For small transmitters, the possibility of using the lighting mains for the anode supply is particularly attractive. The difficulties of application sometimes seem formidable, and even after coupling up, the valves may be found to be very stubborn, but usually this will be found to be due to an incorrect potential distribution of one of the circuits, probably imposed through the necessity of respecting an earthed supply main or similar trouble. In theory, these difficulties can be overcome by ringing the changes on the relative electrical positions of transmitter and supply mains in such a way that points of equipotential are always connected together, either directly or through some suitable coupling of minute impedance. Troubles such as these are usually accentuated when single circuit tuners are used, and as the efficiency of some versions of single circuit tuner is usually 10 per cent. to 30 per cent. higher than that of a magnetically coupled tuner, it is probable that the single circuit tuner will always be used quite extensively.

It is fundamentally a less difficult job to get a double or other magnetically coupled circuit to work, and they are, therefore, often cited as a cure for difficulties due to non-oscillating transmitting sets. Nevertheless, this should not be taken as an excuse for neglecting observance of correct conditions for connecting up the transmitter to the mains, or trouble with fluctuating output, varying wave-length, etc., will very often result.

The usual arrangement of a distribution network of any size, is a three wire supply with the neutral or middle wire connected to ground. This gives a potential difference from either positive or negative conductor to ground of 250 volts. It also introduces the risk of accidental short circuit in case of grounding of one of the "outers"—the positive and negative conductors. The possibility of setting up such a short circuit must be carefully guarded against and in the recommendations made in this article this will be attended to in such a way that there is no abnormal danger.

Supply Positive to Neutral.

A single-sided supply is almost universal when only a lighting supply is called for from the mains. With a positive service, and using a single circuit transmitter, this is the only service that can be used without any alteration to the transmitter connections. The connections are shown in Fig. 1. The stopping condenser and radio frequency choke (a 200-1 000 turn Igranic coil will do for the latter) are essentials, but they are equally necessary whatever the H.T. source. A lamp or other resistance of a minimum of 200 ohms should be connected in series with the positive or anode feed and will effectively remove the chance of a short circuit at the transmitter side of the supply. A 32 c.p. carbon lamp is as good as anything.* If a lamp is

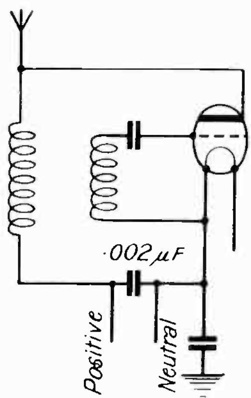


Fig. 3.

*[Personally, we should prefer a metal filament lamp. The lamp will have much less than its rated current through it, and the "cool" resistance of a tungsten filament is much less than when hot, while that of a carbon one is greater.—Ed., E.W. & W.E.]

used as the resistance, it should be rated at the same voltage as the supply, otherwise a short circuit would destroy the lamp.

Supply from Neutral to Negative.

In this case the neutral or grounded conductor is at the highest potential, and if connected direct to the valve anode, will result in earthing of the anode. Fig. 2 shows the correct method of coupling up to a supply of this nature so that the potential balance or distribution remains correct. A fairly large condenser should be connected across the high tension terminals, as these are included in the high frequency circuit. It is also advisable to connect a condenser in series with the earth connection, thus avoiding metallic contact with earth. This earth lead condenser should be quite large, at least ·05μF, and even so large as ·5μF. If it is too small, the speech in telephony will be distorted. The diagram should be faithfully followed, as there are several possible "niggers." A lamp or other resistance can be used in the H.T. negative as an additional precaution. Compare this diagram with the diagram following, Fig. 3, which shows a method similar in principle for taking supply from the positive main. This method can be used instead of that shown in Fig. 1.

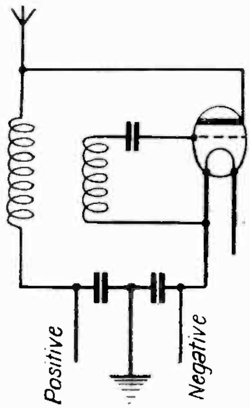


Fig. 4.

Supply Positive to Negative.

This implies the use of both "outers" of a three-wire network and will give about 500 volts for the anode supply. This voltage will work most 30-watt valves, and the writer has actually worked valves rated at 30 watts (dissipation at the anode), and put as much as 50 watts into the high frequency circuit. The circuit shown in Fig. 4 has been devised specially for working "large" small valves. The supply mains are bridged by two similar condensers connected in series. These condensers should be at least ·1μF, and larger values can be used with advantage. The middle connection between condensers is connected to ground and forms the wireless earth. This method provides quite a stable neutral and works well. It can be further stabilised if required by bridging each condenser with a fairly high resistance, say about 1 000 ohms each. A couple of small metal filament lamps will do quite well, but if energy consumption is a desideratum, these resistances can be as high as 100 000 ohms. A couple of anode resistances of a fairly robust type will answer fairly well.

In a future article the writer hopes to introduce some new methods of coupling up to A.C. mains and also to give details of a small static unit for supplying D.C. to a valve transmitter.

A New Method of Producing Ultra-Short Waves.

By J. Taylor, B.Sc. **[R411·0124**

A description of a successful experiment and the apparatus used.

Introduction.

A MOST interesting method has been put forward recently for the production of electro-magnetic waves of very short length. (" A New Source of Very Short Electro-magnetic Waves." *Zeitschrift fur Physik*, 24, B. 3 and 4, H., p. 153.)

Until recently, short electro-magnetic waves had always been produced by ordinary Hertzian oscillators, and this method, although very suitable for the longer wavelengths of the short series, is only with considerable difficulty applicable to the production of the shorter wave-length radiation. This defect is due to several disabilities inherent to the method. There is the destructive action of the discharge on the oscillator itself, the falling off of the energy emission as the wave-length is decreased, and the fact that the wave-length does not decrease in proportion to the decrease of the length of the oscillator in the case of the smaller wave-lengths.

Notwithstanding these difficulties, Nichols and Tear extended the range of explored wave-lengths two octaves down the scale, and obtained wave-lengths as small as 1·8 mm. (*Phys. Rev.* 2, 21, p. 587, 1923.)

Method of Nichols and Tear.

The advance was effected by using extreme precautions in the construction of the oscillators, which consisted of tungsten cylinders (A and B of Fig. 1), 0·5 to 0·2 mm. in diameter, and of length from 5·0 to 0·2 mm., sealed into glass. The diagrams of Figs. 1 and 2 indicate the experimental arrangement used in these researches. The gap of the oscillator itself was immersed in paraffin, which was projected through it by means of a jet (J, Fig. 2). The auxiliary gaps (c and d, Fig. 2) were cooled by compressed air.

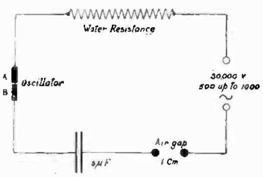


Fig. 1.

Experimental Arrangement for Nichols and Tear's method of producing short waves.

The short wave emission is, of course, given off by the system of the two tungsten cylinders alone, which constitute an oscillator of very small capacity and inductance.

Notwithstanding this decided advance, there still remained a very considerable gap between the shortest known wireless and electro-magnetic waves, and the longest known waves on the other side of the gap, of Rubens and Baeyer (1911).

The following method gives a wave-length range between some 40 mm. and the shortest wave-length yet observed, of 0·082 mm.

The Method.

A mixture of metal filings (in these experiments, brass or aluminium were used) and machine oil (M, Fig. 3), contained in a vessel, is maintained in constant motion by a churn (C, Fig. 3), so that the consistency of the mixture is uniform. A wheel or roller (R) is kept in rotation by a small motor, and thus the oil-filing mixture is raised and carried round on the periphery of the wheel. The leads of an induction coil (L_1 and L_2) are placed in the mixture on the wheel periphery, and discharge takes place through the top layer. As a consequence of the discharge, waves are given off from the oil-filing mixture, the frequency depending largely upon the dimensions of the filings.

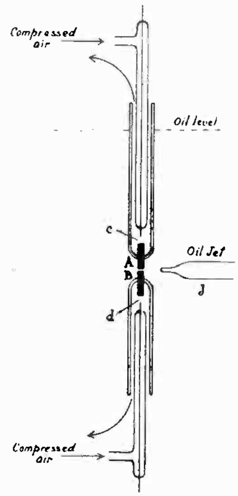


Fig. 2.

Diagram of Nichols and Tear's Oscillator.

The resemblance between the present method and that of Nichols and Tear is obvious. We may consider a pair of filings, between which sparking or a discharge occurs, as a small oscillator giving out its characteristic radiation. The exact length of the emitted wave will consequently depend to a great extent upon the magnitude and shape of the filings, and their distribution, which is maintained as constant as possible by the churning action of C. Further, since there are a large number of these small oscillators in action at any instant, the actual emission of short wave-length energy is much greater than in the previous method, where one oscillator only is in operation during the whole time.

The wave-length and energy distribution were measured by an interferometer method, and it was found in one particular case that a wave-length as small as 0·082 mm. was obtained. The maximum energy distribution was in the region of greatest wave-lengths.

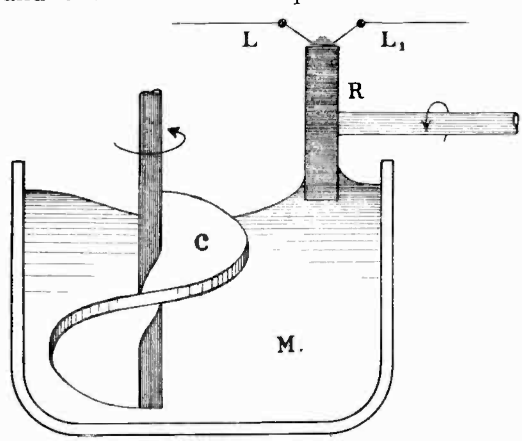


Fig. 3.

The Perfect Set. [R132

Part VI: H.F. Amplification.

Unfortunately it seems likely that this subject, like the last one dealt with, will spread itself over several issues.

IN settling down to study H.F. amplification (of the usual type) we are faced with the disconcerting fact that nearly all the points so carefully dealt with in our previous articles on L.F. work now either cease to apply or (even worse) are exactly reversed.

The cause of this is a simple one. Of the two forms of distortion mentioned (see E.W. & W.E., January, 1925, p. 228) "wave-form" distortion is unimportant and "amplitude" distortion is *desirable.*

In fact, the problem is an essentially different one. Here we wish to amplify currents of one frequency, and not those of other frequencies (this statement needs modification in some cases). Again, we are amplifying simply for the purpose of rectification afterwards: we wish to preserve unchanged the *envelope* of the wave-form (the dot-dash line in Fig. 1), and to a first approximation at any rate, a change in the form of the H.F. current curve, say, from the sine-curve shown in full line to the peaked curve shown dotted, will not affect the form of the envelope. It may affect the L.F. amplitude, but that is another matter.

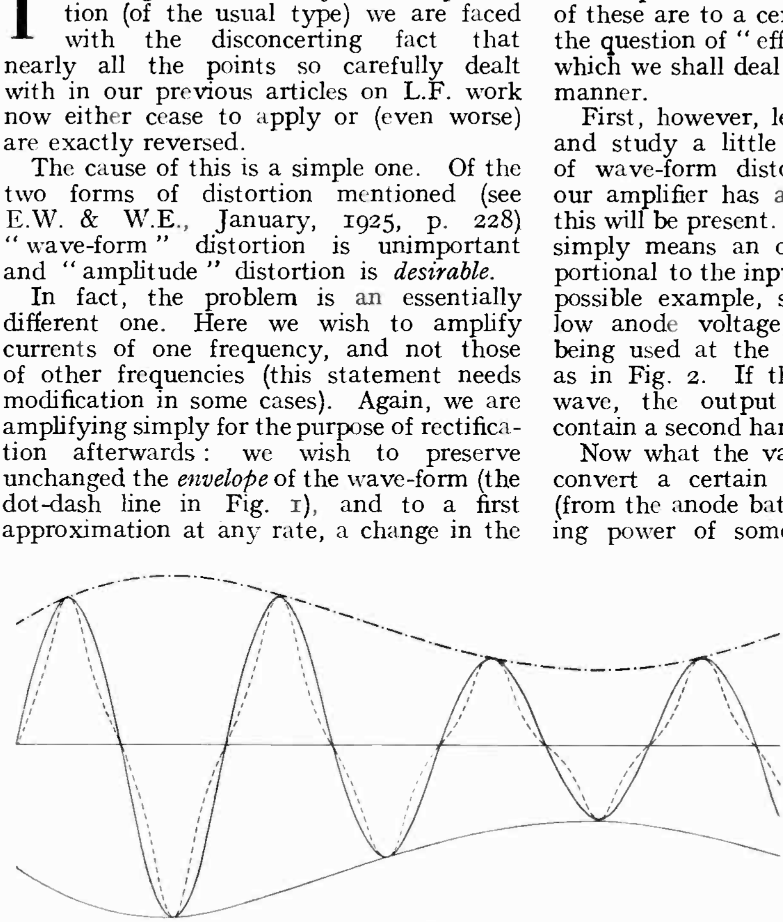


Fig. 1.

These facts give us a certain freedom in the design of an H.F. amplifier, but other matters crop up which limit us again. The most notable of these are oscillation, and low amplification at high frequencies. Both of these are to a certain extent tied up with the question of "effective input impedance," which we shall deal with in a very summary manner.

First, however, let us go back to Fig. 1, and study a little more closely the effect of wave-form distortion. If any part of our amplifier has a "non-linear response," this will be present. "Non-linear response" simply means an output not directly proportional to the input. To take the simplest possible example, suppose we are using a low anode voltage, so that our valve is being used at the lower part of its curve, as in Fig. 2. If the input is a pure sine-wave, the output will not be. It will contain a second harmonic.

Now what the valve is really doing is to convert a certain amount of D.C. power (from the anode battery) into H.F. alternating power of some given frequency controlled by the input. If any of the D.C. power is turned into, say, "300-metre" power instead of "600-metre," it is simply wasted, for the circuits tuned to 600, which follow in other stages, will not allow it to pass. So we are simply reducing the amplification.

Thus, although H.F. wave-form distortion does not necessarily matter as regards L.F. tone, it should be avoided in order to keep up the amplification. This can only be done by seeing that we work on proper voltage values, so that the straight part of the valve curve is used.

Now let us take up the question of instability—unwanted oscillation. There are two main causes of this, one simple, the other much misunderstood. The simple one is unintentional coupling. We usually provide intentional back-coupling, either by coils or capacity-coupling; but it is a

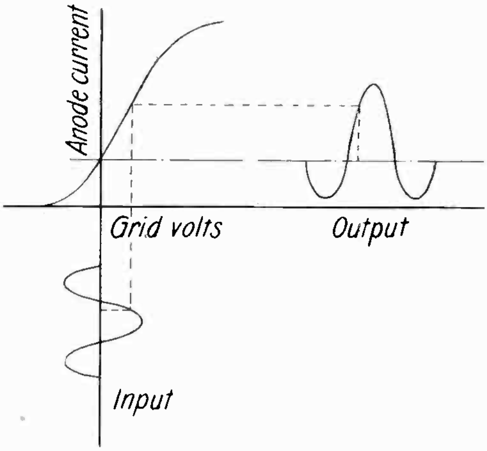


Fig. 2.

truism to state that every part of a set has some coupling, both magnetic and electric, with every other part in the same cabinet. If, owing to faulty design, these couplings are above a certain amount, and of a certain sense, there will be self-oscillation. The remedy is care in design and construction, with screening if necessary.

The other and much misunderstood factor is the effect of the internal capacity of the valve. This is usually held up as a bogey which may cause oscillation without rhyme or reason. As a matter of fact it is capable of quite definite examination, and as far as appears at present, can only cause oscillation under quite definite conditions, of which the most important is that, to have regeneration from this cause *there must be an inductive load in the plate circuit.*

Input Impedance.

Above, we mentioned, but did not define, the "effective input impedance." Suppose that, as in Fig. 3, we apply to a valve set

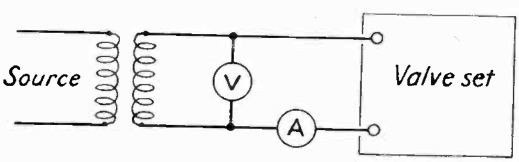


Fig. 3.

a measured voltage at any given frequency, and also measure the current input. Say, voltage E at frequency f ($\omega=2\pi f$), and current I. Then $\frac{E}{I}$ is the apparent input impedance. Now any impedance can be split up into a resistance R ohms and a reactance X ohms, and X may be either positive or negative. A *positive* reactance is that set up by a coil of inductance L henries, where

$$L=\frac{X}{\omega}$$

A *negative* reactance is that set up by a condenser of capacity C farads, where

$$C=-\frac{1}{\omega X}$$

As far as we know at present, the input reactance of a valve is always negative, *i.e.*, the valve behaves towards the input circuit like a small condenser (usually 10 to $50\mu\mu$F) in series with a resistance. The value of the resistance is the crux of the matter.

Let us note, firstly, just what is meant by various values of this resistance;

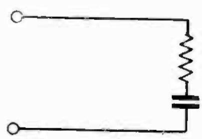


Fig. 4.

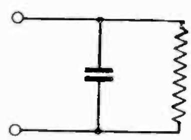


Fig. 5.

remember that it is considered as a resistance *in series with* the capacity load, as in Fig. 4. It is possible also to imagine any impedance as being split up into a resistance in parallel with a reactance, as in Fig. 5. A zero resistance in Fig. 4 gives the same result as an infinite resistance in Fig. 5—a pure capacity load absorbing no power. Generally, a low resistance in series is equivalent to a very high resistance in parallel.

Now there is a common tendency to believe that if the grid is negative, so that there is no D.C. grid current, and hence apparently an infinite parallel resistance in Fig. 5, then the valve acts as a pure capacity load. *This is totally mistaken.* There is quite definite experimental evidence and theoretical proof that whenever there is a load in the plate circuit there is an apparent resistance in the grid circuit; and the value of this resistance depends on the load. We will not go deeply into this matter now, for we are at the moment actually engaged in a lengthy research into the actual numerical values of the resistance under various conditions. But there are certain qualitative results which are quite definite.

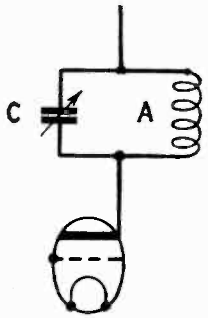


Fig. 6.

The input resistance decreases steadily as the reactance of the load increases. Thus, suppose the anode circuit is of the type shown in Fig. 6. If the condenser is too large for resonance, the whole of A behaves as a condenser; its reactance is negative (see above), and the input resistance is large. Reduce the condenser: the reactance becomes zero (*i.e.*, increases from its negative value), and the R_g (the input resistance) is smaller. Reduce the condenser still further: the whole of A begins to behave as an inductance; its reactance becomes positive and R_g becomes smaller still. At some particular value of C it will be zero, and the valve takes no power from the input circuit. Reduce C still further, and R_g becomes negative.

What does this mean? Here we are faced by the whole question of whether such a thing as "negative resistance" can have any meaning. But we cannot enter into it. For our purposes it simply means that whereas a positive value of R_g means that the valve is absorbing from the input a power of R_g multiplied by the square of the input current, a negative R_g means that it is *supplying* this power to the input circuit. It is, in fact, "Regenerating." Now the input circuit has its own resistance, and the first effect of negative R_g is to reduce the total resistance of the aerial input circuit. If, however, R_g becomes (while still negative in sign) greater in amount than the aerial and input circuit resistance, then the valve will not only overcome these losses, but will supply free power to the aerial: it is oscillating.

When is a "Tuned Anode" Untuned?

If the above statements are accepted, and they are based on reliable authority accepted by the leading wireless engineers, we arrive at one important point. The only case where the valve's internal capacity can set up oscillation is that in which there is an inductive load in the plate circuit. If in practice (as seems, alas! to be the case) oscillation is obtained with the favourite "tuned anode" circuit, it is because the anode circuit is *not* tuned. The user has decreased the capacity below resonance: he gets louder signals, but this is due to the reaction he has introduced by going out of tune. If he kept the capacity up to resonance (say 5 per cent. of its value above the apparent setting for loudest signals), and compensated for the loss of regeneration by moving up the reaction coil, he would get better signals.

To a certain extent this has been a digression, but input impedance is such an important matter, and has been so seldom dealt with, that we think we may be excused. The idea brought out in the last paragraph has to the best of our knowledge never been dealt with before in print.

Coupling Difficulties.

Now we come to another point: the effect of this comparatively low input impedance on the effective amplification of the previous valve. Take the circuit shown in Fig. 7, where Z_a is some kind of impedance in the anode circuit of the first valve—it may be a pure resistance, or a combined resistance and reactance. Note that the H.T. battery is shunted by a condenser. Consequently we can treat the anode circuit, *as regards alternating currents*, as simply an impedance between anode and filament. Also the grid circuit consists of the condenser C_1 the leak

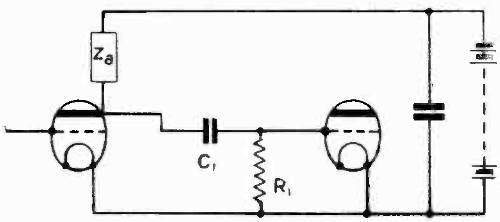


Fig. 7.

resistance R_1, and the condenser and resistance C_g and R_g making up the valve input impedance. It can easily be shown that with usual valves this whole assembly (C_1, R_1, C_g, R_g) forms an impedance not much different from Z_g itself. So that the circuit may be represented by Fig. 8. Further, for circuit purposes, the valve itself is just the same thing as a generator (giving a definite A.C. voltage) in series with a resistance (its own anode impedance), so that Fig. 8 can be further simplified into Fig. 9, where R_v is the internal impedance of the first valve, E_{a1} the voltage developed at its anode, and E_{g2} the voltage on the next grid.

First, suppose that Z_g is very large indeed, as is so often stated. In order to make E_{g2} as nearly as possible equal to E_{a1}, we must make Z_a large compared with R_v—as we are always instructed to do. But suppose, as is actually the case, that Z_g is not so very big—that, in fact, Z_g is about the same as R_v (say 20 000 ohms). Z_a and Z_g are two impedances in parallel, and (except under one special set of conditions detailed below) their net impedance will be *less* than that of the lesser of them. So that, however large we make Z_a, we cannot increase the ratio of E_{g2} to E_{a1}, beyond a certain amount—one-half, if $Z_g = R_v$. This is the main reason why resistance coupling (Z_a = a pure resistance) is a failure at low wavelengths, for Z_g decreases with the wavelength.

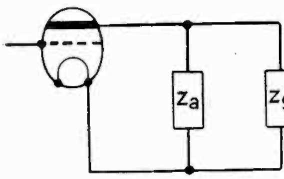


Fig. 8.

There is just one way in which this difficulty may be got over. We have already shown that Z_g is of the nature of a capacity and a resistance. Also, if Z_a is a tuned anode circuit, it can be made of the nature of an inductance and a resistance, as already explained. If, then, the resistances are low, Z_aZ_g becomes really a "rejector" circuit, and may have quite a high impedance if tuned. So we have a further difficulty in tuning the "tuned anode." A certain adjustment may give the strongest signals because (as already explained) it is causing regeneration, or because it is helping to get the previous anode voltage transferred to the grid, or, thirdly, because it is, as shown in this paragraph, helping to get the voltage at its own anode passed on to the *next* grid.

One more point: Adjustment of the second anode circuit alters the grid circuit, and thus alters, as we have explained, the combined value of Z_aZ_g in Fig. 8—*i.e.*, it alters the effective load in the first anode circuit. *But this in turn alters the previous grid circuit, and so on.* In other words, we cannot, as it were, shut up each stage in its own watertight compartment; a change in any stage affects every previous stage right back to the aerial.

It may be asked: Why did we not raise these points in dealing with L.F. amplification? For the simple reason that they are not so important in that case. For audio-frequencies the input impedance is much higher, and the effect of change in load is nothing like so great.

We note with dismay that our allowance of space is up, while we have not yet got down to the "brass tack" side of the business at all. However, we salve our conscience with the thought that this matter of the input impedance of a valve is the foundation of H.F. amplification, and as it has hardly been treated at all in publications available in England, it is as well to have "cleared the air" a little.

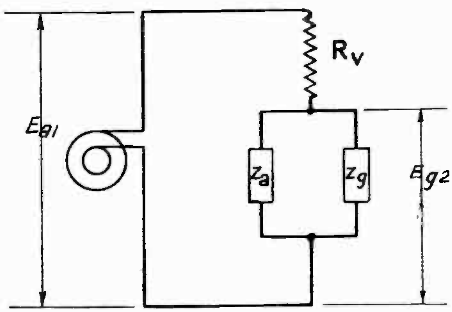


Fig. 9.

Before concluding with a promise of more next month, we must express our indebtedness to the work of Miller, of the Bureau of Standards of America, who worked out the theory of input impedance in relation to output load.

Measuring H.F. Resistance. [R240

By P. K. Turner.

A brief description of the accepted methods and also of two important new ideas.

IN a paper read before the I.E.E. during January, an interesting method of measuring H.F. resistance was developed by Prof. E. Mallett, M.Sc., and A. D. Blumlein, B.Sc.

Curiously enough, we had just heard of another new method, which turned out to be founded on the same fundamental idea as the above; it has been thought out by Mr. P. W. Willans.

The importance of these methods is that each of them avoids certain difficulties in the usual methods. Briefly, the Mallett scheme is free from certain sources of inaccuracy in most methods, while the Willans method has the especially great advantage of not needing any H.F. voltmeter nor ammeter.

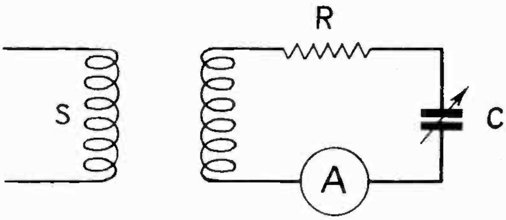


Fig. 1.

In order to appreciate clearly what is fresh in the two new methods, one must have a clear conception of present ones, and we will therefore devote a few words to consideration of two well-known schemes, the "Resistance - variation" and the "Reactance-variation" methods.

Resistance Variation.

This needs a measuring instrument, and some variable or interchangeable resistances of known values at high frequency. Like all these methods, it measures the resistance of the complete circuit, and gives an "equivalent resistance" including all sources of power loss. As shown in Fig. 1, the circuit is supplied with power from a source S, usually a valve oscillator. The extra resistance R is cut out and C adjusted to resonance, as shown by getting a maximum current at A. This current is noted. R is then inserted and the reduced current reading noted. Calling the first current I_o and the second I_r, it is easily shown (see Appendix I.) that R_o (the resistance of the circuit) is given by

$$R_o = \frac{I_r}{I_o - I_r} R \quad .. \quad .. \quad (1)$$

In practice, readings are taken for several values of R, and the results analysed either by least squares or graphically. The latter is done by drawing on a large scale a graph of $\frac{1}{I_r}$ against R, which should be a straight line.

This line, if produced till it cuts the axis of R, does so at a point of "negative" resistance, equal to the actual positive resistance of the circuit. Fig. 2 shows a case based on Table I.

TABLE I.

Added resistance. Ohms.	I_r = current mA.	$1/I_r$ + 100
0	20	5
1	16·7	6
2	14·3	7
5	10	10
10	6·7	15

(This is an imaginary example: $R_o = 5$.)

Reactance Variation.

Here again a measuring instrument is needed, but instead of interchangeable fixed resistances we need a calibrated condenser (or variable inductance) and an accurate knowledge of the testing frequency. The circuit is that of Fig. 1, but without R.

The procedure is simply to measure the current at exact resonance and also for a given amount of detuning.

It is shown in Appendix II. that if C_r is the capacity in circuit at resonance, C_a the capacity when detuned, and $\omega=6{\cdot}28\times$ frequency at resonance,

$$R = A \cdot \frac{1}{\omega C_r}\left(1-\frac{C_r}{C_a}\right) \quad \ldots \quad \ldots \quad (2)$$

where A depends on the ratio between resonant and detuned current, and is given in the following table :—

$\frac{I_a}{I_r}$ =	·707	·446	·316	·243	·164	·124	·1
A =	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{10}$

(I_a = " detuned " current, I_r = resonant current.)

Comparisons.

The second method (reactance variation) has the advantage of not requiring a set of known interchangeable resistances, but in practice it is none to easy to get accurate results. In ordinary circuits it may be assumed that R will be about 1/100 of $\frac{1}{\omega C_r}$, which means that either A or $\left(1-\frac{C_r}{C_a}\right)$ will be small. If we choose a small value of A, we have to read a small current in the detuned position, and few H.F. ammeters are good at the lower end of their range. (We cannot substitute a more sensitive instrument for the second reading, as it would alter R.) If, on the other hand, we keep A at $\frac{1}{2}$ or 1, then $\left(1-\frac{C_r}{C_a}\right)$ must be about 1/100, or the change in capacity to detune will be about 1 per cent. of the capacity in use. This is near the limit of accuracy of an ordinary commercial condenser, although the difficulty may be dodged by using a combination of condensers.

On the other hand the first method offers some quite appreciable difficulties in the design of the resistances. These must be of fine wire, so that their H.F. resistance does not differ appreciably from that at L.F. The same requirement makes it essential that the power absorption in them is that of a pure ohmic resistance ; dielectric losses would make them give false readings. Further, changing one for another must not alter the inductance or capacity of the circuit.

It must not be forgotten that the resistance of the circuit, as found by either of these two methods, includes the resistance of the ammeter. This means that a fairly powerful source must be used, as if one tries to work with a very sensitive meter its resistance is

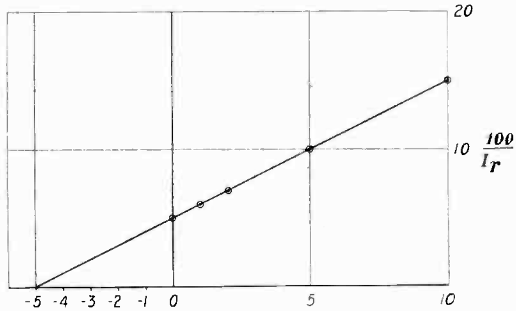


Fig. 2.

so high as to reduce the accuracy of measurement very considerably. For example, an error of 1 per cent. in measuring a resistance of 44 ohms in all, including a 40-ohm thermo-junction, becomes an error of over 10 per cent. in the resulting estimate of 4 ohms for the rest of the circuit.

Increased current must not be got by using closer coupling to the source, for if this is done a change of current in the measuring circuit appreciably influences the source, and the whole system of calculation (which assumes a constant source) breaks down.

For this reason the writer much prefers to use a Moullin voltmeter to measure the voltage across the circuit instead of measuring the current in it.

If the voltage is measured across some part of the circuit which is unaltered during the test—either condenser or coil in the first method, or across the coil in the second method—the ratio of voltages may be used in the equation above in place of the ratio currents with no other change. The power loss in the voltmeter naturally appears as a resistance, but this is extremely low, its apparent series resistance being of the order of 0·5 ohm, while the sensitivity is above that of ordinary thermo-junctions.

A Different Principle.

The two new methods both depend on a rather different principle, and have the advantage that they measure the resistance of a circuit without the necessity of any measuring instrument in the circuit. They are allied to the "click" method.

As the mathematical development of the principle involved is really an essential part of the method it is given here instead of in an appendix.

If, as in Fig. 3, we have an oscillating source, and in its neighbourhood a circuit such as A, then currents in the source set up voltages and currents in A. If M is the mutual inductance between the two circuits, $\omega = 2\pi \times$ frequency as usual, and I_1 the current in the source, then the voltage induced in L is $j\,\omega\,M\,I_1$.

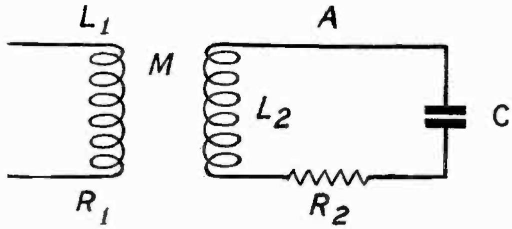


Fig. 3.

The impedance of the circuit A is

$$Z_2 = R_2 + j\left(\omega L_2 - \frac{1}{\omega C_2}\right) \quad .. \quad (3)$$

Taking amplitudes only, we have

$$I_2 = \frac{\omega M I_1}{Z_2} \quad .. \quad .. \quad (4)$$

or using γ as an abbreviation for $\frac{I_2}{I_1}$, we have

$$\gamma^2 = \frac{\omega^2 M^2}{R_2^2 + X_2^2} \quad .. \quad (5)$$

where X_2 is the reactance of circuit A:

$$X_2 = \omega L_2 - \frac{1}{\omega C_2} \quad .. \quad (6)$$

Now it is a well-known principle of transformer action, easily proved, that when a current flows in a secondary circuit (A in this case) the resistance and the reactance of the primary (the source coupling coil in this case) apparently change. If the primary resistance and reactance, without the secondary effect, are R_1 and X_1, then, calling R' and X' the effective values with a secondary current flowing,

$$R' = R_1 + \gamma^2 R_2 \quad .. \quad .. \quad (7)$$

$$X' = X_1 - \gamma^2 X_2 \quad .. \quad .. \quad (8)$$

The essential feature of both the new methods is to utilise as a basis of calculation the change in R' and X' caused by the change in R_2 and X_2 as the circuit A is tuned through resonance.

In the Mallett-Blumlein method Z', the apparent impedance $(= R'^2 + X'^2)$ is measured, and a graphical construction is used to find R_2. A measuring instrument is needed, and a fair amount of work is involved; but great accuracy is claimed.

In the method due to Mr. P. W. Willans, late of the Marconi Co., the source coupling "coil" is actually the pair of coils of an oscillator. The change in X' means a change of effective inductance of these coils, which in turn causes a change in the emitted frequency. This is heard as an alteration of the beat note in phones connected to an oscillating receiver in the neighbourhood (a third and quite distinct circuit, of course). This method may be used either with substituted resistances or by knowing accurately the frequency and condenser calibration, *i.e.*, with the information required for the two older methods; but it has the great advantage of needing no measuring instrument at all.

The Willans Method.

Taking the Willans method first, the change in frequency of the source will be directly proportional to the change of reactance, which is $\gamma^2 X_2$.

But $\gamma^2 = \frac{\omega^2 M^2}{R_2^2 + X_2^2}$ (see (5) above)

so that we have

$$\text{Frequency change} \propto \omega^2 M^2 \frac{X_2}{R_2^2 + X_2^2} \quad (9)$$

It is easily proved that (for ωM constant) this is a maximum when $R_2^2 = X_2^2$,

or $$X_2 = \pm R_2 \quad .. \quad .. \quad (10)$$

The actual change in frequency will follow a curve of the shape of that in Fig. 4; no vertical scale is provided, for the "size" of the change will depend on M, the amount of coupling to the source. For reasons to be taken up later, the change must be kept small. Luckily this does not matter, as the beat note method of judging the change is so extremely sensitive.

In this case, the curve is drawn for a value of tuning condenser of ·000 4μF at resonance, giving a condenser reactance of 500 ohms at 377 metres. The inductance coil to tune would be of 100μH. Under these conditions, with a value for R of 5 ohms, the curve will be as shown in solid line, and for 10 ohms as shown dotted (the change would be smaller in the latter case, but this is compensated by increasing the coupling).

Translating this curve into sounds heard, and assuming that the condenser tunes to resonance at 100°, we find that on bringing the closed circuit within range, with condenser all out, there will be a scarcely perceptible change in the beat note. As we get nearer resonance the note will change perceptibly (it may be either a rise or a fall, according to whether the separate receiver is above or below the source in frequency). Assuming that it is a rise, we shall find that as we vary the condenser from 95 to 105, the note will rise to a maximum pitch, fall to a minimum, and then come back towards normal. All we have to do is to note carefully and exactly the positions for the highest and lowest notes.

Looking up from the calibration curve the capacities at these points (C_a and C_b), we can easily prove from Equation (10) that

$$2R_2 = \frac{1}{\omega}\left(\frac{1}{C_a} - \frac{1}{C_b}\right) \quad \ldots \quad (11)$$

accuracy of H.F. resistance measurement by such methods.

It is obvious that this method really replaces the ammeter in the normal method described above. If we use it as just described, it is exactly analogous with the "Reactance Variation" method, as will be seen by comparing Equations (11) and (2) above. It is obvious that by our change of beat note we have found the points corresponding to $I_a/I_r = \cdot 707$ when using an ammeter. (See Appendix 2.)

On the other hand, we can use it instead of an ammeter in the "Resistance Variation" method, for if we insert various known H.F. resistances in the closed circuit, and plot $\left(\frac{1}{C_a} - \frac{1}{C_b}\right)$ against added R_1 we get a straight line from which the resistance of the circuit itself can be found exactly as already described. In actual practice it will be found quite accurate enough to plot added R against $C_b - C_a$, which is simpler: in fact if we know that the condenser is a good one, so that the change of capacity for given change of angle is steady, we can actually plot added R against degrees between the two points, and so find the H.F. resistance without knowing what capacity

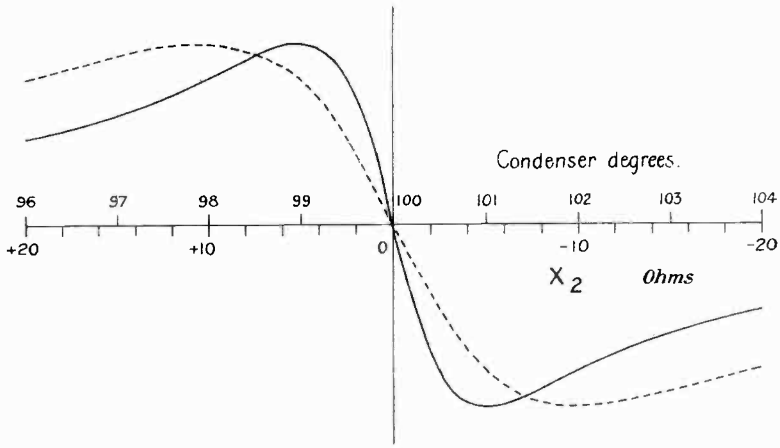


Fig. 4.

One important point must be mentioned. The mathematical argument is based on the assumption that ωM is unchanged. But this is not absolutely correct, for our change in beat note is based on a change in ω. In actual practice, however, this is negligible. For our rise or fall in frequency will be (say) 250 cycles, the beat note varying from 500 to 1 000. Now at 377 metres our frequency is about 800 000, so that the change of 250 amounts to a change of $\frac{250}{800\,000}$, or 1 part in 3 200. This may cause an error of 1 part in 1 600 in our results, which is small compared to other likely errors, for 1 part in 100 is the approximate

is being used. It is simplest to use the "good" variable condenser as a vernier across a large fixed condenser, to get reasonable sensitivity.

All that we need with this method is a set of interchangeable H.F. resistances, which can be cheaply made : with them and no other calibrated instrument one can measure H.F. resistance quite well to about 2 per cent.

Further, owing to the great sensitiveness of telephone reception, it can be used with a low-power source (an ordinary small local oscillator).

Incidentally, it might be noted that the mean of the two capacity readings—strictly the harmonic mean—gives a very accurate value for resonance, and so allows us to calibrate a closed circuit without interfering with it by connecting a detector.

A Precision Method.

Now as to the Mallett-Blumlein method. As already stated, this depends on measuring the actual impedance of the source coupling coil.

Going back to Equations (7) and (8), these can be combined into the following form :—

$$Z' = Z_1 + \gamma^2 Z_2 \quad \ldots \quad \ldots \quad (12)$$

where Z stands for impedance.

But, as we have shown,

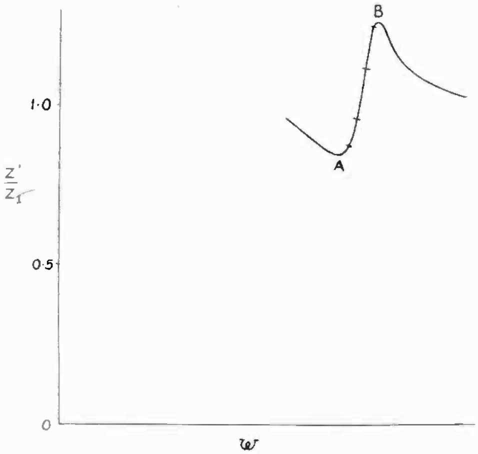


Fig. 5.

$$\gamma^2 = \frac{\omega^2 M^2}{Z_2^{\,2}}$$

(see Equation (5) above)

so that

$$Z' = Z_1 + \frac{\omega^2 M^2}{Z_2} \quad \ldots \quad \ldots \quad (13)$$

or

$$\frac{Z'}{Z_1} = 1 + \frac{\omega^2 M^2}{Z_1 Z_2} \quad \ldots \quad \ldots \quad (14)$$

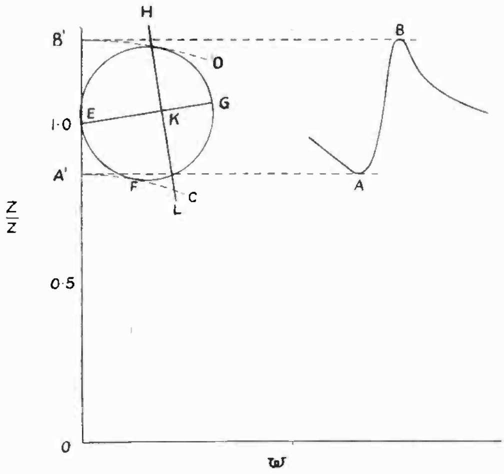


Fig. 6.

Now $Z_2 = R_2 + jX_2$, and so, if we know ω, M, $\frac{Z'}{Z_1}$, and X_2, we can find R_2.

But X_2 is known if we know L_2, the resonant frequency, and ω, and the necessity for knowing M is avoided by taking two readings and solving simultaneously for M and ω. In actual practice a set of several readings is taken and a graphical form of solution employed. We propose to give definite directions as to the graphical solution, its proof being available in the original paper.

The reading to be taken is impedance of coupling coil for various values of frequency : one can either vary the emitted frequency or the "tuning" of the test circuit, the change of natural frequency in the latter case being calculated from the change in capacity. The impedance is also measured with the test circuit broken or removed, and a curve of Z'/Z_1 plotted against ω, as in Fig. 5.

Now, the highest and lowest points A and B of the curve are noted on the left-hand vertical line (A' and B' see, Fig. 6), and with centre O, at the intersection of the axes, arcs $A'C$ and $B'D$ drawn. The circle EFG is thus drawn to pass through the point $E\left(\frac{Z'}{Z_1}=1\right)$ and to touch $A'C$ and $B'D$. The diameter EG is drawn, and the line HKL perpendicular to it. The position of this line is not fixed; it may be anywhere along EG, but for choice more or less as shown.

Now we take one by one a series of points on our original curve, and follow out the routine given hereunder for point 2 as an example (see Fig. 7).

First carry the height of 2 straight across to 2′: then strike the arc $2'P$ from centre O.

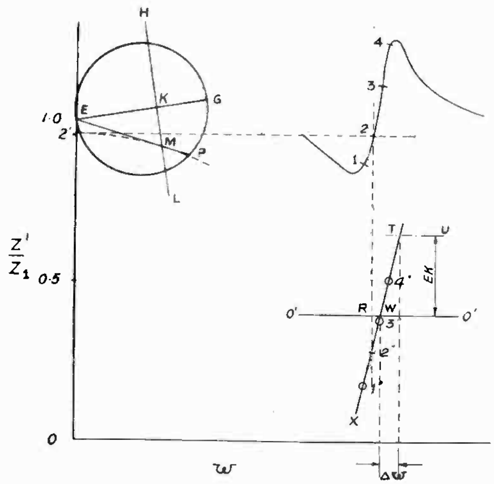


Fig. 7.

Join EP, and note the point M, where EP intersects HKL. Now choose some zero line below the original curve, such as $O'O'$, and directly below the original point 2 set off $R2''$ equal to KM, above or below the zero line according as KM is above or below EG.

The various points thus found, 1″, 2″, 3″, 4″, should lie on a straight line. Draw the line (XT) and also draw TU, parallel to the zero line $O'O'$ and a distance equal to EK above it. Measure, on the original scale of ω, the distance $\gamma\omega$, got by projecting downwards the points T and W (the latter being the intersection of XT and $O'O'$). Then

$$R = 2 . \gamma\omega . L, \quad \ldots \quad \ldots \quad (15)$$

where L is the inductance of the coil in the circuit to be tested.

As will be seen, this method is not altogether simple; but it appears to have important advantages as regards accuracy. It may have a great future for serious laboratory work. The original paper will appear in due course in the *Journal of the I.E.E.*, and should be consulted for full details.

Conclusion.

We fear that these notes on the subject are rather sketchy. It was originally our intention merely to describe the newer methods, but it seemed impossible to make clear wherein lies their novelty without some description of the accepted methods, and we have been led into a longer article than was intended.

As a personal opinion, we are inclined to think very highly of the Willans method, which, while not necessarily more accurate than the older methods, has the very great advantage of avoiding altogether the need of an H.F. measuring instrument, and therefore brings H.F. resistance measurement within the scope of nearly every amateur.

The Mallett-Blumlein method seems also of great importance; but its main claim, that of greatly improved accuracy, is one that can only be proved in the high-class laboratory, and we must wait for reports from such sources before expressing an opinion.

APPENDIX I.

Regarding Fig. 1 (repeated herewith): If the coupling to the source, and the source current, are unchanged, the EMF E induced in the closed circuit is constant.

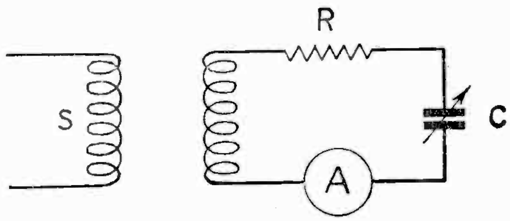


Fig. 1.

Further, as the closed circuit is tuned, its reactance is zero. Hence, if R_0 is the resistance of the circuit itself, and I_r is the current in it

$$I_r = \frac{E}{R+R_0} \quad \ldots \quad \ldots \quad (16)$$

When R is cut out, we have a current I_0 given by

$$I_0 = \frac{E}{R_0} \quad \ldots \quad \ldots \quad (17)$$

from (16) and (17) we have

$$E = R_0 I_0 = R I_r + R_0 I_r$$

$$\text{or } R_0 = \frac{I_r}{I_0 - I_r} R \quad \ldots \quad \ldots \quad (18)$$

APPENDIX II.

If Z is the impedance of the closed circuit, we have

$$Z = \sqrt{R^2 + X^2} \quad \ldots \quad \ldots \quad (19)$$

where X is the reactance, and is given by

$$X = \omega L - \frac{1}{\omega C} \quad \ldots \quad \ldots \quad (20)$$

Now, as in Appendix I., E is constant, and

$$I = \frac{E}{Z} \quad \ldots \quad \ldots \quad (21)$$

At any particular setting of the condenser, giving a capacity C_a, we have a corresponding reactance X_a, and a current I_a, while at resonance we have $X = O$, and

$$I_r = \frac{E}{R}$$

Hence

$$\frac{I_r}{I_a} = \frac{Z_a}{R} = \sqrt{1 + \frac{X_a^2}{R^2}} \quad \ldots \quad (22)$$

or

$$\frac{X_a^2}{R^2} = \frac{I_r^2}{I_a^2} - 1 \quad \ldots \quad \ldots \quad (23)$$

or

$$R^2 = \frac{I_a^2}{I_r^2 - I_a^2} X_a^2 \quad \ldots \quad \ldots \quad (24)$$

Now at resonance, as already stated, $X = O$ or

$$\omega L = \frac{1}{\omega C_r}$$

Therefore, at any other setting,

$$X_a = \frac{1}{\omega}\left(\frac{1}{C_r} - \frac{1}{C_a}\right) \ldots \quad \ldots \quad (25)$$

or, from (24)

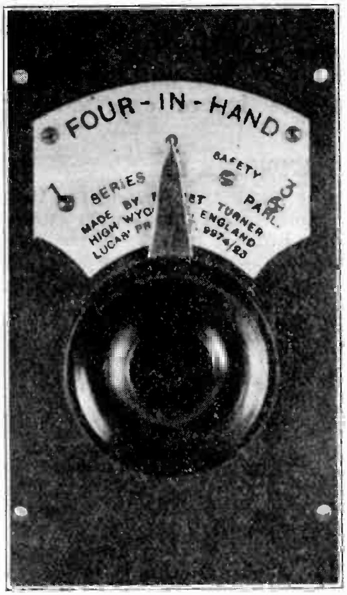
$$R = \pm\sqrt{\frac{I_a^2}{I_r^2 - I_a^2}} \cdot \frac{1}{\omega C_r}\left(1 - \frac{C_r}{C_a}\right) \quad \ldots \quad (26)$$

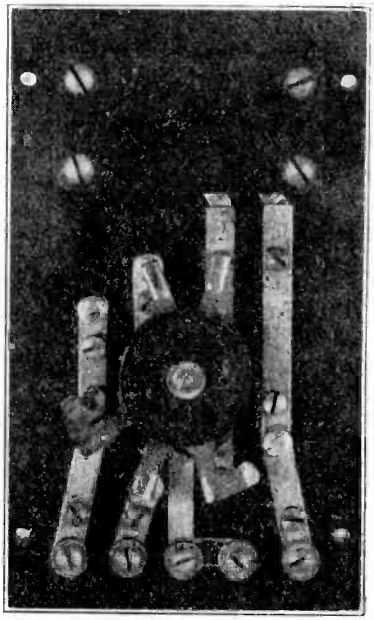
The factor A in Equation (2) is

$$\sqrt{\frac{I_a^2}{I_r^2 - I_a^2}}$$

and the $\pm$ sign allows for the fact that the detuning may be on either side of resonance, so that C_r/C_a may be either greater than 1 or less: in either case we take a positive value for R.

A Useful Series-Parallel Switch.





It is often very useful to be able to switch over one's aerial condenser from series to parallel, but the advantage is trebled if by so doing an overlap in wave-length can be obtained without altering the aerial coil. This fact has been realised by Mr. Ernest Turner, of High Wycombe, who has patented an arrangement a back and front view of which is reproduced herewith.

The five terminals at the foot are connected to the aerial, variable condenser, aerial end of the tuning inductance and earth respectively; and by means of the multiple switch shown, the variable condenser can either be connected in series with the aerial (first position), or a small fixed condenser (about ·000 5) can be placed in shunt with the tuning inductance when on stud two. In position 3 (safety) aerial and earth are shorted, while the fourth places the variable condenser in parallel with the inductance—the fixed condenser being shorted.

Oliver Heaviside, F.R.S.

A Founder of Wireless. [R097

ALL our readers will know of Oliver Heaviside, for the "Heaviside layer" is a commonplace among them; but we propose to give a few words to the other work of this great man, so long misunderstood that when at last appreciation came to him he was beyond enjoying it.

In some ways Heaviside was the typical scientist of fiction and alleged humour—a king at his work, but lost in public; and rather prone to fight his brother scientists. In this last matter, however, there is much to be said on his behalf, for he was so much in advance of his time that his work for a long period received a reception unworthy of his fellows and to the last degree embittering to himself.

Always of eremitic temperament, his desire for solitude was accentuated by these troubles, and his "life" apart from his work presents few features. He was born in 1850, and his early work was done in Kentish Town, London. It was not well received at first, but eventually received recognition. But he would not stay to enjoy this late appreciation: he moved down to Devonshire, where he lived alone in a cottage, only meeting his fellow men on his periodical visits to the nearest village for food. He lived without help of any kind and apparently with very little means.

By 1891, the scientists of his day had begun to find the value of his work. In that year he was elected a Fellow of the Royal Society. Later he was made Hon. Ph.D. of Göttingen, and Hon. Member of the American Academy of Arts and Sciences. In 1922, on the establishment of the Faraday Medal (to commemorate the 50th anniversary of the "Society of Telegraph Engineers," which was the first title of the I.E.E.), the highest honour of the institution, it was decided to confer it first upon Heaviside.

A few weeks ago it was stated that he had quite by chance been found very ill and removed to hospital. He did not recover.

His Work.

In spite of the fact that the amateur will usually connect his name with the famous "layer," all wireless workers will have come

A striking photograph of the late Dr. Oliver Heaviside, F.R.S., whose recent death will be lamented by scientists throughout the world.

in touch with his work at an earlier stage in their knowledge. For it was Heaviside who actually invented the word "inductance." He had to do so, for he was the first to carry out a thorough investigation of the thing now called by that name. Kelvin, it is true, had an idea of this entity, but had not really dealt with it. Heaviside also coined the words "reluctance," "reactance," and others now in regular use.

In the course of the work for which he invented these words he developed the whole theory of telegraphy on wires, showing first that signals are propagated as waves, and do not simply leak along the wires as it were. He went beyond this, and took hold of Clerk-Maxwell's famous theory of radiation, invented a new mathematical system to deal with it, and extended it. His work on wire telegraphy indicated that improved results would be got by artificially increasing the inductance of the line. The idea was dismissed with scorn by the telegraph engineers of this country, and it was left to Pupin, in America, to develop the practical application in conjunction with the American Telegraph & Telephone Co., so that the loading coils now in general use for long line work—which have made real long-distance telephony possible—are known as Pupin coils instead of being called by the name of Heaviside.

It was in his investigation of radiation that he tackled the problem of how and why "free" waves (such as those used in wireless) may be actually tied down to the conducting surface of the earth, and in this connection he suggested that as the upper layers of the atmosphere get less and less dense there must come at a certain height a layer which is not an insulator but a gaseous conductor. This layer, he pointed out, would be a guide or a reflector for waves, and the view now generally held is that only by means of this layer do we achieve long-range wireless working.

It is true that a German scientist is stated to have developed an hypothesis which accounts for long-distance work without the Heaviside layer, just as, for many years, some chemical professors of that nation have refused to mention atoms because the Englishman Dalton was entitled to the credit of the atomic theory. Recently the work of Sir Joseph Larmor has further elucidated the mechanism of the layer, and there seems little doubt as to Heaviside's foresight in this as in everything else that he handled.

It is interesting to note the opinions expressed on Heaviside by his colleagues when, in later days, they had understood his work. An official tribute was that of J. S. Highfield, President of the I.E.E., in his message covering the first Faraday Medal :—

"In the course of the meetings they [the I.E.E.—Ed.] have been again reminded of, and have recognised, the great importance of the classic work achieved by Mr. Heaviside and published by him in his papers and writings from 1887 onwards, and especially of his discovery of the importance of Inductance in circuits for the transmission of telegraph and telephone signals without distortion ; and of him as the originator of the methods now universally employed for this purpose ; and in no less a measure of his investigations and discoveries relative to the propagation of electro-magnetic waves in space, the results of which are now being utilised in Wireless Telegraphy and Telephony. They are convinced that, as now, so in the future, the name of Heaviside will rank among those of the great founders of the Science of Applied Electricity."

And lest we feel too much the injustice that he suffered, we can conclude in the sympathetic words of Sir Oliver Lodge—one of Heaviside's few friends—in *The Electrician* of February 13 :—

"I do not think the man was unhappy ; though at one time he was rather embittered by the misunderstanding and hostility of those in authority—an attitude which a genial man like Sir William Preece would have been the first to lament had he been better informed. Heaviside lived an independent, self-contained life : and no doubt his insight into Nature (whether recognised by his contemporaries or not) must have given him moments of sincere pleasure. The least we can do now is to recognise his genius, and wish that it had been earlier recognised and more widely known."

Radio 2GW. An Amateur Station.

By *J. Allan Cash.*

[R612

Aerial Experiments.

RADIO 2GW is, unfortunately, situated out in the wilds of Cheshire, where no electricity is obtainable. So the tale of its growth may interest other amateurs in this predicament who are, like the writer, not very "wealthy," and yet who want to become known in Europe. Most of the workable countries of Europe are now acquainted with this station.

During the last few years many and varied aerial systems have been tried. The house in which 2GW is situated is somewhat tall, so it has been a fairly easy matter to obtain a good aerial.

received, declared emphatically that it could not be so, as he could see that the wires did not reach to Paris !

This aerial sufficed for some time, but a lot of trouble was caused through the aerial wires not being strong enough to hold back the tree when it swayed in a gale !

Then a 20-ft. flag-pole was fastened in another tree, and the aerial swung round and up to it, making it 45 ft. up at the house end, and 57 ft. at the tree end. This was a decided improvement, but the writer is never satisfied, so some 22-ft. hollow spars were obtained from Southport, 40 miles away, and brought in on a touring car.

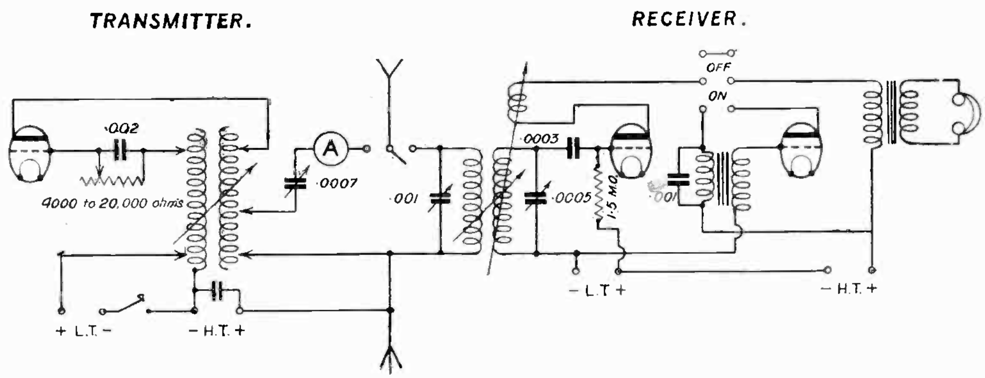


Fig. 1.

Schematic diagram of the circuits at present in use at 2GW.

At first a chimney stack and a tree were used, and a twin-wire aerial slung between them—to the utter amazement of the neighbourhood, by the way, as wireless was an unknown quantity to most people in those days. Then a 15-ft. mast was fixed on the roof, and the same aerial slung to it.

It was after this that a sorely puzzled neighbour, hearing that Paris had been

Two of these poles were bolted together, and with much careful balancing and roof-crawling, the whole 40 ft. mast was secured on the roof.

A convenient chimney-stack was found, just about the middle of the roof, and the eleven stay wires were taken to the four corners of the house. In this way no stay was more than 50 ft. long, whereas if they had been taken down to Mother Earth, some of them would have been quite 90 ft. long. All stays were split up with insulators every 20 ft. and at both ends.

This looked really "posh," and some admiring neighbours immediately christened the house "Lusitania." Whether this was a bit of sarcasm, in view of the fact that

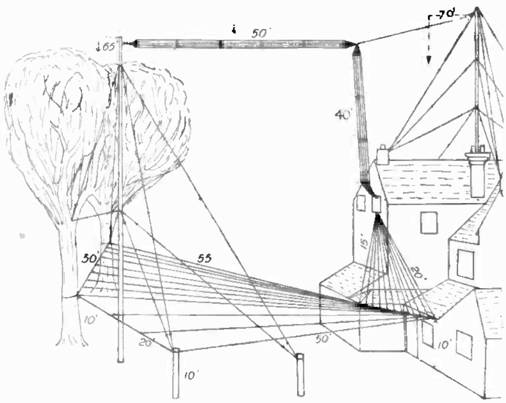


Fig. 2.

This sketch illustrates 2GW's earth and aerial systems, and gives accurate measurements, while—

the *Lusitania* went "down," has never been ascertained. However, various people predicted that the aerial would come down as soon as the wind so much as looked at it; but I am glad to say that it has remained erect successfully for seventeen months.

The tree end still swayed badly, although now only sideways, and in the end it was decided to scrap trees once and for all, and two larch poles, one 42 ft. and the other 32 ft. long, were obtained. These were stripped, painted and bolted together, and a hollow spar fastened on the end, making an 82 ft. mast. It was a big jog getting it up, but when it did point skywards, it was "some stick." Unfortunately, however, the back stays could not be brought out at a big enough angle, and the top length gave up the ghost in a terrific gale. Now, to serve until something better turns up, the larch-poles have been re-erected; and they make a very fine 65-ft. mast.

The aerial now in use is a six-wire cage. The wire is 7/26 S.W.G. hard-drawn copper, and the hoops, 12 in. diameter, are made of $\frac{1}{4}$ in. aluminium rod. These latter were made locally, and a rather larger number than necessary had to be procured. A few are still available at cost price, if any enthusiastic amateur would care to try them. The aerial is 50 ft. long, and the lead-in 40 ft., both being caged in the same manner. The lead-in tube is of thick ebonite, and the lead to the change-over switch is of $\frac{3}{4}$ in. copper strip, four feet long.

A twelve-wire counterpoise is now used, and is far better than any earth ever in use at 2GW. This is fanned downwards from the window of the "den" to a strong piece of wire 12 ft. long. Then the wires are fanned to about 40 ft., each one being about 70 ft. long altogether. Every wire is carefully insulated, and the counterpoise is about 10 ft. from the ground.

So much for the outside. Now let's get in out of the rain!

Difficulties Encountered—and Overcome.

Many different sets and circuits have been employed, and wave-lengths of 1 000 metres, 440 metres, and 200 metres, in turn were used, according to the fancy of H.M. Postmaster-General. Small dry cells were used for H.T. on the first few transmitters, and quite good work was done on them. It was only when really low wave-lengths were becoming "fashionable" that the flash-lamp battery was finally abandoned.

Some little time ago a Wilson break was obtained from 2PC, and the necessary junk gradually obtained for using it. A very well made ex-Government transformer was kindly given to the writer by 2WO. The primary of this was re-wound to give, as nearly as possible, 1 500 volts off the secondary with 20 volts input. The transformer was designed for 500 cycles, so it was hoped that something would happen.

The "juice" of 24 volts in accumulators (borrowed from all the B.C.L.'s in the district) was put on to the break, and the transformer connected. The motor alone took only ·25 amp to run light. To test the transformer, we shorted the secondary. If it came through, we thought we could rely on it! It came through with flying colours—and sparks! The amps went up to four, but there was no sign of a breakdown anywhere.

So that was that, and the transformer is still in use. Another one, designed rather more accurately, is now being made, with various voltage taps.

The Transmitting Circuit.

The whole transmitter was then rigged up and tested. After a few alterations the aerial ammeter slowly crept round a little way. Great hopes were entertained till suddenly a sharp crack was heard in the dim interior of the set, and shocks were felt on touching any single thing. The plate condenser had blown up, but as it was only a 1 000 volts condenser, this can be excused. Then a condenser off a spark set (supposed to stand 50 000 volts) was used and this blew up, too!

About this time summer holidays asserted their authority. On returning, however, from this necessary evil, the writer set to and re-hashed the set, rigging up another circuit. A condenser had been made up by scrapping a $1 \mu F$ mica condenser (Government junk) and putting five sheets of mica between each plate instead of one. This was sure F.B., and the set worked almost immediately.

On 130 metres the first night, Holland, Sweden and South France were worked, as well as various English stations. The aerial current was only ·13 amp, and will not go up at all unless a bigger voltage is used. Probably the new transformer will tickle its imagination a little, but it is a curious fact that, all along, comparatively small aerial currents have been obtained at 2GW, even though different ammeters have been tried.

Of course the high aerial has something to do with it. Ranges up to 1 000 miles can be obtained with only 20 volts input, which give ·11 amp in the aerial. When 30 volts are used, all Europe seems to answer a call!

No attempt has been made to rectify the plate supply yet, but this may be done later on.

The receiver at 2GW was the result of a determined attempt to make a really efficient short wave set. It was decided to put the components as nearly as possible in the order that they come. Also connecting wires were to be as short as possible. The standard coupled circuit is used with detector and one-step.

Much good work has been done by the writer with H.F. amplifiers, but it has now been decided that it is easier to read weak signals with very little QRM, than stronger signals with all sorts of weird noises thrown in. Everything that H.F. amplification brings in can be heard on one valve if the set is properly designed.

The Receiver.

The low-wave coils are all home-made. They are single-layer inductances wound with 22 S.W.G. enamelled wire. A set of these (6) has been made with 5, 7, 10, 15, 20 and 30 turns respectively. They will reach well below a hundred metres without any trouble. Special low-loss coils are being made to go down lower still.

Dubilier condensers are used throughout, both fixed and variable. The coil mount is a product of the Manchester Radio Co., Ltd., as are also the L.F. and phone transformers.

A home-made heterodyne wavemeter is always connected up by the side of the receiver, and all amateur waves can be given instantly.

The receiver has done all that was expected of it. Countless American amateurs have been received, mostly on one valve. Argentine CB8 was once received, while KDKA was always easily "readable" on 100 metres with one valve, and with two was nearly loud-speaker strength. Occasionally (but not often, let it be known) broadcasting is received, and all the big stations and most of the relay stations can be heard on only one valve. In fact, the writer often wonders why there is an amplifier at all!

It is not claimed that 2GW is as perfect as it could be, but as it is rather novel in some respects, and as almost everything is home-made, it was thought worthy of a description. QSL cards and letters are always answered immediately, and a complete log book of all work is kept. Fading curves of many stations are often taken (when they stay on long enough); but extensive experiments in fading have shown that the best are those which come in oversea—either the North Sea or the Atlantic.

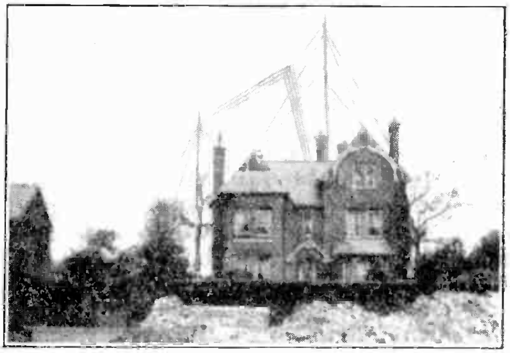


Fig. 3.
—this shows the actual appearance of the aerial

Error in Measurements. [R800 : R519

By P. K. Turner.

A very simple explanation of how one finds the estimated accuracy and most probable true value of a measured quantity.

NO measurement is ever accurate, except by pure accident. True, errors in measurement are sometimes very small. The N.P.L., it appears, can check a wave-length—or, rather, a frequency—to within one part in 100 000, or a resistance to even greater accuracy; but, even so, the measurement is not given as absolutely correct, and this article is an attempt to set out some of the simpler ways of handling the results of measurements to get the smallest error and to find what that error is. We do not propose to deal with the actual details of the measurements.

Suppose that, by any method, we have measured a fixed condenser, and find its capacity to be ·001 5μF. All that we can say is that its true capacity is *about* that. We can only guess how close to the measured value by previous knowledge of how accurate the method used is likely to be. Suppose we measure it again, and find it ·001 4μF. What has happened? Any one of many things. There was an error in reading our instruments in either case. The capacity of the condenser itself changes with temperature and other things. Our standard condenser was not absolutely constant—and so on.

But it is natural to say that the average of our two results (·001 45μF) is the best guess we can make at the true value, and this is really true under certain conditions, as may be shown mathematically. The "certain conditions," as far as ordinary testing goes, boil down to two—that the results, ·001 4 and ·001 5, should be read directly and not calculated from other readings; and that, as far as one may judge from the conditions of test, they are of equal closeness and accuracy.

This latter point is an important one. Suppose that we are testing a condenser believed to be of ·000 2, by substituting it for a variable condenser in an oscillating circuit in the well-known manner. Suppose, also, that we have two calibrated standard condensers, one of ·000 2 and one of ·001, and that we make a test with each of them. The small one would be used "all in," and an error of half a degree in setting or reading it would give an error of $\frac{1}{2}\times\frac{1}{180}$ part in 1, or about $\frac{1}{3}$ per cent.

With the large condenser, it would be set at about 36°, and the same error of half degree in setting or reading would result in an inaccuracy of $\frac{1}{2}\times\frac{1}{36}$, or about $1\frac{1}{2}$ per cent. So that the first test is five times as accurate as the second, and an average of the two results would not be the best guess at the true value. This point, however, we must leave aside for the moment.

Going back to our first test—a condenser of about ·001 5—we got, let us say, two results—·001 5 and ·001 4. Now suppose, by another method, we got two results—·001 45 and ·001 46. We should naturally conclude that the latter method was the more accurate one, and that the error in the result was probably much less. We can, in fact, calculate the "probable error" in either case, and the calculation is a quite simple one.

But we must first define "probable error."

Probable Error.

One is inclined to think, from the two results of ·001 4 and ·001 5, that the correct value is ·001 45, in which case the error in either reading is ·000 05. But we cannot state this definitely. It is quite probable that the true value is ·001 47, for example, one error being ·000 03 and the other ·000 07; and it is *possible*, though not probable, that the real value is ·001 6, with errors of ·000 1 and ·000 2. It is correct to say that in this case errors above ·000 1 or so are unlikely, or the two values found would not have been so close together. If we could hit on the correct figure, we might be able to say truly that there was an equal chance of the error being smaller or larger than this amount; and this is what we do in giving the "probable error."

Another point. If we make several measurements of the same condenser or other device, and each measurement has a "probable error" of a certain amount, we are safe in saying that the average of all our results is a much more accurate guess than any individual measurement, *i.e.*, its probable error is less.

To show how we find these errors, we will take a numerical example. Suppose we make six measurements on the same condenser, with the following results:—

TABLE I.

	·001 50
	·001 40
	·001 48
	·001 40
	·001 41
	·001 39
Average	·001 43

The first thing is to find the average in the usual manner (add the results and divide by the number of tests). This has already been done in Table I.

Next, find the difference of each result from the average, as in the second column of Table II. It is a useful check to note that if the averaging is correct the sum of positive errors must equal that of the negative.

TABLE II.

Readings.	Errors.	Errors Squared.
·00150	+ 7	49
·00140	− 3	9
·00148	+ 5	25
·00140	− 3	9
·00141	− 2	4
·00139	− 4	16
Av. ·00143	+12 −12	Sum 112

Now square each error, and add the squares all together. This amounts to 112 in our case (remember that we have omitted a decimal point and string of o's). To find the probable error of one reading, divide this 112 by *one less than the number of tests*—

$$112 \div 5 = 22{\cdot}4$$

Then take the square root—

$$\sqrt{22{\cdot}4} = \underline{4{\cdot}84}$$

This is the probable error of a single reading. It is more useful, as a rule, to have the probable error of the average. This is found in the same way, but after dividing by one less than the number of tests, we divide by the number of tests:—

$$112 \div 5 = 22{\cdot}4$$
$$22{\cdot}4 \div 6 = 3{\cdot}73$$

and then extract the square root—

$$\sqrt{3{\cdot}73} = \underline{1{\cdot}93}.$$

Remembering that our errors of +7, − 3, etc., were really ·000 07, ·000 03, etc., we see that the probable error of our average is ·000 019. We usually say "the capacity is ·001 43±·000 019," or we can express the fraction $\frac{\cdot 000\ 019}{\cdot 001\ 43}$ as 1·3 per cent., and say ·001 43±1·3 per cent.

Indirect Measurements.

Other cases which arise cannot be dealt with in quite this simple way. Suppose, for example, we want to find the H.F. inductance of a coil. We put it across a calibrated condenser, and find the wave-length of the combination.

Then, *if the coil had no self-capacity*, we

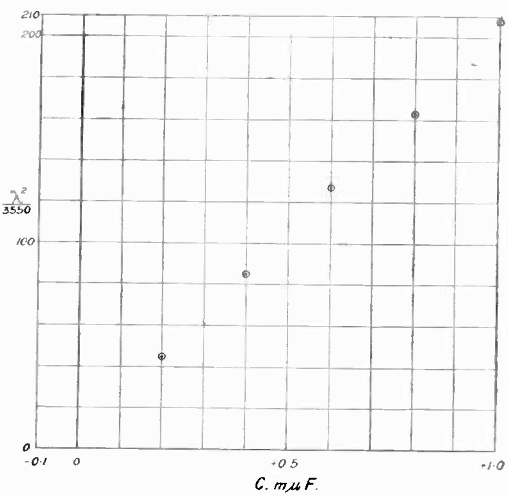


Fig. 1.

could find its inductance from the old formula for inductance, capacity, and wave-length. But the coil *has* self-capacity, of value unknown, and we must allow for this. The calculation is best shown in the form of elementary algebra. If L is the inductance and C_T the total capacity, we have

$$\lambda = 1\,885\ \sqrt{C_T L}$$

if C is in microfarads and L in microhenries.

This can be re-stated as

$$C_T L = \frac{\lambda^2}{3\,550}, \text{ with } C_T \text{ in m}\mu\text{F.}$$

$$(\cdot 001\mu F = 1 m\mu F.)$$

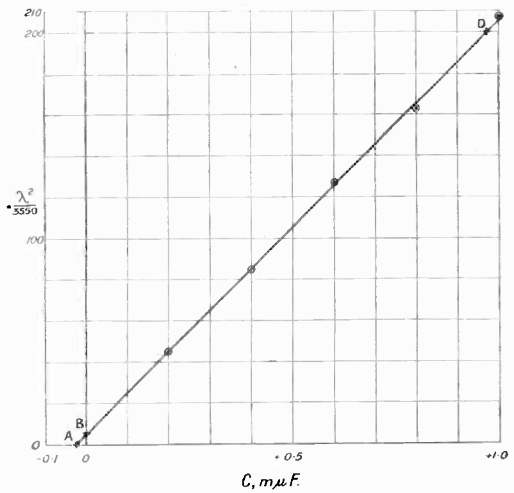


Fig. 2.

Now, if the self-capacity of the coil is C_s, and we make two tests with different values, C_1 and C_2, of the condenser, giving λ_1 and λ_2 as wave-lengths, we have

$$LC_1 + LC_s = \frac{\lambda_1^2}{3\,550}$$

$$LC_2 + LC_s = \frac{\lambda_2^2}{3\,550}$$

From these two equations we can find L and C_s, the two unknown quantities.

But in all probability we shall take several readings, not only two; and if we take the results two by two and find L and C_s from each pair, we shall get different results. How shall we find the most probable values? Well, for accurate purposes there is a perfectly definite method, that of "Normal Equations," which will be found treated in works on the "Method of Least Squares." But it involves a fair amount of work, and I do not propose to explain it unless readers of E.W. & W.E. ask for it. One can arrive at a fair approximation in a simpler way graphically.

This graphical method is simple, but depends to a great extent on skill in use. We first have to arrange our results in such a manner that when plotted in a graph they fall on a straight line. In the above case, we want to plot wave-length against added capacity (λ against $C_{1, 2}$ . . .etc.). But this will not give a straight line.

Perhaps it is hardly necessary to explain that in order that x and y shall give a straight line, the equation connecting them must be of the form

$$ax + by + c = 0,$$

or some equivalent form; it must not contain xy nor x^2 nor y^2, nor any other power, nor sin x nor log x—nothing, in fact, but simple x and y and constants. Now the equation under consideration is of the form (remember that C and λ correspond to x and y)—

$$LC - \frac{1}{3\,550}\lambda^2 + LC_s = 0,$$

where L and C_s are constants.

But suppose that instead of plotting C against λ, we plot C against λ^2. Then we *shall* get a straight line. We shall actually get a series of points, something like Fig. 1. If now we draw a straight line as nearly as possible through these points, we get Fig. 2. Now consider the points A and B. At A we have $\lambda = 0$. From our equation, this gives $LC + LC_s = 0$, or $C_s = -C$. In words, the negative capacity, as read on the scale, is the self-capacity of the coil. At B, $C = 0$, and we thus have, from the same equation,

$$L = \frac{\lambda^2}{3550 C_s},$$ which gives the true inductance.

The real difficulty is to hit on the straight line which lies most truly among the points.

The case shown in Fig. 2 is from the experimental results of Table III.

TABLE III.

Test of an inductance with various capacities across it.

Added capacity, C (mμF)	Wave-length (metres).
1·0	860
·8	760
·6	672
·4	550
·2	398

This particular case was worked out graphically, and gave, on the original large-scale drawing, $C_s = \cdot 028 \text{m}\mu\text{F}$ $(= 28\mu\mu\text{F})$. At B, $\frac{\lambda^2}{3\,550}$ was 5·5, and this, divided by C_s, gave $L = 196$. But a more accurate way of finding L is to take some point higher up the line, and divide $\frac{\lambda^2}{3\,550}$ by $C + C_s$. Thus if $C = \cdot 972$, $C + C_s = 1$. At this point, marked D, $\frac{\lambda^2}{3\,550}$ is exactly 200, and L is therefore 200.

Further, we can arrive at some idea of the probable error by seeing how closely the points lie on the line. In this case, two points are about 3 units below or above the line, at values on the scale of about 150 and 200, we can therefore estimate the accuracy, quite roughly, as 2 per cent. or so, for L. This is also the accuracy for $(C + C_s)$, and as C is nearly 1 and C_s is only about ·03, a 2 per cent. error in $(C + C_s)$ would involve a $\frac{1}{\cdot 03} \times 2$ or 66 per cent. error in C_s. Hence we can only claim 66 per cent. as the accuracy of C_s.

An actual investigation, by the normal method, gave the following values :—

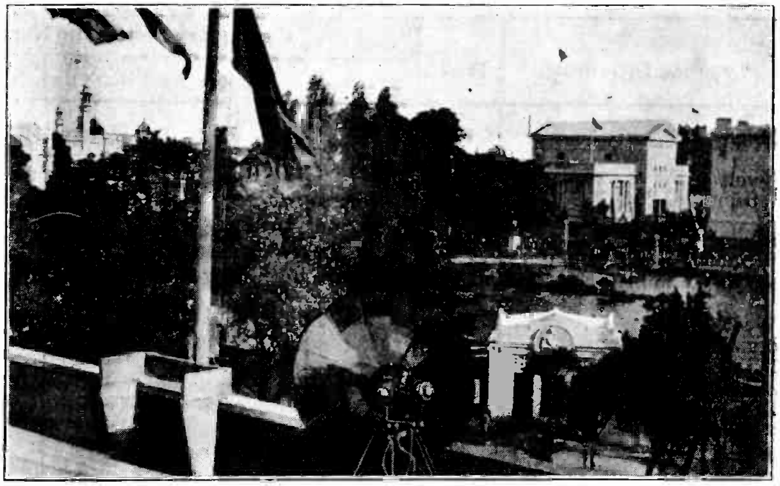
$L = 202 \pm 3\cdot 7$ (=2 per cent. approx.).

$C_s = \cdot 021 \pm \cdot 012$ (=60 per cent. approx.).

Valve Designations.

A Suggestion for Standardisation of Markings.

SINCE the introduction of the dull emitter valve there has been a very rapid increase in the number of different types of valves (as distinct from different *makes*) available to the public. We imagine that this is the natural consequence of the fact that users are now beginning to learn that a general purpose valve, while an excellent compromise, naturally cannot do so well as a series of separate valves each designed for its special purpose. There is also the fact that the use of power valves was previously limited, owing to the high current consumption—the very much lower input needed for dull emitter valves has made the use of power valves more practicable on the ordinary receiver. It is, however, an unfortunate fact that while in most cases several of the important makers have put on the market valves having practically identical characteristics, they have not only given these valves different key letters—B for the B.T.-H. valves, D.E. for the Marconi-Osram, and D.F.A. for Mullards, etc.—



We regret that in the article, "Power Amplification for Loud Speakers used at Wembley," which appeared in our last issue, no acknowledgement was made to Messrs. Alfred Graham & Co., whose Amplion "Goliaths" were used. Above we show a corner of the Exhibition with one of the loud speakers in the foreground.

but they have not in any way systematised the key numbers.

For example, the type of power valve taking 0·25 amp at $5\frac{1}{2}$ to 6 volts is called the B.4, D.E.5, or D.F.A.1 by its various makers, while the well-known 60 milliamp type is known as B.5, D.E.3, or D.06. Some weeks ago, we wrote a letter to the Valve Makers' Association calling attention to the fact that this was causing endless confusion among users, and suggesting that there would be no real difficulty in the way of adopting a uniform numbering scheme, while maintaining the individual letters as distinguishing features for each maker. We also submitted a scheme carrying this out, which appeared to have advantages.

We were informed by the Valve Makers' Association that the scheme was being favourably considered, but up to date no conclusion seems to have been reached. We have, therefore, decided that we will publish the scheme, with the hope that even if the valve makers do not of their own initiative set it in operation, it will be useful to users; we ourselves propose to use this method of describing valves in future issues.

Briefly, the idea is to substitute for the key numbers of individual makers a three-figure number, of which the first figure shall indicate the approximate rated voltage for the filament, and the last two figures the rated current. Thus the type of valve already referred to, which is designed for 6 volts and takes 0·25 amp, will be known simply as a 625 valve. Our suggestion to the Valve Makers' Association was that each maker should place in front of this number his own key letters; but for journalistic purposes it is usually desired to indicate a type of valve without specifying the particular maker, and for this purpose the figures alone will serve. In one or two cases where valves are made with the same input, but designed to give specially high or low magnification, we propose that the Association should follow the practice already in use to a certain extent, and put after the number a small letter—"a" in the case of valves of extra low magnification, and "b" in the case of extra high magnification. The Marconi-Osram valve taking 6 volts and 0·25 amp with a magnification of 20 is at present known as the D.E.5b, and we suggest that this would be known as the 625b type. The table below gives the majority of valves in common use to-day, divided into types, with the names given them at present by their various makers, and our suggested type numbers. It is obvious that one can continue to elaborate the type numbers to include reference to magnification, output current, and so forth, but we do not consider that this would be an advantage.

Type and Description.	Price.	Present Key Letters and Numbers.					Suggested Type No.
		B.T.-H.	Cossor.	Ediswan.	M.-O.	Mullard.	
Bright G.P.	11/-	R	P 1, P 2	A R., R.	R., etc.	R., Ora, H.F., L.F.	**460**
5-volt G.P.	11/-	—	—	—	R.5v	—	**560**
"Semi-dull" G.P. ..	18/-	B.3	—	A.R.D.E.	D.E.R.	D.3, H.F. and L.F.	**235**
Special Ditto	18/- 20/-	— —	W.1. & 2 W.R.1 & 2	—	—	—	**225**
·06 or 60 milliamp ..	21/-	B.5	—	A.R.·06	D.E.3	D.·06, H.F. and L.F.	**306**
Weco	21/-	—	—	—	—	Weco	**125**
6-volt D.E. Power ..	30/-	B.4	—	P.V.5D.E.	D.E.5	D.F.A.1	**625**
Ditto, High Magnification	30/-	—	—	—	D.E.5b	D.F.A.4	**625b**
4-volt D.E. Power ..	26/-	—	—	—	D.E.4	D.F.A.0	**435**
Low-current Power ..	32/-	B.7	—	—	—	D.F.A.3	**606**
2-volt Power	22/6	—	—	—	D.E.6	—	**245**
3-volt Power	30/-	B.6	—	—	—	—	**312**

Notes on the New Bill.

From every point of view the new Wireless Bill at present before the House is bad for serious amateurs, as the extracts and our comments below will show.

THIS new Bill may be considered as one of the cleverest examples of oppressive legislation that has ever been drafted. For it contains a bold clause—that dealing with the searching of houses—which has attracted everyone's attention. Unless great care is taken, other and much more serious interference with wireless work will slip through uncriticised, while the Press and the public are chasing a red herring.

We have, first, Section 1, which follows the old Act in stating that :—

> A person shall not establish or maintain any wireless telegraph station, or install, work, or maintain any apparatus for wireless telegraphy, in any place or on board any ship or aircraft to which this Act applies except under and in accordance with a licence granted in that behalf by the Postmaster-General.

This, of course, is from the old Act ; and as there are sound reasons why wireless must be controlled by some Government Department, there is no comment to be made.

Section 1 (3) defines the maximum penalties for offences under the Act. They are heavy, but this is not so important as has been stated in the lay Press, for, after all, the actual penalty inflicted in any given case is decided by a magistrate or judge, who only inflicts heavy penalties when they are really called for.

Section 1 (4) is the "search" clause which has caused such a flutter. Why, we cannot think, for there has always been the right of the police to apply to a magistrate for a search warrant if they have information that premises are being used for any of quite a long list of unlawful purposes. According to the "Dailies," one conjures up visions of any Post Office official having the right to enter premises at his own sweet will. What the Bill actually says is :—

> If a justice of the peace is satisfied by information on oath that there is reasonable ground for supposing that a wireless telegraph station has been established, or is being maintained, without a licence in that behalf, or that any apparatus for wireless telegraphy has been installed, or is being worked or maintained in any place or on board any ship or aircraft within his jurisdiction without a licence in that behalf, he may grant a search warrant to any police officer or any officer appointed in that behalf by the Postmaster-General, the Admiralty, the Army Council, the Air Council, or the Board of Trade and named in the warrant, and a warrant so granted shall authorise the officer named therein to enter and inspect the station, place, ship or aircraft and to seize any apparatus which appears to him to be used, or intended to be used, for wireless telegraphy therein.

It will be seen from this that the powers are not excessive at all.

Section 1 (5) reads :—

> The expression "wireless telegraphy" means any system of communication by telegraph as defined in the Telegraph Acts, 1863 to 1924, without the aid of any wire connecting the points from and at which the messages or other communications are sent and received.

It will be seen that this covers telephony and broadcasting.

The Amateur's Position.

Much more serious matters are those of Section 2, which are made to *look* as if they maintain the rights of amateur experimenters, but actually give no rights at all. These are most deceptive. Take, for example, Section 2 (1) :—

> Where the applicant for a licence proves to the satisfaction of the Postmaster-General that the sole object of obtaining the licence is to enable him to conduct experiments in wireless telegraphy, a licence for that purpose shall be granted, subject to such special terms, conditions, and restrictions as the Postmaster-General may think proper, but he shall not be subject to any rent or royalty.

That looks excellent. But note "proves *to the satisfaction of the Postmaster-General.*" It is notorious that during the last year or two this "satisfaction" has been as capricious as a maiden's fancy. It has turned down serious professors, desirous of conducting scientific experiments, and admitted careless youths quite unfitted to handle apparatus ; and there are signs that it is getting less reasonable as time goes on. Justice demands either that the consideration of applications should be in the hands of an impartial body (say, one representative each from the G.P.O. and the R.S.G.B., with a neutral referee) or that definite qualifications should be laid down in the Bill.

Again, look at the last few words of the clause: " . . . shall not be subject to any rent or royalty."

How nice that sounds! But compare it with Section 2 (3) :—

The provisions of this section and of the enactment replaced thereby, providing that a licence is not to be subject to any rent or royalty, shall not prevent, and shall be deemed never to have prevented, fees (periodical or otherwise) prescribed for the purpose being charged in respect of the grant or renewal thereof.

And it is not as if these fees were nominal. No sensible broadcast listener objects to 2s. 6d. out of his 10s. being used to defray clerical expenses; and the experimenter would not much mind the whole of his 10s. being devoted to that purpose. But, we wonder, do our readers realise that experimenters do not get their licence for 10s.? Directly an experimenter wants any reasonable facilities as to hours or power, up go his fees to £5 or more, and there is no limit to the P.M.G.'s powers in this respect.

Regulations.

But perhaps the most pernicious of all is Section 3. Under 3 (1) "The Postmaster-General may make regulations"—about practically anything he pleases to do with wireless. 3 (2) provides heavy penalties for breach of such regulations, and 3 (3) shows that the only safeguard against these regulations, which have the full force of law, is that they must be laid before Parliament for 21 days: If an address be presented by the House praying for their annulment, His Majesty in Council may annul them.

Now, these are absurd claims to autocratic power on the part of a Government department. It is quite reasonable for the Post Office to say that the science of wireless advances so rapidly that it is impossible to cater in detail for it, and that there must be the power of making regulations from time to time. But the scope of such regulations should be severely limited, and it should be laid down that they have no force until formally ratified by Parliament after proper discussion.

Section 4 gives particulars of messages which may not be sent—obscene matter, false distress signals, etc., and we have no quarrel with it, nor with 5 and 6. But 7, again, tries to encroach unreasonably. It is, however, ambiguous. The exact words are :—

The provisions of this Act shall apply to the installation and working of apparatus for utilising etheric waves for the purpose of the sending or receiving of energy without the aid of any wire connecting the points from and at which the energy is sent and received as they apply to the installation and working of apparatus for wireless telegraphy.

The difficulty is in the word "as." If it means that the Act shall apply to such apparatus, because it is like wireless apparatus, then it is not necessarily true. If it means that the Act shall apply to such apparatus as far as it is like wireless apparatus, then it goes too far. The application should be limited to cases in which such apparatus could actually be used for wireless without substantial alteration.

Section 8 deals with an "emergency," *i.e.*, war, etc. But here again the Bill goes too far. The first words read :—

"If at any time in the opinion of a Secretary of State an emergency has arisen . . ."

Thus, any sufficiently important politician could stop wireless at a few days' notice! There is nothing about the proclamation of a state of emergency as the result of full Government deliberation.

A Danger to All.

It will be obvious from what we have said that the Bill, if passed into law, will give autocratic power to a department which has not in the past shown itself considerate or helpful. The amateur will be in a much worse position than to-day.

Do not let us forget that behind the scenes there are always the Services and the big commercial companies, all of whom want the whole ether if they can get it, and who would only too willingly push the amateur experimenter right out of existence.

This Bill should be fought to a standstill, and it is up to every reader to get in touch with his M.P. and ask him to oppose it.

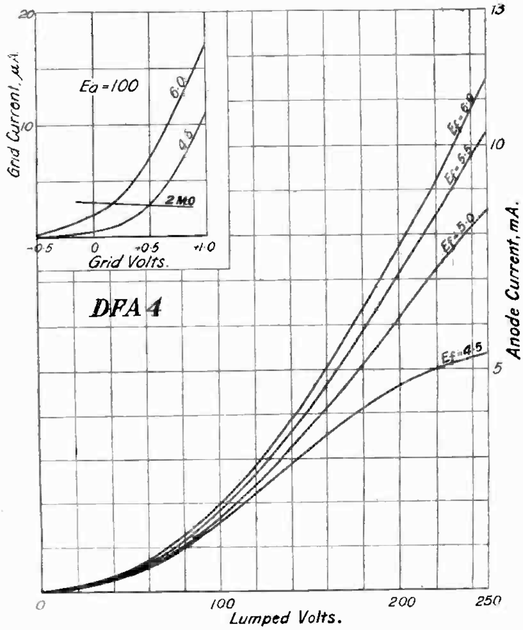
It may be said that our criticism is entirely destructive. This is true as far as this article is concerned; we have, in fact, formulated some quite definite constructive proposals, which have been put forward in the right quarter.

Some More New Valves.

Below we describe five more new valves—another Mullard, two Cossors, a Luminax and a Löwe Audion.

The D.F.A. 4.

THIS is a valve similar to the D.F.A.1 by the same makers—a dull power valve rated at 5·5V, ·2 amp—but with a close grid for resistance amplification. Tested as usual it showed a filament current slightly below its rating. The output was



also rather below the average for valves with these filaments, being 30mA maximum instead of the usual 40. We are inclined to think that the filament of this sample had a resistance slightly above the average, and so was running cooler. The anode

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	·17	6	27 000	15·0	8·5	8
5·0	·18	14	21 000	14·0	9·3	15
5·5	·19	20	17 000	12·5	9·1	19
6·0	·20	30	13 000	10·5	8·5	25

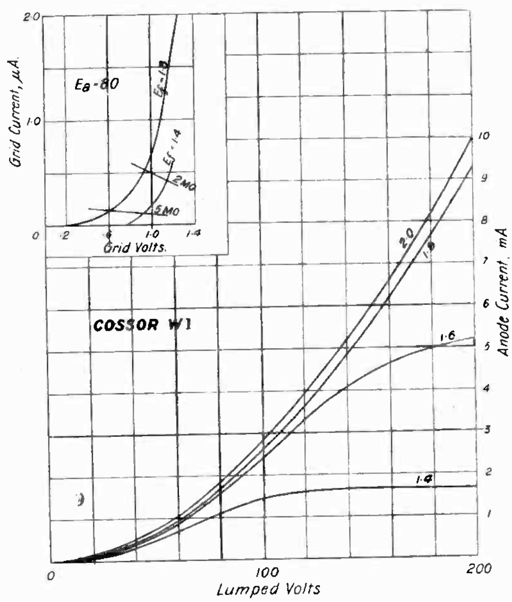
impedance varied between 27 000 and 13 000, and the μ between 15 and 10·5; our curves show the actual currents. The grid current diagram carries the line of current for a 2MO leak; it would appear that a higher leak (3MO) would be better, and that with this the valve should be an exceptionally good detector. Price 30/-

The Cossor W.1.

This is one of the two new Cossor "Wuncell" valves, and is designed as a dull emitter G.P. valve for use in place of the bright Cossor P.1 ("plain top"). It is rated at 1·8—2V

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	·27	1·8	47 000	9·8	2·0	4·7
1·6	·29	6	26 000	6·2	1·6	13
1·8	·31	—	13 500	4·0	1·3	—
2·0	·34	—	12 500	3·6	1·1	—

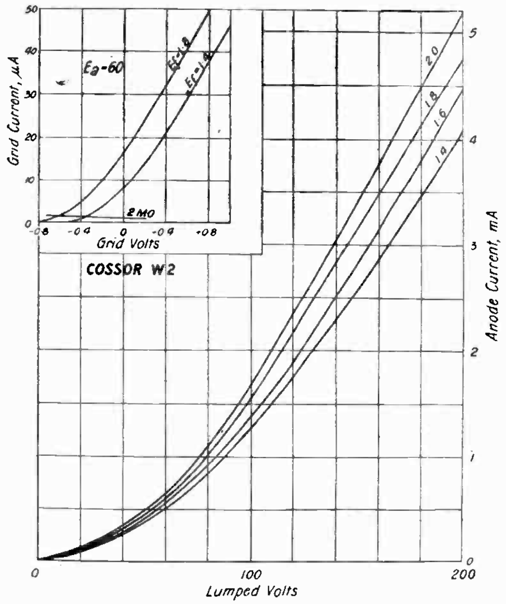
on the filament, and, as shown, was tested at various voltages between 1·4 and 2, the current being ·27 to ·34 amp. This puts it on the same footing as the well-known 235 type (see p. 363) although it is actually rather more economical, and differs entirely in construction, having an oxide-coated filament.



Our table shows the values of its constants at various filament heats; but we could not find all the saturation currents. On attempting to arrive at them, we simply caused a steady increase of current (at all filament heats above 1·6 volts) and found that the valve was ionising. In practice we should recommend a maximum load of 7-8mA, to avoid disintegration of the filament.

The extremely small grid current is a notable feature.

In construction, the valve has some excellent points. The cap is now without the usual metal band, and, further to reduce capacity, the moulding



is completely cut away between the legs, being in fact only a hollow, cylindrical shell. The electrode supports have been rearranged to allow for a central support to the filament.

Price : 18s.

The Cossor W.2.

This is the companion valve to the previous one, corresponding to the bright Cossor "Red-top." As will be seen from our curves and tables, the main difference is a grid of closer mesh (or heavier wire) giving a higher magnification. Otherwise it is essentially similar, except that it takes quite a large grid current at zero volts ; it should make a sensitive detector with a 2-megohm leak.

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 $\left(=\frac{I_s}{\text{Watts.}}\right)$
1·4	·28	—	33 000	8·8	2·3	—
1·6	·31	—	30 000	8·0	2·1	—
1·8	·33	—	28 000	7·8	2·3	—
2·0	·36	—	25 000	8·3	3·7	—

It is to be noted that both the valves can be supplied in a useful modification, known as types WR1 and 2, in which there is incorporated within the cap a fixed resistance of about 8 ohms. This is cut in or out by a small milled-head screw, and when in circuit, enables the valve to be used safely with a 4 or 6-volt battery and the usual 6-ohm rheostat. In this modification, both types sell at 20s.

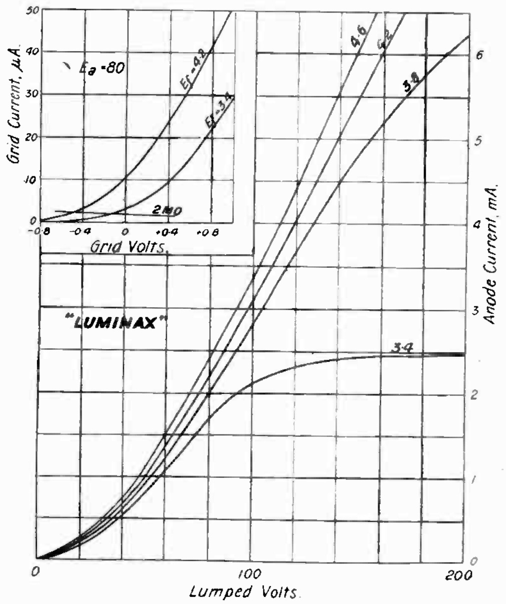
"Luminax."

This is a new British valve sold by Messrs. "Luminax" Electric Supplies, 553, Mansion House Chambers, Queen Victoria Street, E.C.4. It is in appearance a typical "R" type, with round

Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. Is	Anode Imped-ance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
3·4	·66	2·4	33 000	6·6	1·3	1·1
3·8	·70	6·8	25 000	6·6	1·8	2·5
4·2	·74	17·5	18 000	6·0	2	5·7
4·6	·77	31·5	15 000	5·5	2	9·0

bulb, but it is rated to take 4—5 volts on the filament. We found on test that it would do good work with less, and at its rated voltage has enough output to handle a fair-sized loud-speaker.

Our table shows that its anode impedance is quite low, and the magnification medium ; and it will be seen from the drawing that the curves are very nice and straight. These show that the valve should be a quite exceptional amplifier for this type, and it should detect quite reasonably



well. It is magnesium exhausted, and appears to be dead hard.

Altogether, a very good valve, especially in view of its low price of 8s. 6d.

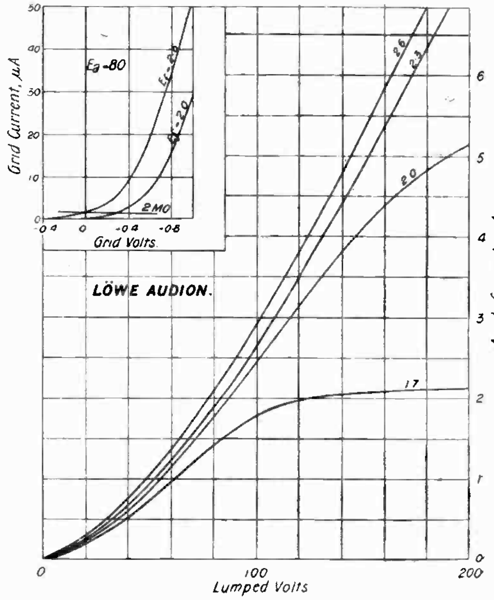
Löwe Audion.

A German valve, handled in this country by Messrs. R. Stitchling, 52, Dorset Street, W.1 The one tested is a dull-emitter, rated to take ·16—·17 amp. at 2·0—2·5 volts on the filament; it was tested at 1·7 to 2·6 volts. It is a neat and small valve, with a bulb of the general shape of the well-known B.T.H. B5 ("306" type, see p. 363) It is magnesium exhausted.

Fi 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 $\left(=\frac{I_s}{\text{Watts.}}\right)$
1·7	·15	2·1	48 000	3·3	·23	8·4
2·0	·16	6·3	28 000	3·6	·45	19·5
2·3	·17	12·6	22 000	3·0	·42	32
2·6	·18	21	21 000	2·9	·42	45

A notable point in view of the small input—about ·4 watt—is the high saturation current, which reached no less than 21mA. Unfortunately, however, the magnification is much lower than that of the valves which are most popular in this country.

The grid current should make it a fairly successful detector, but here again it is handicapped by low μ. Price: 15s. 6d.



Some Fixed Condensers.

A number of these have been recently received for test, and details are given below.

OCTOPUS CONDENSERS.

THESE were a series of apparently Mansbridge type fixed condensers supplied by Messrs. Radio Stocks, of Radio House, Newman Street, W.1. Prices 2s. 4d. to 4s. 8d. The table below shows nominal and actual capacities:—

Nominal	Actual	Price.
·01	·005	2/4
·25	·305	3/-
·5	·45	3/4
1·0	·875	3/10
2·0	2·0	4/8

The condensers were not tested for power factor, but appeared to be normal in this respect.

EDISON BELL FIXED CONDENSERS.

These are condensers for use in radio circuits, and are of the small enclosed mica type. Two samples were sent, nominal capacities ·001 and ·002. The actual capacities were ·000 809 and .002 17. They were not tested for power factor. General design and construction appeared very good. Supplied by Messrs. J. E. Hough, Ltd., Edison Bell Works, Glengall Road, S.E.15. Price 1s. 3d.

PARAGON CURTIS CONDENSERS.

These are mica condensers for use in radio circuits and are special in construction. The makers state that they are made up very carefully with high quality mica and are then placed in moulds and sealed complete in solid bakelite under heavy pressure. They are claimed to be within 5 per cent. of rated values, and also to be entirely waterproof. It may be remembered that they were exhibited under boiling water at the White City show. We have seen test reports which show very good power factor. Reports of tests after being placed in water for some time at the N.P.L. show that the insulation remains high but the power factor increased until the condensers had dried off. Two samples were submitted, nominal capacities ·000 3 and ·001, actual capacities ·000 312 and ·001 028, the errors being within the 5 per cent. limit mentioned above. Supplied by Messrs. Peter Curtis, Ltd., 34/36, Whitfield Street, W.1. Prices range from 1s. 9d. to 3s. 6d.

For the Esperantists.

The following, it must be understood, is not the translation of any article appearing in English elsewhere in this issue. It is an entirely independant feature specially prepared for our Esperanto-speaking readers.

Pri l'Absorbo de Ondoj Mallongaj.

Resumo de tre interesa artikolo, verkita de J Granier, kiu aperis franclingve en "L'Onde Electrique."

EKSPERIMENTOJ por determini la rezistancojn kaj dielektrikajn perdojn de diversaj substancoj ĉe oscilaj kurentoj de frekvencoj de 10^{-8} (ondlongo de 3 metroj). Tri-metra oscilatoro estas malapude kuplita al fermita oscila cirkuito enhavanta fiksan induktancon, varian kondensatoron, konatan varian rezistancon kaj indikatoron de altfrekvenca kurento.

Oni mezuras la rezistancon de konduktoro, unue enmetante la konduktoron en la cirkuiton kaj ĝuste resonancigante la cirkuiton kun la oscilatoro per la varia kondensatoro. Poste oni anstataŭigas la konduktoron mezurotan per la konata rezistanco, kiun oni alĝustigas ĝis oni obtenas la saman kurenton je resonanco kiel antaŭe. Por dielektrikoj, oni ilin enmetas anstataŭ la kondensatoro. Anstataŭigante la dielektrikon mezurotan per aera kondensatoro de malgranda perdo, kaj realĝustigante la rezistancon por doni la saman kurenton, oni alvenas je la ekvivalenta seria rezistanco, kiu egalas la dielektrikan perdon.

Estante malgrandaj, la altfrekvencaj kurentoj bezonas indikatoron pli sentivan ol la ordinara varmfadena ampermetro, kaj la instrumento fakte uzata estas interesa pro malkareco kaj inĝenieco. Oni enmetas en la altfrekvencar cirkuitor ordinaran l-kandelpovan bulbon poŝlampan de malmulta konsumo, tiel ke ĝia filamento estas pli aŭ malpli varmigata de la altfrekvencaj, kiuj fluas tra ĝi; ĉi-tio ŝanĝas la kontinukurentan rezistancon de la bulbo, registritan ĉe Ponto Wheatstone'a kompensita por kontinua kurento, de kiu la bulbo estas unu brako. La aranĝo estas, fakte, simpla bolometra ponto.

La rezultoj de mezuroj faritaj je ĉi-supra treege alta frekvenco estas interesaj. La surfaca efiko de fero estas multe troigita pro sia trapenetrebleco, kaj ĝia histerezo provizas pluan fonton de perdo. Oni trovis, ke fera fadeno, diametre unu milimetron, havas rezistancon de 20 omoj por metro. Oni trovis, ke stanita kupra fadeno havas rezistancon 2·8-oble pligrandan ol nuda fadeno, ĉar la forta surfaca efiko fluigas la pligrandan parton de l'kurento tra la surfaca tavolo de stano kaj ne tra la korpo de la kupro. Zinkita fero estus pli bona konduktoro ol stanita kupro, ĉar zinko estas pli bona konduktoro ol stano.

La kondukiveco de fadeno mergita en elektrolitoj diversfortaj, montris interesajn efikojn. Kiam la fadeno estis ĉirkaŭita de elektrolito nur iomete kondukiva, la plej multan parton de la kurento portis la fadeno. Dum oni pliigis la kondukivecon de l'elektrolito, pli granda proporcio de la kurento vojaĝis pere de l'elektrolito, dum la neta rezistanco de la sistemo pliiĝis.

Ekzemple, fadeno kun longo 3 c.m. kaj diametro 0.1 c.m., mergite en sulfatacido 0·9-procenta, montris rezistancon de 2·2 omoj, sed mergite en sulfatacido 20-procenta, montris rezistancon de 4·8 omoj.

La potencan faktoron de akvo kiel dielektriko en kondensatoro oni mezuris uzante distilitan akvon, riveran akvon, kaj maran akvon, respektive. Ĉe la lasta, la funkcipovo de l'kondensatoro ĉesis rilate al la agordita cirkuito. Oni ankaŭ faris mezurojn de potenca faktoro de nombro da ordinaraj dielektrikoj, kaj kvankam oni ne pretendas, ke la ciferoj ricevitaj estas absolute ĝustaj oni povis aranĝi nombron de tiuj substancoj laŭ klara ordo de merito. Parafino kaj glimo facile estas la plej bonaj, sekvataj de seka briko kaj seka tero. Sekvas vitro kaj vaksita papero, dum sub ili en la listo ebonito egalas ordinaran brikon! Humidaj objektoj, ekz., folioj kaj neseka tero, estas la plej malbonaj dielektrikoj.

La aŭtoro de l'artikolo diskutas la eblan rilaton de siaj observadoj ĉe treege mallongonda sendado, kaj klarigas la seriozan efikon pro ĉeesto de malbonaj dielektrikoj en mallongonda aparato.

Listo de Mallongigoj uzataj por Radio-Telegrafia Sendado.

List of Abbreviations used in Radiotelegraphic Transmission.

Eltirita el la Internacia Radiotelegrafia Kunveno.

Mallongigo.	Demando.	Respondo aŭ Informo.
— . — . — — . — (CQ)	.. ..	Demanda signalo uzata de stacio, kiu deziras korespondi. *Inquiry signal employed by a station which desires to correspond.*

Mallongigo.	Demando.	Respondo aŭ Informo.
—. —. (TR)	.. ..	Signalo anoncanta la sendon de indikoj pri ŝipstacio. *Signal announcing the sending of indications concerning a ship station.*
— — . . — — (!)	.. ..	Signalo indikanta, ke stacio estas sendonta grandpotence. *Signal indicating that a station is about to send with high power.*
PRB	Ĉu vi deziras komuniki kun mia stacio per la Internacia Signala Kodo ? *Do you wish to communicate with my station by means of the International Signal Code ?*	Mi deziras komuniki kun via stacio per la Internacia Signala Kodo. *I wish to communicate with your station by means of the International Signal Code.*
QRA	Kio estas la nomo de via stacio ? *What is the name of your station ?*	Tiu-ĉi stacio estas...... *This station is......*
QRB	Kiom malproksime vi estas de mia stacio ? *How far are you from my station ?*	La distanco inter niaj stacioj estas......maraj mejloj. *The distance between our stations is......nautical miles.*
QRC	Kio estas via ĝusta biro ? *What are your true bearings ?*	Mia ĝusta biro estas......gradoj. *My true bearings are......degrees.*
QRD	Kien vi celas ? *Where are you bound ?*	Mi celas...... *I am bound for......*
QRF	De kie vi venas ? *Where are you coming from ?*	Mi venas de...... *I am coming from......*
QRG	Al kiu kompanio aŭ linio de navigacio vi apartenas ? *To what company or line of navigation do you belong ?*	Mi apartenas al...... *I belong to......*
QRH	Kio estas via ondlongo ? *What is your wave-length ?*	Mia ondlongo estas......metroj. *My wave-length is......metres.*
QRJ	Kiom da vortoj vi havas por sendi ? *How many words have you to transmit ?*	Mi havas......vortojn por sendi. *I have......words to transmit.*
QRK	Kiel vi ricevas ? *How are you receiving ?*	Mi ricevas bone. *I am receiving well.*
QRL	Ĉu vi ricevas malbone ? Ĉu mi sendu 20-foje . . . — . por ke vi povu alĝustigi vian aparaton ? *Are you receiving badly ? Shall I transmit* 20 *times . . . — . so that you can adjust your apparatus ?*	Mi ricevas malbone. Sendu 20-foje . . . — . por ke mi povu alĝustigi mian aparaton. *I am receiving badly. Transmit* 20 *times . . . — . so that I can adjust my apparatus.*
QRM	Ĉu vi estas ĝenata ? *Are you disturbed ?*	Mi estas ĝenata. *I am disturbed.*
QRN	Ĉu la atmosferaĵoj estas tre fortaj ? *Are the atmospherics very strong ?*	La atmosferaĵoj estas tre fortaj. *The atmospherics are very strong.*
QRO	Ĉu mi pligrandigu mian potencon ? *Shall I increase my power ?*	Pligrandigu vian potencon. *Increase your power.*
QRP	Ĉu mi malpligrandigu mian potencon ? *Shall I decrease my power ?*	Malpligrandigu vian potencon. *Decrease your power.*
QRQ	Ĉu mi sendu pli rapide ? *Shall I transmit faster ?*	Sendu pli rapide. *Transmit faster.*
QRS	Ĉu mi sendu pli malrapide ? *Shall I transmit more slowly ?*	Sendu pli malrapide. *Transmit more slowly.*
QRT	Ĉu mi ĉesigu sendadon ? *Shall I stop transmitting ?*	Ĉesigu sendadon. Mi havas nenion por sendi. *Stop transmitting.* *I have nothing to transmit.*
QRU	.. ..	Mi havas nenion por vi. *I have nothing for you.*

Mallongigo.	Demando.	Respondo aŭ Informo.
QRV	Ĉu vi estas preta ? *Are you ready ?*	Mi estas preta. Ĉio bonorde. *I am ready. All is in order.*
QRW	Ĉu vi estas okupata ? *Are you busy ?*	Mi estas okupata kun alia stacio (aŭ kun......), bonvolu ne interrompi. *I am busy with another station (or with......), please do not interrupt.*
QRX	Ĉu mi atendu ? *Shall I wait ?*	Atendu. Mi vokos vin je......a horo (aŭ kiam mi bezonos vin). *Wait. I will call you at......o'clock (or when I want you).*
QRY	Kiu estas mia vico ? *What is my turn ?*	Via vico estas No....... *Your turn is No.......*
QRZ	Ĉu miaj signaloj estas malfortaj? *Are my signals weak ?*	Viaj signaloj estas malfortaj. *Your signals are weak.*
QSA	Ĉu miaj signaloj estas fortaj ? *Are my signals strong ?*	Viaj signaloj estas fortaj. *Your signals are strong.*
QSB	Ĉu mia tono estas malbona ? *Is my tone bad ?*	La tono estas malbona. *The tone is bad.*
	Ĉu mia sparko estas malbona ? *Is my spark bad ?*	La sparko estas malbona. *The spark is bad.*
QSC	Ĉu la interspacado estas malbona ? *Is the spacing bad ?*	La interspacado estas malbona. *The spacing is bad.*
QSD	Ni komparu poŝhorloĝojn. Mia horo estas...... Kiom via horo ? *Let us compare watches. My time is...... What is your time ?*	La horo estas...... *The time is......*
QSF	Ĉu la radio-telegramoj estos sendataj alterne aŭ serie ? *Will the radiotelegrams be transmitted alternately or in series ?*	La sendado estos alterna. *The transmission will be in alternate order.*
QSG	.. ..	La sendado estos laŭ serio de kvin radio-telegramoj. *Transmission will be in series of five radiotelegrams.*
QSH	.. ..	La sendado estos laŭ serio de dek radio-telegramoj. *Transmission will be in series of ten radiotelegrams.*
QSJ	Kiom la prezo kolektota por...... ? *What is the charge to collect for...... ?*	La prezo kolektota estas...... *The charge to collect is......*
QSK	Ĉu la lasta radio-telegramo estas nuligita ? *Is the last radiotelegram cancelled ?*	La lasta radio-telegramo estas nuligita. *The last radiotelegram is cancelled.*
QSL	Ĉu vi havas la ricevateston ? *Have you got the receipt ?*	Bonvolu doni ricevateston. *Please give a receipt.*
QSM	Kio estas via ĝusta direkto ? *What is your true course ?*	Mia ĝusta direkto estas...... gradoj. *My true course is......degrees.*
QSN	Ĉu vi komunikas kun la tero ? *Are you communicating with land ?*	Mi ne komunikas kun la tero. *I am not communicating with land.*
QSO	Ĉu vi komunikas kun alia stacio (aŭ kun......) ? *Are you in communication with another station (or with......) ?*	Mi komunikas kun......(pere de......). *I am in communication with...... (through the medium of......).*
QSP	Ĉu mi signalu al......, ke vi vokas lin ? *Shall I signal to......that you are calling him ?*	Informu al......, ke mi vokas lin. *Inform......that I am calling him.*
QSQ	Ĉu mi estas vokata de...... ? *Am I being called by...... ?*	Vi estas vokata de...... *You are being called by......*
QSR	Ĉu vi forsendos la radio-telegramon ? *Will you despatch the radio-telegram ?*	Mi forsendos la radio-telegramon. *I will forward the radiotelegram.*
QST	Ĉu vi ricevis ĝeneralan vokon ? *Have you received a general call ?*	Ĝenerala voko al ĉiuj stacioj. *General call to all stations.*

Mallongigo.	Demando	Respondo aŭ Informo.
QSU	Bonvolu voki min, kiam vi estos fininta (aŭ je......a horo). *Please call me when you have finished (or at......o'clock).*	Mi vokos vin, kiam mi estos fininta. *I will call you when I have finished.*
QSV	Ĉu okazas publika korespondado ? *Is public correspondence engaged ?*	Okazas publika korespondado. Volu ne interrompi. *Public correspondence is engaged. Please do not interrupt.*
QSW	Ĉu mi pliigu mian spark-frekvencon ? *May I increase the frequency of my spark ?*	Pliigu vian spark-frekvencon. *Increase the frequency of your spark.*
QSX	Ĉu mi devas malpliigi mian spark-frekvencon ? *Must I diminish the frequency of my spark ?*	Malpliigu vian spark-frekvencon. *Diminish the frequency of your spark.*
QSY	Ĉu mi sendu je ondlongo de......metroj ? *Shall I transmit with a wave-length of...... metres ?*	Ni transigu al ondlongo de......metroj. *Let us transfer to the wave-length of......metres.*
QSZ	.. ..	Sendu ĉiun vorton dufoje. Mi malfacile ricevas viajn signalojn. *Transmit each word twice. I have difficulty in receiving your signals.*
QTA	.. ..	Sendu ĉiun radio-telegramon dufoje. Mi malfacile legas viajn signalojn, aŭ *Transmit each radiotelegram twice. I have difficulty in reading your signals, or* Ripetu la radio-telegramon, kiun vi ĵus sendis. Ricevo duba. *Repeat the radiotelegram you have just sent. Reception doubtful.*
QTB	.. ..	Nombro da vortoj ne konsentita ; mi ripetos unuan literon de ĉiu vorto kaj unuan ciferon de ĉiu grupo. *Number of words not agreed ; I will repeat first letter of each word and first figure of each group.*
QTC	Ĉu vi havas ion por sendi ? *Have you anything to transmit ?*	Mi havas ion por sendi. Mi havas unu (aŭ kelkajn) radiotelegramojn por.... *I have something to transmit.* *I have one (or several) radiotelegram for......*

Kiam demandsigno sekvas mallongigon, ĝi aludas al la demando indikita rilate al tiu mallongigo.

Ekzemplaro.

Stacio.		
A	QRA ?	Kio estas la nomo de via stacio ?
B	QRA Rimutaka.	Ni estas la Rimutaka.
A	QRG ?	Al kiu kompanio aŭ linio de navigacio vi apartenas ?
B	QRG Linio New Zealand QRZ.	Mi apartenas al la Linio New Zealand. Viaj signaloj estas malfortaj.

La stacio A tiam pliigas la potencon de sia sendilo, kaj sendas :—

A	QRK ?	Kiel vi ricevas ?
B	QRK.	Mi ricevas bone.
	QRB 100.	La distanco inter niaj stacioj estas 100 maraj mejloj.
	QRC 70.	Mia ĝusta biro estas 70 gradoj.

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.

Valve and Valve Holder Measurements.

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

DEAR SIR,—May I be allowed to offer you my hearty congratulations, and to express the hope that future issues of E.W. & W.E. will prove as interesting as those of the past?

With reference to the articles in recent issues on the Inter-Electrode Capacities of Valves I have made some measurements on valves and valve-holders myself and I venture to hope that the results, which I enclose, will be of interest.

The method of testing used is as follows: An oscillating valve circuit is set up and tuned by means of a calibrated variable condenser of maximum capacity, 0.0001 mfd. The valve-holder to be tested is connected in parallel with the variable condenser. Another oscillating circuit is now coupled to the first one and adjusted by heretodyning to oscillate at the same frequency.

The valve-holder under test is now disconnected from the circuit, the wires forming the connections being left in position. By varying the capacity of the calibrated condenser the circuit is readjusted to the original frequency. The increase of capacity of the calibrated condenser required to do this is the capacity of the valve-holder previously removed from the circuit. These tests were made on a wave-length of about 300 metres.

Brighton. W. G. WHITE.

Anode	to Filament (1)	5·5mmF.	Valve-holder mounted on wood block for laboratory work.
A	,, F (2)	5·5	
A	,, F_1 & F_2 joined	9	
Grid	,, F_1	6	
G	,, F_2	6	
G	,, F_1 & F_2 joined	10	
A	,, G_1	5	
A	,, F_1 F_2 joined	3	Valve-holder of standard design.
G	,, F_1 F_2 ,,	4	
A	,, G	3	
A	,, F_1 F_2 joined by filament	7	
G	,, F_1 F_2	7·5	Mullard Ora valve after allowing for holder.
A	,, G_1	3	
A	,, F_1 F_2 joined by filament	8·5	
G	,, F_1 F_2	8	Marconi-Osram R.5.
A	,, G	4	
A	,, F_1 F_2 joined by filament	8·5	
G	,, F_1 F_2	8·5	Ediswan 5·5V.
A	,, G	2·5	
A	,, F_1 F_2 joined by filament	8	
G	,, F_1 F_2	7·5	Marconi-Osram R.A.
A	,, G	3	
A	,, F_1 F_2 joined	4	V.24. Valve-holder.
G	,, F_1 F_2	4	
A	,, G	2	

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

DEAR SIR,—Having only just discovered your most interesting periodical, E. W. & W. E. I have perused the first number which has come into my possession (January) with care, and among the many articles which attracted my attention was that by Mr. Barton Chapple concerning the inter-electrode capacities of valves. The principal reason for my special interest in this article is the fact that about a year ago I went to considerable trouble to make a series of similar measurements. I am surprised to find, however, that there are considerable differences between my results and those of Mr. Barton Chapple, and on repeating one or two of my own measurements, I got results so closely agreeing with my previous ones that I did not repeat the whole series.

My method was to use two oscillating valves heterodyning one another, one having a grid condenser and leak, and having telephones in the anode circuit. One of the tuning condensers had shunted across it a special vernier consisting of two concentric tubes, the inner one sliding and fitted with a scale. Now, the capacity of such a condenser, or, rather, the *difference in capacity between two settings*, can be very accurately calculated from the formula :—

$$K = \frac{L}{4\,145\,400 \log_{10} \dfrac{R_1}{R_2}}$$

Where K = capacity in microfarads

L = length of overlap of tubes
R_1 = inside diameter of outer tube
R^2 = outside diameter of inner tube
} in centimetres.

[NOTE: The absolute capacity of any given setting cannot be calculated because of the "fringe" effect.]

The two oscillating circuits were so tuned with respect to one another as to produce an audible beat note in the telephones of a pitch fixed by a tuning fork, the tubular vernier being set at a convenient reading near its maximum capacity.

The capacity to be measured was then shunted across this vernier, and the movement necessary to restore the beat note to its original pitch is a direct measure of the capacity.

The accuracy of this method of measurement is very great indeed provided that the obvious precautions are taken, and I found that results were reproducable to within about 0·1 micromicrofarad.

My figures, which are rather more complete than Mr. Barton Chapple's, are as follows:

	A-G	G-F	A-F
Complete Valves—			
Marconi 4V.R.	3·5	4·2	3·9
Ediswan AR (Bright)	3·1	5·4	4·4
Cossor P.1	4·0	5·2	4·2
Mullard Ora (Bright)	2·5	3·6	3·8
Extraudion	5·4	5·5	4·8
Standard valve base and pins	1·1	1·6	1·4
Marconi 4V.R., electrode only, specially mounted for measurement	2·0	1·1	0·8
Standard valve holder	2·9	8·2	6·0

[These figures are in micromicrofarads.]

In all cases G-F and A-F were measured with the two filament pins connected together.

Points of special interest in the above table are, firstly: The large relative value of the figures for the standard valve-holder (the ordinary type where the valve sockets are embedded in a moulded block), but it must be remembered that these figures would depend to a great extent on the outside diameter of these sockets (in this case ·25 inches); secondly: If we consider the two sets of figures relating to the Marconi valve, together with those for a standard four-pin base, we find that, for A-G, for instance,

$$3·5 - (2·0 + 1·1) = 0·4,$$

which figure must represent the whole capacity due to the internal connections, including the much-maligned "pinch"—apparently not such a serious item as is generally supposed.

I made no measurements on the V.24 holder, but examination of one of these, or even of Mr. Barton Chapple's own diagram, is surely sufficient to cast grave suspicion on his figures. Considering the relative position of the contact springs, is it not very remarkable that the figures should all be so nearly the same? And is it not also remarkable, considering the end for which the holder was specially designed, that it is apparently very little better than the old-fashioned article (again according to Mr. Barton Chapple's figures)?

Some of the discrepancies seem to suggest a missing decimal point—not in my figures because the scale of my vernier, which I have marked to read directly in micromicrofarads, agrees with the scale on a calibrated ·005 condenser which I was using at the same time.

Now to a quite different subject.

The article on aerials by Dr. Smith-Rose and Mr. Colebrook interested me greatly, and I was pleased to read of many moot points definitely settled. I think, however, that the experiments might have been made complete by investigating the properties of the **T** aerial.

This type of aerial possesses advantages for short wave work, and, moreover, is in some environments the only type which can be used without considerable sacrifice of length.

I am thinking more particularly of the much discussed question as to the position of the junction to the down lead. The laws which govern this question with regard to the aerial might be expected to apply in some degree at least to the counterpoise, and yet I notice that the authors took the connection to the counterpoise neither at its end nor at its centre. Was this a mere haphazard arrangement, or was there any good reason other than convenience in making connection to the set?

P. G. DAVIDSON.

Avon Leys,
Stratford-on-Avon.

Change of Address.

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

DEAR SIR,—I beg to inform you that I have now removed my experimental radio station, 2SP, to the address below, and should esteem it a favour if you would insert the change in E.W. & W.E.

R. MANSFIELD,
A.M.Inst. R.E

27, Rutland Road,
Southport, Lancs.

Call Signs.

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

DEAR SIR,—The Call Sign 2II (two i i) which formerly belonged to the Southport Wireless Society of Southport, has now been allocated to me; and as I believe that reports are still being addressed to Southport, I should be very much obliged if you will give the correct address in a future issue of your paper. The wave-lengths in use are 115-130 metres and 200-440 metres.

A. M. RALLI.

14, Torrington Road,
Wallasey,
Cheshire.

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

DEAR SIR,—We beg to submit our radio call sign, 2GY, which was previously held by a London amateur. We shall welcome any reports on our transmissions.

91A, Temple Street,
Bristol.

F. C. HARDWELL & SON,

2ABR.

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

Please note that above call sign was allocated to me 3/10/24. Ten watts.

ALAN SMITH.

48, High Street,
Yewsley, Middlesex.

More for Beginners.

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

DEAR SIR,—May I express my endorsement of "Beginner's" letter which appeared in your February issue? In that letter he expresses exactly what I have thought myself, but he does it far better than I could have done. Particularly do I agree with his statement that "Text-books . . . . do not show us how to allow for the errors, etc."; and I think many amateurs would be grateful if you would indicate the precautions necessary with various instruments, and in various measurements, to ensure the results obtained being accurate.

In addition, may I ask if it would be possible for you to run an "Experiments" section, in which you would indicate experiments which might be undertaken on subjects about which little data is available, together with a brief statement of the procedure which might be adopted and the precautions necessary?

For example, I have not yet seen any details published of the effect of the spacing of the turns of an inductance coil, or the effect of using very thick wire, etc. I have seen general statements, but not quantitive measurements showing the benefits, or otherwise, that would result.

I would like to undertake some such measurements myself, but do not feel competent. With your suggestions on the lines indicated, I would approach the problem with much more confidence.

Such a section would also be of very great value to "Wireless Societies" that wish to rise above "circuit testing" but lack the necessary "professor."

In the January issue, on page 201, speaking of the Moullin voltmeter, you say that the grid condenser and leak type has the disadvantage of putting a measurable load on the circuit. Moullin, in his original article, appears to me to show that it is such a small amount as to be entirely negligible. Perhaps you will be good enough to show, when practicable, how to calculate the power consumed by this type?

In conclusion, may I congratulate you on the excellence of E.W. & W.E. "Every month in every way it gets better and better."

JAS. HUDSON.

Hulme, Manchester.

A Plea for Better Keying.

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

DEAR SIR,—May I, through the medium of your correspondence columns, make an appeal for better "fists" on the air?

It is really surprising how many of our best-known transmitters are indifferent performers upon the key, and I am sure that such measure of success as they have achieved would be considerably increased if they would pay more attention to this.

In the first place, indifferent sending would seem to arise from a general tendency to key too fast, and this is particularly in evidence when calling and signing off—just when the most careful and deliberate keying is needed. Greater care in this matter would certainly result in a greater number of reports.

There are, of course, exceptions to whom the above remarks do not apply, and it is refreshing to tune such a sender as G2OD after guessing at some of the others.

It has been remarked that G2OD "gets there" time after time, while others, whose signals seem stronger, are less successful, and I believe that his remarkable successes are due in the first place to his correct and deliberate keying, and secondly to his perfectly pure C.W. note, which is undoubtedly made penetrating through QRM and QRN than raw A.C. or imperfectly smoothed D.C.

G2OD does not send fast. I doubt if he ever exceeds 12 to 15 w.p.m. At any rate, when working DX, and our own experience of listening to DX stations certainly indicates the advantage of such methods.

In order to disarm possible criticism I will admit that I am not a fast reader, although I would far sooner copy a good fist at 20 w.p.m. than an indifferent one at 15, and I think this is a common experience, but the point is that there appears to be few amateur operators whose style at even 12 w.p.m. is passably correct. It must be remembered that the majority of amateurs have "picked up" their keying. They have not had the advantage of practice at a telegraph school, under supervision of a qualified instructor, and this is why the professional operator's keying at 30 w.p.m. is superior to the amateur's at 20 or less.

In conclusion, then, may I urge transmitters who have not been trained in keying to listen to G2OD or U2XI for example, and then go and do likewise.

Let us make the GS conspicuous for their good style and correctness on the air.

HUGH J. B. HAMPSON (G6JV).

Johannesburg Reception.

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

DEAR SIR,—Perhaps you may be able to find room for the following short "par." in connection with my article in the January issue of E.W. & W.E. The small error on the part of your draughtsman was quite excusable, but I should like to see the matter corrected.

VICTOR HART.

Johannesburg.

["In the diagram accompanying the article, 'Remarkable Reception of KDKA in Johannesburg,' published on page 239 of the January issue, an error of wording can be noted. The first anode coil, at top left of diagram, was marked as having $4\frac{1}{2}$ turns; this must be corrected and should read $9\frac{1}{2}$ turns."]

Reports Wanted.

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

DEAR SIR,—Can you find space in an odd corner in E.W. & W.E. to say that 2RA would be pleased to receive reports of low power transmissions from any amateur, British or foreign, who may hear me working?

My call is not in any of the published lists, as I have used the radiating aerial only when absolutely necessary and up to the present have not been in need of reports from outside.

With all good wishes for the prosperity of E.W. & W.E., which is, in my opinion, the only paper for the transmitting amateur.

FREDK. F. WARNER.

Radio 2RA,
Northdene, High Lane,
Nr. Stockport.

[R050

From the World's Wireless Journals.

R100.—GENERAL PRINCIPLES AND THEORY.

R113·8.—WIRELESS AND THE ECLIPSE. *Electn.*, Feb. 6, 1925).

Some curves are given showing the results of observations on wireless signals during the eclipse of January 24, 1925. The signal intensity measured at a receiver in Somerset of the signals from a transmitter at Rocky Point, Long Island, U.S.A., showed an abnormal increase during the eclipse followed by an abnormal decrease. Observations made at Slough on the effect of the eclipse on signal bearings yielded negative results.

R200.—MEASUREMENTS AND STANDARDS.

R220. — UBER KAPAZITÄTEN IN ELEKTRONENRÖHREN.—E. Schrader (*Jahrb. d. drahtl Tel.* Vol. 24, No. 2).

Details of theoretical and practical research on the inter-electrode capacities of valves. The subject is treated with special reference to effective capacities at high frequencies. Since work of this kind involves the measurement of very small capacities (of the order of a few centimetres or $\mu\mu$F) very delicate methods are necessary, the one used in this case being of particular interest. The measuring circuit consists of an isolated resonant circuit comprising an inductance shunted by two variable condensers, in parallel, one of these condensers being calibrated and providing fine adjustment of tuning. Essentially the procedure is to tune this circuit to a certain frequency, to shunt the capacity under measurement across the existing condensers, and then to bring the circuit back to its original resonance by varying the fine condenser. The method by which this resonance is indicated is the interesting feature. Loosely coupled to the measuring circuit are a valve oscillator and an oscillating detector, the latter being connected to a telephone receiver. These two oscillators are adjusted to give an audible heterodyne note in the telephone receiver. Now if the measuring circuit is varied by turning one of its condensers so that it passes through resonance with, say, the oscillating detector, the pitch of the heterodyne note will vary in the neighbourhood of the resonant point, rising above normal just below the resonant point and falling below normal just above it.* Hence by specifying a definite heterodyne pitch in the immediate vicinity of the resonant point one also fixes a definite resonant frequency in the measuring circuit. This pitch is fixed by a third oscillator generating at a fixed audio-frequency which forms low period beats with the heterodyne note in the telephone receiver. The two audible frequencies may be brought so close together as to form only about one beat per second or even less. In this way the resonant frequency of the measuring circuit may be always brought back to the same value with a high degree of precision. So sensitive is the method to capacity effects from the body that it may be necessary to make condenser dial readings with the aid of a telescope. The valve capacities are measured under working conditions and the dependence of effective capacity upon the external loading of the anode circuit are investigated. The results are compared with the work of H. G. Möller and J. M. Miller, an agreement being found at low frequencies but serious deviations from the theory being found at high frequencies. In measuring the capacity of a valve the A.C. voltage applied to the grid must be sufficiently small to make the valve operate on a linear portion of its characteristic. The space-charge in a valve may alter the capacity of the valve by about 3 cms. The capacities C_{ga}, C_{gf} and C_{af} are not the values given by inclusion in the measuring circuit and a method is given of arriving at the true values for these capacities.

* See p. 348.

R220·333.—THE INTER-ELECTRODE CAPACITIES OF THERMIONIC VALVES.—L. Hartshorn, B.Sc. and T. I. Jones, B.Sc. (*Exp. W.*, Feb., 1925).

This paper deals with important questions of the capacities between the electrodes of thermionic valves and gives details of a series of experiments which were made to determine the value of these capacities in normal types of valve. The contributions to the total capacity of an R valve due to the electrodes themselves, the leads through the pinch, the pins and the valve-socket respectively were determined.

R223·240. — R. F. PROPERTIES OF INSULATING MATERIALS.—J. L. Preston and E. L. Hall (*Q.S.T.*, Feb., 1925).

Some measurements made by the Bureau of Standards on the dielectric properties of a number of common insulating substances. The frequency at which the measurements were made is not specified further than by stating it to be "average radio-frequency." The results are given in a table showing the dielectric constants and power factors as expressed by phase angles in degrees. It appears that most woods are quite good when carefully dried or boiled in paraffin or ceresin. As received from the timber dealer, however, wood may show a large phase angle. Good mica has easily the lowest phase angle (·04° as against ·5° for most glasses). Asbestos and asbestos compositions show up particularly badly. For further information the reader is referred to the article itself.* It is surprising to see that no results are included for ebonite or bakelite.

R240.—THE EFFECT OF OXIDATION ON THE HIGH-FREQUENCY RESISTANCE OF AERIAL WIRES. —L. B. Turner, M.A. (*Journ. Inst. E.E.*, Jan., 1925).

By two different methods the high-frequency resistance of hard-drawn copper wire and stranded phosphor bronze wire when bright and when oxidised was measured over a range of wave-lengths varying from 4 to 20 kilometres. The results indicate no increase in resistance whatever due to oxidation even when the surface of the wire is wet. The oxide film referred to is that which is produced by weathering. A note is added on the measuring of the H.F. resistance of thick wires.

R270.—ESSAIS ENTRE PARIS ET ALGER SUR ONDES DE 180, 90 ET 50 MÈTRES.—A. Colmant (8AG) (*Onde Elec.*, Jan., 1925).

Some experiments made during 1924 are described which were carried out with the object of ascertaining the possibility of reliable radio communication on short wave-lengths and with a power of about 100 watts between Paris and Algiers. Signals sent out regularly from a transmitting station at Paris were observed at a receiver at Algiers. The aerial used at the transmitter was a 4-wire flat-top, 23 metres high, with a fundamental wave-length of 200 metres and pointing E. and W. A valve transmitter was used, the filaments being heated with A.C. at 53 cycles and the plate current being obtained by synchronous rectification and filtering. On 180 metres, with a power of 65 watts input, signals were received very loudly at night in Algiers. There was no trace of fading and signals were still easily readable when the power was reduced to 25 watts. In the daytime no results were obtained even with a power of 225 watts. When the wave-length was reduced to 90 metres the signals at night-time in Algiers were stronger than ever, but still no daylight signals could be heard there even with a power of 380 watts. At other stations in France and England, however, the 90-metre signals were frequently heard as well by day as by night. Next the 50-metre wave-length was tried, the oscillatory circuit used at the transmitter being of the Mesny double type. The aerial was worked on a harmonic. The reception at Algiers on this wave-length was apparently less constant. Sometimes the signals were very strong but with sudden short fading. Even on 50 metres and with a power input of 125 watts the transmitter only seems to have made itself properly heard at Algiers during the day on one occasion. More frequent, but still very occasional, daylight receptions were reported from La Réole. Night reception at Algiers was always reported as favourable from November 30 to December 12, whereas reception had been erratic during the summer.

* See p. 325.

R275.—MESURE DES TAUX DE MODULATION ET COMPARISON DES INTENSITÉS DE RÉCEPTION AU MOYEN D'UN NOUVEL OSCILLOGRAPHE ELECTROMAGNETIQUE.—Raymond Dubois, Ing.E.P.C.I. (*Onde Elec.*, Jan., 1925).

Description of a method of measuring the extent of modulation in received wireless signals. The signals are first brought up to suitable detecting strength by means of H.F. amplification without reaction. They are detected by means of a crystal detector in series with the grid of a three electrode valve and the rectified component is magnified by means of a D.C. resistance amplifier. This reproduces at the output not only the A.C. modulation component but also the D.C. component due to the carrier wave. The output is directly connected to the control windings of a special type of audio-frequency oscillograph designed by the writer. By means of a beam of light controlled by the oscillograph, photographic records are obtained on a moving strip. Some oscillograms thus obtained are reproduced in the article.

R300.—APPARATUS AND EQUIPMENT.

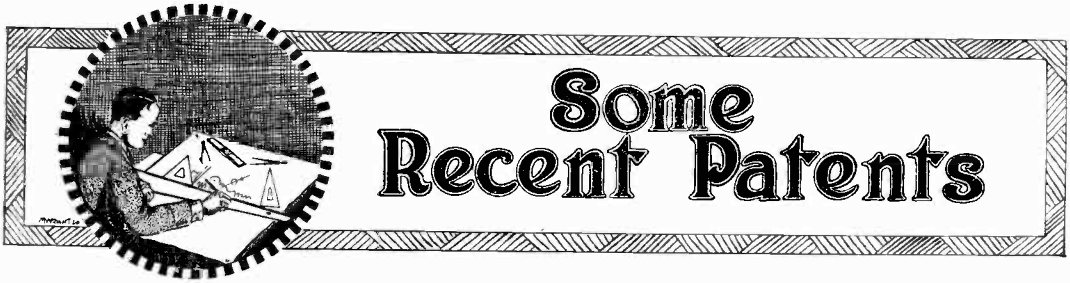
R343.—THE MCCAA ANTI-STATIC DEVICES. PART I. (*Q.S.T.*, Feb., 1925).

Description of a system developed by Dr. G. McCaa for reducing the ratio of parasitic influences to a tuned C.W. signal in a receiver. A loose-coupled receiver is employed, the aerial inductance being divided into two parts coupled in opposite senses to the secondary circuit so that normally both signal and parasitic currents are cancelled in the receiver. Across one of the parts of the aerial inductance is shunted another relatively high inductance which normally does not upset the balance of the system, this inductance being coupled to a local oscillator. The effect of the latter is to cause large periodic variations of the shunt inductance, which has the effect of throwing the aerial coupling system alternately in and out of balance. This favours the transference of undamped signals from aerial to closed circuit to a greater extent than that of atmospherics. Modified circuits employing the same general principle are also described. Exactly why the system is effective is not quite clear to us at present, but it is stated that in practice it limits the parasitic amplitudes to that of the received signal and impresses the operator with feeling that the reduction of interference is really much greater than this. The frequency of the local oscillator is not specified, nor is the loss in signal strength consequent upon the increased selectivity.

R800.—NON-RADIO SUBJECTS.

R800.—STUDIES OF ELECTRIC DISCHARGES IN GASES AT LOW PRESSURES. PART V.—Irving Langmuir and H. Mott-Smith, Jr. (*Gen. El. Rev.*, Dec., 1924).

This article continues a series of earlier ones on the use of spherical collectors to determine the characteristics of electrical discharges in gases at low pressures, presenting additional experimental data relative to this form of electrode and entering on a dissertation on the effects of magnetic fields upon the discharges. Starting from the equations of Townsend for the mobility of ions in a magnetic field, a theory of these effects is developed, experimental results are recorded and a comparison made.



Some Recent Patents

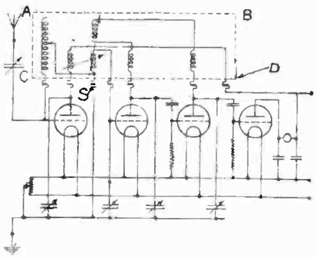
(The following notes are based on information supplied by Mr. Eric Potter, Patent Agent, Lonsdale Chambers, 27, Chancery Lane, W.C.2.)

[R008

AMPLIFIER CONSTRUCTION.

(Application date, June 9, 1923. No. 220,745.)

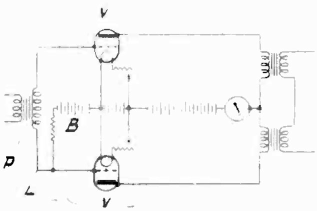
The accompanying illustration shows a form of amplifier construction for which a patent has been granted to W. J. Brown and Metropolitan-Vickers Electrical Co., Ltd. The invention really lies in providing all the inductances used in a radio-frequency amplifier in one box or compartment which is sealed up, and so constructing it that it can be interchanged. Some suitable form of spring clips, shown as S in the illustration, are used for this purpose and the special compartment is outlined at A B C D. The invention also provides for a fixed magnetic reaction coil which is rendered operative electrostatically. The first claim of the patent is exceedingly broad and covers the use of a separate removable compartment containing all the high frequency coils. We were under the impression that we had seen a device of this nature several years ago, but, of course, we are open to correction.



A PUSH-PULL AMPLIFIER.

(Application date, July 17, 1923. No. 222,981.)

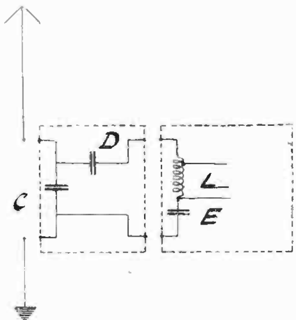
An interesting push-pull amplification scheme is described by P. G. A. H. Voigt in the above British Patent, in which the familiar differential input transformer is eliminated. It will be seen from the accompanying illustration that the input of the device consists of an ordinary transformer R, of which the secondary is connected to the grids of two valves V. An impedance in the form of a resistance L is connected between the secondary and the filament through a grid battery B. The explanation of the device as given by the inventor is as follows: When an alternating voltage is applied to the primary, the voltage on the secondary will, for half a wave, tend to make one grid more positive and the other grid more negative. If the positive voltage applied to one grid is greater than the voltage of the grid battery B, the grid will become positive and grid current will commence. The grid current has a double effect. First, it establishes a temporary connection between that end of the secondary and the filament. Secondly, it gives the secondary as a whole a negative charge, which in leaking down the resistance L, causes a volt drop that has the same effect as an increase in the biasing voltage. Thus an automatic grid bias equal to the peak voltage applied to the grid is obtained in the same way as with the familiar grid leak and condenser method of rectification. The scheme as outlined above should prove an interesting subject for experimental work.



INTERFERENCE ELIMINATION.

(Convention date, June 13, 1923. No. 217,601.)

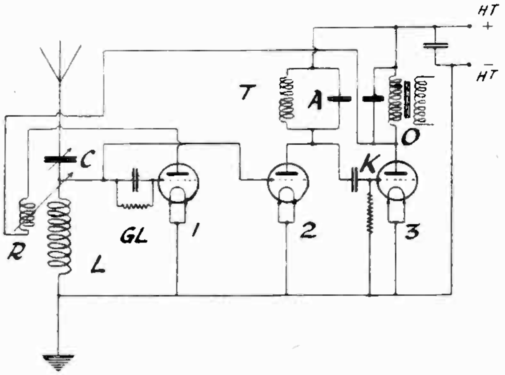
British Patent No. 217,601, granted to Telefunken Gesellschaft fur Drahtlose Telegraphie, describes a selective circuit arrangement illustrated by the accompanying diagram. The specification describes an apparatus suitable for insertion between the aerial and earth terminals and a receiver. Between the aerial and earth there is a condenser C, having a capacity of two or three times that of the aerial-earth capacity. The normal tuning circuit of the receiver is the inductance L and the capacity E, the potential to be applied to the grid of the first valve being taken across the inductance L. This tuned circuit LE is connected across the condenser C, through another condenser D, the capacity of which is not stated. Without further information regarding the constants of the circuit it is rather difficult to see exactly in what manner the selectivity is obtained.



AN INTERESTING RECEIVER.

(Application date, July 2, 1923. No. 222,562.)

N. Ashbridge describes in British Patent No. 222,562 a receiving system which is suitable for rapid search and should be very suitable for amateur use. Although three valves 1, 2 and 3 are shown in the diagram, the receiver is only intended to operate as a single valve receiver or as a tuned anode and detector. It will be seen that the ordinary aerial tuning circuit LC is connected to the grid and filament of valve 1, through a grid condenser and leak and also directly across the grid and filament of the second valve 2. The anode circuit



of the second valve 2, contains a tuned circuit TA, which can be tuned to the desired signal. The anode of the second valve is coupled to the grid of valve 3 through a capacity K, and the grid is connected to the filament through another leak. The anode circuit of the first valve contains a reaction coil R, which is connected in series with the primary of an output transformer O, or a telephone receiver. The primary of the output transformer is also included in the anode circuit of the third valve. The receiver is used in the following manner: In order to search for a station the filaments of the valves 2 and 3 are switched off and the first valve is used alone. It will be seen that the circuit is now functioning as a single valve reaction receiver. When the desired station has been picked up the filaments of the other two valves are switched on. The third valve now acts as a detector and the second valve as a high frequency amplifier. The great advantage of the system is that whatever may be the tuning of the anode circuit of valve 2 the signal will not be lost, although it may be slightly weakened owing to the extra loading of the grid circuit of valve 2. The anode circuit of valve 2 is then accurately tuned and should the system tend to oscillate, the coupling of the reaction coil is reduced. We imagine that the above circuit arrangement should be appreciated by the wireless experimenter who spends much of his time searching the ether for transatlantic amateur signals.

A NEW GAS DISCHARGE DEVICE.

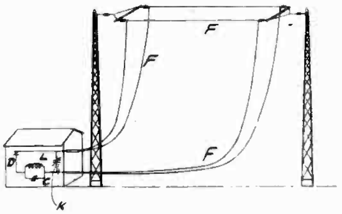
(*Convention date, January* 31, 1923. *No.* 210,728.)

A patent numbered as above assigned to the General Electric Co., Ltd., from Germany describes a gas discharge tube in which other than the rarer gases may be successfully employed. The well-known Moore lamps filled with nitrogen or carbon dioxide had to be provided with some means for maintaining a constant supply and pressure of gas. The object of the invention is to provide a discharge device containing a chemically active gas which shall be fairly constant in operation. This is achieved by using electrodes made of conducting chemical compounds. For example, when oxygen or carbon dioxide are employed magnetic iron ore (magnetite) is suitable. On the other hand when nitrogen is used, nitrides, such as zirconium, titanium and vanadium nitrides are employed. Sulphur containing gas or sulphur vapour with galena electrodes is also mentioned. Although the idea is no doubt originally intended for illumination purposes there seems to be no reason why it should not be applied for radio purposes in a similar manner to that in which the neon lamp is frequently used.

SELECTIVE RECEPTION.

(*Application date, July* 23, 1923. *No.* 223,642.)

A system of selective reception which should be of interest to amateur experimenters is described in British Patent No. 223,642 by A. W. Sharman. The system consists in using an exceedingly large loop or frame aerial in conjunction with rejector circuits. In the accompanying illustration the aerial F is shown supported between two masts and is tuned as a closed loop by the condenser K. Another feature of the invention is that the total effective length of the aerial is not less than one-sixth of the wave-length which is to be received. Owing to the size and relative lengths of the components of the loop there is little directional effect.

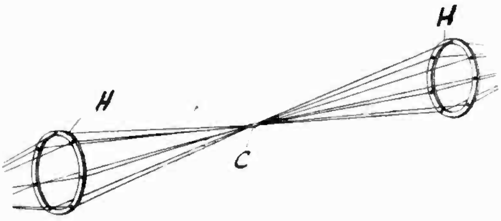


The potentials produced across the ends of the loop are rectified by means of a detector or other device D. The detector circuit is not connected directly across the ends of the loop, but is in series with a rejector circuit LC. The invention provides for various modifications of the receiving circuits.

AERIAL CONSTRUCTION.

(*Application date, October* 27, 1923. *No.* 223,742.)

A rather peculiar type of aerial is described by J. W. Fothergill in British Patent No. 223,742.

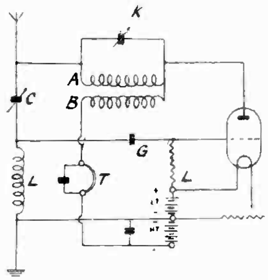


It will be seen from the accompanying illustration that the aerial consists essentially of a series of conical shaped sections. It is made by fixing a number of wires round the periphery of hoops H in a manner similar to that used in the construction of the ordinary cage type aerial. Between each pair of hoops there is a "contractor" C, which is simply a small tube through which the wires are passed. It is stated that the object of the invention is to obtain increased efficiency, but we fail to see exactly how this was obtained with the construction described in the specification.

A PECULIAR SINGLE VALVE RECEIVER.

(*Application date, October* 24, 1923. *No.* 223,061.)

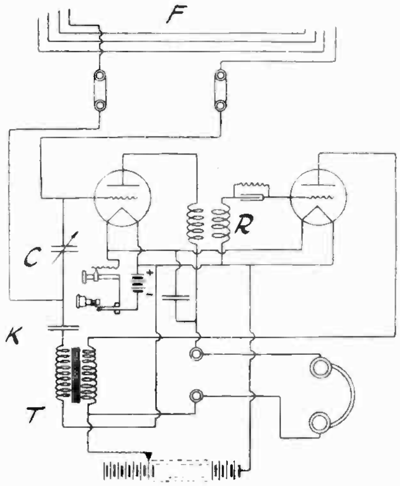
The above British Patent granted to Mann, Egerton & Co., Ltd., and H. R. Taunton, describes a type of receiving circuit illustrated in the accompanying diagram. The most peculiar feature lies not so much in the circuit itself, but in the construction of the "transformer" AB. It is stated that for broadcast wave-lengths two concentric coils A and B are wound with about 14 and 56 turns respectively, but it is also stated that the ratio may be between one to two and one to six. The aerial circuit consists of a capacity C, in series with an inductance L, which is connected across the grid and filament. The anode circuit consists of the secondary winding of the special transformer and the telephone receivers T. The valve acts as a detector by means of the grid condenser G, and leak L. Reaction is obtained through the special transformer, since it is indirectly coupled to the grid circuit. It will be noticed that the primary winding A is tuned by the condenser K, one end being connected to the anode and the other to the aerial and simply functions as an ordinary shunt reaction device. It is stated that the arrangement is particularly stable in operation.



A REFLEX CIRCUIT.

(*Application date, July* 23, 1923. *No.* 223,648.)

A. W. Sharman describes in British Patent No. 223,648 a type of reflex circuit which is illustrated by the accompanying diagram. The novelty of the circuit lies in the scheme used for determining the grid potential of the first valve. It will be noticed that the first valve functions as a dual amplifier, the anode circuit of which is coupled by the radio-frequency transformer R to the second valve which acts as a detector. The anode circuit of the detector valve contains the primary winding of an audio-frequency transformer T. In a normal reflex circuit the secondary of the transformer is connected directly in the grid circuit on the earth side. In this particular case the receiver is shown with a loop aerial F, which is tuned by the variable condenser C. One side of this tuned circuit FC is connected to the grid of the dual valve, and the lower end, instead of going directly to the secondary of the transformer, is

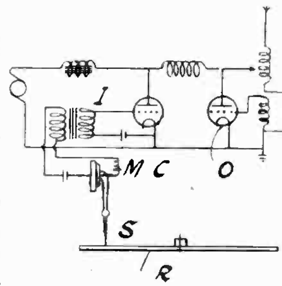


joined through a condenser K of small capacity. It will be apparent that the grid is accordingly isolated, and will therefore assume a negative potential. It is stated that this negative potential is sufficient to prevent the system from oscillating, and also that the valve is in its most sensitive and responsive condition. Exactly why this is the case is not altogether apparent. It seems to us that if the sole function of the condenser is to maintain a desired grid potential it would be more practical to utilise grid cells or a potentiometer and at the same time eliminate the disadvantages of a free grid.

SECRET TRANSMISSION.

(*Application date, August* 22, 1923. *No.* 224,621.)

Vickers Limited and C. P. Ryan describe a system of secret transmission in British Patent No. 224,621, which is illustrated by the accompanying diagram. The valve O and the associated circuits represent an ordinary radio-frequency oscillator, while the valve C and associated circuits represent the usual form of control. The input to the control valve is the transformer I, the primary of which is connected to a special microphone M. The microphone M is connected to a stylus S, which is in contact with a gramophone record or similar device R. The invention relates

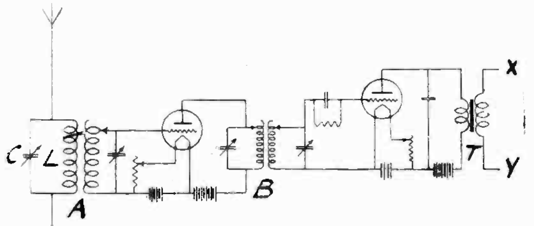


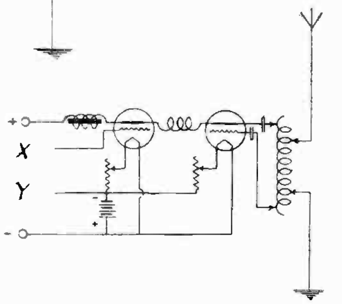
to control rather than to the transmission of intelligence and the record is arranged to transmit, when run at the correct speed, a predetermined series of acoustic signals. Interposed between the correct signals there are a number of interfering signals of various acoustic frequencies which renders the transmission unintelligible to any but authorised receiving stations.

AUTOMATIC RELAY OF BROADCASTING.

(*Application date, June* 27, 1923. *No.* 222,547.)

A. W. Sharman describes in British Patent No. 222,547 a system of broadcast transmission which is illustrated in the accompanying diagram. The object of the invention is to overcome the difficulties of reception in districts where the conditions are unfavourable for the use of ordinary broadcast receivers. In order to obviate the use of land lines connecting the main station with relay stations, it is proposed





to use a wireless link of the type illustrated. Referring to the diagram, a selective receiver having an aerial circuit LC is installed; two valves are shown coupled to the aerial and each other by highly selective circuits A and B. The last valve acts as a rectifier and is coupled by an output transformer T, which is connected at XY to the control valve of a low power transmitter. The system does not appear very novel to us, as we think similar schemes have been used prior to June, 1923. The idea of a wireless link, while being excellent from many points of view, always suffers from the effects of interference and atmospherics.

AN IMPROVED GROUND AERIAL.

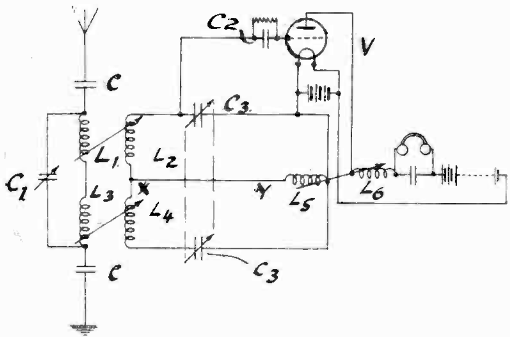
(*Application date, September* 28, 1923. *No.* 224,661.)

H. P. T. Lefroy describes in British Patent No. 224,661 an improved form of buried aerial. Ground aerials which have been previously used have generally taken the form of rubber-covered wire laid on the surface of the ground or merely buried just below the surface. Both these types of aerial have been subject to fairly considerable high frequency losses. These losses, which are chiefly due to dielectric hysteresis, are considerably reduced in the present invention by placing the aerial in a tunnel or chamber which either contains air, a gas, or is evacuated. It is stated that the tunnel may be a trench about two feet wide, at any depth below the surface of the ground. A tunnel aerial, it is claimed, gives greater freedom from atmospheric disturbances and stronger signals are obtained with greater selectivity.

PREVENTION OF RADIATION.

(*Application date, June* 27, 1923 *No.* 220,765.)

N. P. Hinton describes an interesting anti-radiation circuit in British Patent No. 220,765. In the accompanying illustration the aerial circuit comprises two condensers C, on either side of the split inductance L_1 L_3, which is tuned by C_1. Inductance L_1 and L_3 are coupled to two identical inductances L_2, L_4, which are in circuit with two equal variable condensers C_2, C_3. The mid points of the inductances and condensers are joined by a common wire through an inductance L_5, which is coupled to L_6 in the anode circuit of a valve V, while the condenser C_2 is connected to the grid circuit of the valve. It is easily seen that current induced into L_5 from L_6 will flow along the neutral wire XY, and will be in opposite phase relation in L_2 and L_4. Since L_2 is part of the grid circuit



a reaction effect is obtained between L_2 and L_6 resulting in increased signals. Should oscillations be generated, it is stated that the currents being equal and of opposite phase in L_2 and L_4, their combined induced effect in L_1, L_5 in the aerial circuit will be substantially zero, or in other words there will be no radiation from the aerial.