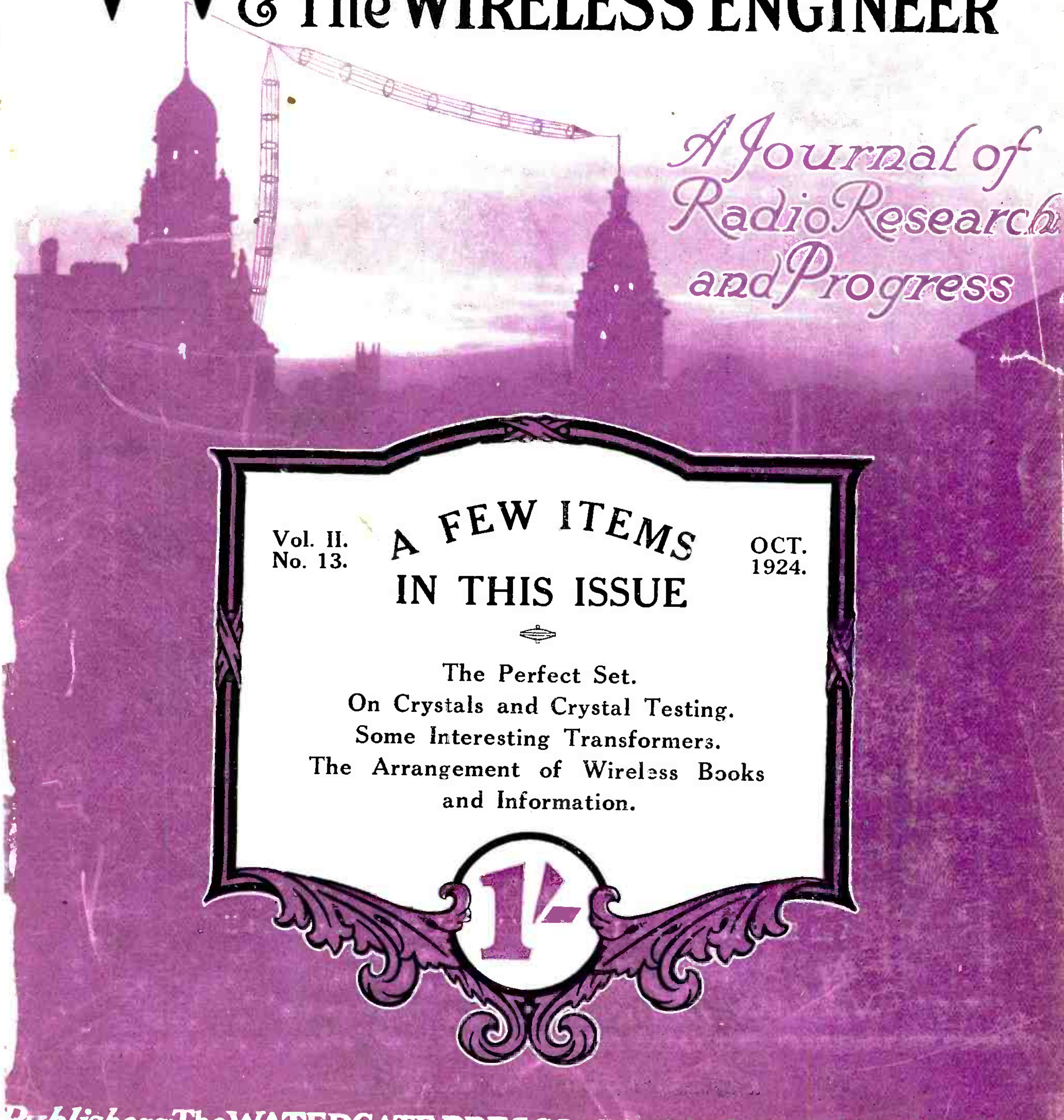
EXPERIMENTAL WIRELESS

& The WIRELESS ENGINEER



A Journal of Radio Research and Progress

Vol. II.
No. 13.

OCT.
1924.

A FEW ITEMS IN THIS ISSUE

The Perfect Set.
On Crystals and Crystal Testing.
Some Interesting Transformers.
The Arrangement of Wireless Books and Information.

1/-

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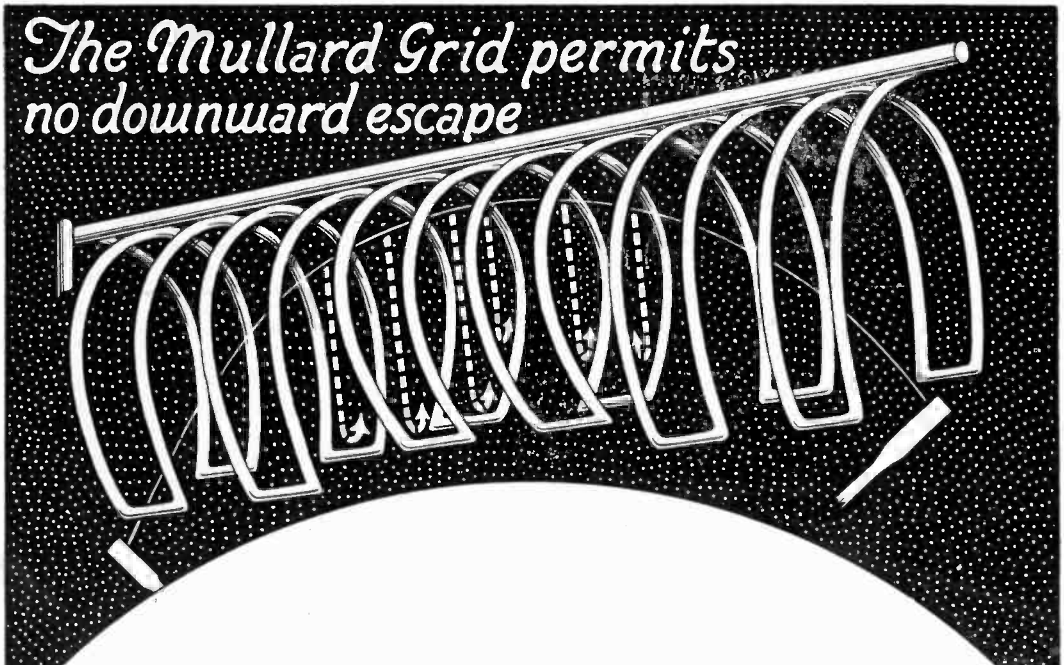

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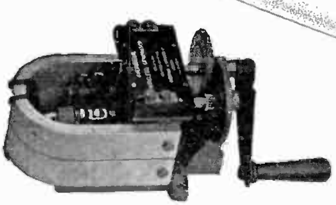

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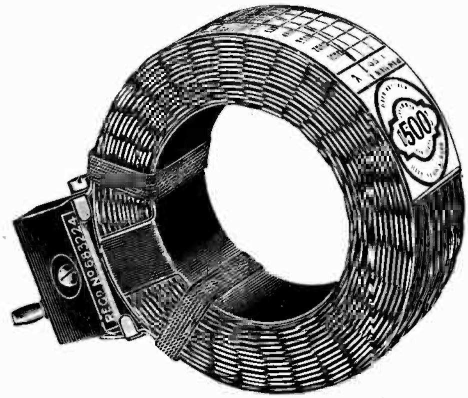

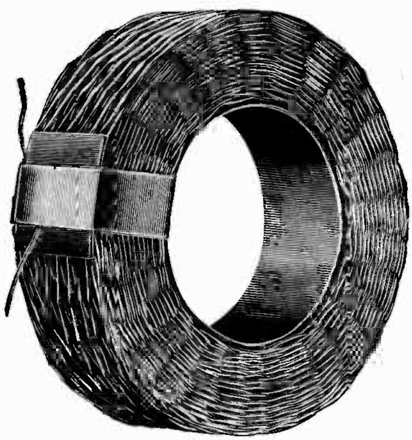

All-British Wireless Exhibition
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2171

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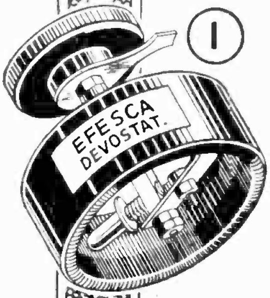
EFESCA



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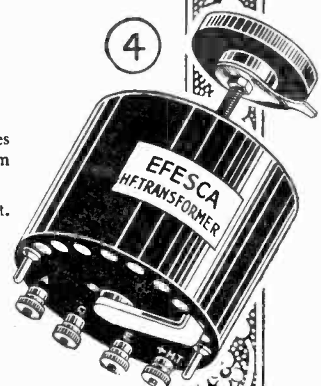

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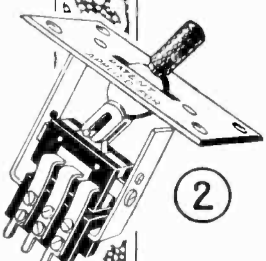

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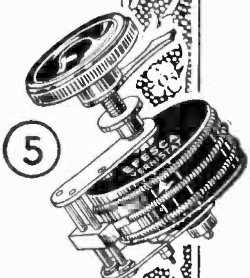

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The Components illustrated are:

1 **EFESCA "DEVOSTAT"** (Pat. applied for). A specially designed Rheostat for dull Emitter Valves consuming ·06 amps. The contact carrier rotates concentrically with the resistance former and is fitted with a ball pointed brush making contact with the resistance wire. A spring plunger maintains the ball at even pressure at every turn of the wire thereby ensuring fine adjustment, smooth and noiseless contact throughout its action. Wound on Ebonite former. Resistance 30 ohms. Complete as illustration, **4s. 6d.**

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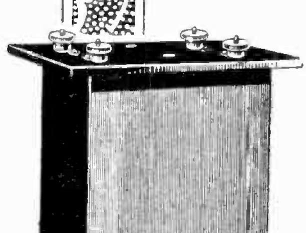

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EXPERIMENTAL WIRELESS

and The WIRELESS ENGINEER

A Journal of Radio Research and Progress

VOL. II, No. 13. OCTOBER, 1924. MONTHLY.

CONTENTS OF THIS ISSUE.

The Editor is always prepared to consider suitable articles with a view to publication. MSS. should be addressed to the Editor, "Experimental Wireless and the Wireless Engineer," 19, Surrey Street, Strand, W.C.2. Especial care should be taken as to the legibility of MSS. including mathematical work.

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EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

VOL. II, No. 13. OCTOBER, 1924. 1s. NET.

Editorial Views.

The Albert Hall Exhibition.

OUR readers may take it that as a general rule we shall not inflict upon them any account of the domestic troubles of the wireless trade. There are times, however, when these troubles have a direct affect upon the amateur, and this is one of them. It has been fairly widely advertised that a Wireless Exhibition is being held at the Albert Hall at the date on which these words appear ; and some of our readers may be led by the name of the exhibition to expect it to resemble that at the White City last year. But they will be disappointed ; for although many eminent firms will be exhibiting there, a large proportion of the goods in which readers of EXPERIMENTAL WIRELESS AND THE WIRELESS ENGINEER would be most interested—components and the like—have been excluded.

A few words are called for on the reasons for this peculiar position.

Some of the large and well-known firms of manufacturers have formed an association, the main object of which (according to its officers) is to settle, on a fixed basis, the terms on which wireless goods are sold by the manufacturer to the retailer. This Association, the N.A.R.M., or National Association of Radio Manufacturers, has for reasons of its own decided to exclude from the show which it has organised any of the following apparatus not made by its own members :—

(1) Complete broadcasting receiving sets.

(2) Sets of parts, unassembled (*i.e.*, constructors' sets).

(3) Amplifiers (valve or otherwise).

(4) Loud-speakers.

(5) Head telephones.

(6) Coils and coil holders.

(7) Condensers (fixed and variable).

(8) Transformers.

(9) Valve holders.

(10) Resistances (fixed and variable), and rheostats.

(11) Variometers and variocouplers.

(12) Plugs, jacks and sockets, including multiple distributors.

(13) Grid-leaks (fixed and variable).

(14) Crystal detectors (assembled or in parts).

Further, the members of the Association are bound not to allow their goods to be exhibited at other shows.

It is not for us here to discuss, from the trade point of view, the merits or demerits of these regulations. All that concerns us is that, instead of the hundred and fifty or more firms who might have exhibited, the show is confined to fifty or so, and will be by just that proportion less interesting and representative of what the industry can really do.

At the moment of going to press we hear that the excluded firms will almost certainly arrange to exhibit at a second show to be held elsewhere in London at an early date, so that everything will be exhibited after all. But why should the public have double trouble and pay double fees to further a trade dispute ?

Short Wave Radiation.

Among the many new problems set for us to solve by the recent work on short waves is that of radiation from an aerial on waves shorter than its fundamental. The attack from the mathematical side has already been made to some extent, but in most cases with simplifying assumptions which render it necessary, before accepting the analysis, to subject it to the test of experiment. Unfortunately the test is an extremely difficult one. It would appear that, if we regard the aerial as divided into separate parts, each independently oscillating, there is every probability that in certain directions there may be interference (in the optical sense) which may lead to the absence of radiation. Even if the aerial is symmetrical, as in the case of a plain vertical one, the radiation will not cover the whole free hemisphere from the zenith to the horizon, but may proceed along certain paths only, each forming a hollow cone. The directions in which there is radiation would seem to be affected by the loading as well as the aerial itself.

Extraordinary effects in long-distance work seem to be caused by slight alterations; but we should expect that slight changes in the Heaviside layer would also produce such effects, and it is hard to separate the two without a long series of tests most accurately carried out. It would seem that there is scope here for something in the nature of amateur "U.R.S.I." signals on low power and short wave, tests being made with various changes of aerial loading, etc., under all conditions of weather. Considerable co-operation would be required, as the tests would be useless without a considerable number of accurate receiving stations both near and far.

Mysterious Numbers.

For readers who may have missed the note in our last issue as to the arrangement of wireless books, cuttings, etc., a few words may be advisable in connection with the article on p. 3, and the reference numbers which appear at the right-hand side of the title of articles in this issue. Briefly, the article outlines a scheme, originated by Melvil Dewey and extended for wireless by the Bureau of Standards of America, for keeping books, press-cuttings, etc., in such order that everything connected with one subject is kept together, with allied subjects close to it; and the references in the titles of articles give the key numbers for those articles.

It will be found that in some cases the reference numbers are more detailed than those given in the article itself; but that need not interfere in any way with their use; it will be found that if all the articles were arranged in numerical order, they would also be (as far as practically possible) in logical order. We regret that various technical requirements of publishing prevent us from actually placing them in that order in the journal itself.

We may add that it is our hope to publish, in due course, not only an alphabetical index but a "subject index"; one in (more or less) logical order.

H.F. or L.F.?

In the September E.W. & W.E., Mr. S. R. Lewer expressed himself (in an article on "The Use of Low Frequency Amplification for Long-distance Reception") strongly in favour of L.F., to the disadvantage of H.F. In this issue Mr. F. C. Hogg joins issue with him, stating that for his part H.F. amplification is thoroughly successful.

Against most supporters of L.F. this would be a complete reply, for as a rule the only objection laid against high-frequency amplification is that of impracticability. But Mr. Lewer and (curiously enough) another contributor, in an article which we hope to publish shortly, attack it on various other points. Some of these points, we must confess, do not seem very cogent: for example, to cite selectivity as an advantage and "extra difficulty in tuning" as a disadvantage is hardly logical; they are different expressions for the same thing: one would hardly, when speaking of a top-hat, claim darkness as an advantage and at the same time point at absence of whiteness as a disadvantage!

It may seem unkind to put it so baldly, but we cannot help a suspicion that those who so eloquently point out the superiority of L.F. have had a little trouble with H.F. which further trials might show to be not entirely insuperable.

The Arrangement of Wireless Books and Information. [025·4

We present below a sketch of the Dewey system and the Bureau of Standards extension of it, by which press-cuttings, books, etc., can be arranged in order.

THE general question of the classification of knowledge is a matter much too wide for us to enter into here. But it has its interest for many of our readers, perhaps quite unknown to themselves. We believe that there are thousands of our keener readers who have shelves full of books, back numbers of wireless periodicals, experimental logs, and what not, all containing useful information. But as soon as the collection becomes large, the information takes too long to find. Sometimes an attempt is made to get rid of useless matter by keeping only cuttings, but the real difficulty here is in arranging the cuttings.

As was pointed out in an editorial note in our last issue, an alphabetical arrangement fails miserably, because it brings totally unrelated subjects together. It is desirable to follow some scheme which presents a more or less logical classification of wireless subjects.

Now, as many of our readers will know, there are already in existence several schemes, used largely in libraries, which purport to classify all knowledge; or perhaps it is fairer to say which give a consistent scheme of arranging books, etc., on all subjects. For reasons which will become obvious later, we propose to give an outline of one that is perhaps the most famous of them all: the Decimal Classification of Melvil Dewey.

In this, all books or other written matter are divided into ten main classes, which are numbered :—

000	General works.	500	Science.
100	Philosophy.	600	Useful Arts.
200	Religion.	700	Fine Arts.
300	Sociology.	800	Literature.
400	Philology.	900	History.

Each of these ten classes is divided again, and we give the divisions of the two, 500 and 600, which most concern us :—

500	General works.	550	Geology.
510	Mathematics.	560	Palæontology.
520	Astronomy.	570	Biology.
530	Physics.	580	Botany.
540	Chemistry.	590	Zoology.

And, as regards 600 (Useful Arts) :—

600	General.	660	Chemical Manufactures.
610	Medicine.	670	The Metal Industries, etc.
620	Engineering.	680	Mechanics' Trades.
630	Agriculture	690	Building Trades.
640	Domestic Economy.		
650	Commerce.		

Now, coming down to our own particular interest, it is obvious that wireless might be treated as a department of Physics, which includes Electricity, or as a department of Engineering, which includes Electrical Engineering. It has seemed best to include it under the latter heading, and we will fall in with this decision, in order that our classification shall be consistent with those of others. We will therefore further examine 620. This is divided as follows :—

620	General	625	Roads & Railways.
621	Mechanical and Electrical.	626	Canals.
622	Mining.	627	Harbours, etc.
623	Military.	628	Sanitary Engineering.
624	Roofs and Bridges.	629	Other.

By now it will be fairly obvious to our readers that the space allowed for wireless work is, to say the least of it, hardly adequate. It is a fact that since the inception of the Dewey Scheme there has been an increase in the literature of Science and Engineering beyond all proportion to the importance of these subjects as viewed at that time. But it is one of the great beauties of the system that this makes little difference, as will be seen. It seems in these later days ridiculous that the whole of Electrical Engineering should form a sub-class of Mechanical Engineering, which itself is given only one-tenth the importance of "Mechanics' Trades"! Still there are such enormous advantages in adhering to the classification that we will continue. Class 621 is divided into :—

621·1 Steam Engineering.
621·2 Hydraulic Engineering.
621·3 Electrical Engineering.
621·4 Internal Combustion Engineering.
621·5 Compressed Air and Vacuum Engineering.
621·6 Pumping Engineering.
621·7 Workshops.
621·8 Parts of Machines.
621·9 Machine Tools.

And 621·3 is classified thus :—

621·30 General Electrical Work.
621·31 Dynamo-Electric Generation.
621·32 Lighting.
621·33 Traction.
621·34 Other Power Uses.
621·35 Voltaic and Chemical Generation.
621·36 Thermo-Electrics.
621·37 Electro-Chemical Applications.
621·38 Electric Communication.
621·39 Other Industrial Applications.

So that all telegraphy and telephony is rather hidden among "etceteras." The first mention of wireless itself occurs in the next sub-division, which is :—

621·38 Electric Communication.
·381 General.
·382 Telegraphy, Systems.
·383 ,, Instruments.
·384 Wireless.
·385 Telephony, Systems.
·386 ,, Instruments.
·387 ,, Exchanges.
·388
·389 Other Electric Communications.

So here at last we have it. In a general library the whole of our books or cuttings would be sub-divisions of the one number 621·384. The original Dewey had, of course, no provision for wireless at all, and the source of our further sub-classification is Circular No. 138 of the Bureau of Standards of the U.S.A., which extends the Dewey Scheme by a full classification of Wireless subjects.

In order to avoid the constant repetition of the figure 621·384, the B.S. (by which abbreviation we shall irreverently refer to the Bureau of Standards) propose to substitute for it the letter R. It would not do to omit some such key, for otherwise a number, say 520, might be mistaken for Dewey 520 instead of Dewey 621·384·520. Adherence to this makes it possible to give other books or matter their ordinary Dewey references.

The B.S. Extension.

This being understood, the B.S. extension proceeds thus :—

R000 Wireless in General.
R100 Theory and Principles.
R200 Measurements and Standardisation.
R300 Apparatus and Equipment.
R400 Systems of Working.
R500 Applications.
R600 Stations, and their Operation.
R700 Manufacture.
R800 (See below.)
R900 Miscellaneous and Sundries.

R800 is kept open for subjects not directly wireless : matter on mathematics, chemistry, programmes, and so forth, of which (if it were arranged on strict Dewey) some would come before and some after the purely wireless material. It is more convenient really to have one place for it.

Why a detailed list is needed.

Before we go into further sub-division, perhaps we may pause and see where all this is leading us. What is the object of it ? This natural question may be answered as follows. Suppose that you have fifty books, cuttings, etc., dealing with wireless, and that the parts of the subject which they individually deal with are fairly evenly divided among the various parts of the science. Then if you labelled each one with its class number, and put them on a shelf in numerical order, you would always quite easily find what you want. For example, an article dealing with 5XX would be under R600, and would easily be found among the four or five other station descriptions. But suppose you have two or three hundred cuttings, and are a specialist in broadcast reception. Then probably 90 per cent.—or say two hundred and fifty items—will all be put under R300, and you would have a terrible search.

So the B.S. extension has been carried further, in two distinct stages. There is a short list of 65 headings, covering main divisions for a small general collection ; and there is a larger list of about 600 headings, suitable either for a large collection or for a smaller collection which is specialised. A third, and very useful item, is an alphabetical index to wireless subjects, stating under what number they should be placed.

It is proposed to give here the short classification, and to give from time to time extracts of the full one. It must be realised that credit for the skill and labour expended on these lists is due entirely to the Bureau of Standards: to get the best out of the classification it is well worth while to get the Circular itself, which is easily obtainable.*

It is only fair to state that in reproducing the schedule we have in some cases substituted words commonly used in England where they differ from the favourite names in America (such as "valve" for "toob," etc.). We have also inserted some explanatory notes, and can only hope that the B.S. will consider our interpretation a satisfactory one.

One matter, of considerable help to the classifier, will first be brought forward. It will be noticed that throughout both Dewey and the B.S. extension, the "o" divisions are "general"; *e.g.*, 620, General Engineering; 621·30, General Electrical Works, etc. Now the further division of these classes follows a uniform scheme, depending mainly on the form in which the subject is presented: and this "form division" can be applied to any number throughout the scheme. Thus, as will be seen below, 007 signifies "Laws or regulations as to . . ." So that while R007 means "Laws as to Wireless," R520·07, since it ends with 007, means "Laws as to the use of Wireless for Aviation"; for the main scheme which follows gives 52, or 520, as "Wireless applied to Aviation"

We give these form divisions separately, to emphasise the fact that they can be applied anywhere.

* Circulars of the Bureau of Standards; No. 138; *A Decimal Classification of Radio Subjects—an Extension of the Dewey System.* Author not stated. To be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., U.S.A. Price 10 cents plus postage.

The Form Classification.

- ·001 Statistics of . . .
- ·002 Quantities, costing, etc., of . . .
- ·003 Specifications, contracts, tenders, etc. (*not* Patent Specifications, for which see ·008). This, of course, is not much used by the private enthusiast.
- ·004 Designs and drawings of . . .
- ·005 Rules, administration, etc. This, like ·002 and ·003, is really for the professional.
- ·006 Working, operation instructions, maintenance of . . .
- ·007 Laws, legal regulations, etc., as to . . .
- ·008 Patent specifications as to . . .
- ·009 Test reports, logs, etc., as to . . .
- ·01 General theory of . . .
- ·02 Text-books on . . .
- ·03 Cyclopedias, glossaries and dictionaries of . . . (including signs and symbols.)
- ·04 Essays, lectures, papers read on . . .
- ·05 Periodicals, etc. This is provided for *information as to periodicals* (addresses, contribution rates, etc.), as well as for the journals themselves.
- ·06 Societies, institutions, exhibitions, etc. This again is for details as to the societies themselves as well as their transactions.
- ·07 Education, training schools, museums, etc.
- ·08 Tables, calculating charts, maps, etc.
- ·09 Historical and biographical notes.

With this preamble, we can come to the list itself: this being called by the B.S. the "abbreviated classification of Radio subjects." We shall call it the B.S. short scheme, although, in actual fact, we have included a few headings from the full scheme, so that this is rather fuller than the original B.S. short list.

R000 General.

An important class, looking after many items that could hardly be placed elsewhere. Remember, however, to place under more detailed headings further on matters which, although general, are yet confined to one branch: *e.g.*, R007 Laws as to Wireless generally; R540.07 Laws as to Private Installations.

- R007 Laws and regulations.
- R030 Cyclopedias, dictionaries, glossaries, symbols, etc.
- R050 Periodicals, bibliography, etc.
- R060 Societies, institutions, and their proceedings and transactions.
- R080 Collected tables, charts, and sundries, as under :—
  - R081 Books of tables, etc.
  - R083 Humour.
  - R084 Maps.
- R090 History of Wireless, and Biography.

R100 General Principles and Theory.

This is a wide class: be careful to keep out of it matter of practical design and performance, which go under later headings.

R110 Wave motion and wireless waves and their behaviour.
R120 Aerials and their theory: for practical construction, see R320.
- R124 Frame aerials.
- R126 Earths.

R130 Valve theory: for actual apparatus and design, see R330.
- R131 Characteristics and general properties.
- R132 Amplifying by valves.
- R133 Oscillating valves.
- R134 Detecting by valves, including reaction and heterodyne.
- R135 Modulating by valves.

R140 The theory of circuits: such matters as resonance, inductance, beats, etc.

R150 H.F. generating apparatus, other than valves.

R160 Receiving apparatus: general matters such as sensitivity, tuning, etc.

R200 Measurements and Standardisation.

Under R200 itself come general points important in all measurement.

R210 Frequency and wave-length measurement and standards. The words "measurement and standards" apply also to the following headings:—
R220 Capacity.
R230 Inductance.
R240 Resistance, damping, and losses generally.
R250 Current.
R260 Voltage.
R270 Signal strength.
R280 Properties of materials (insulators, conductors, etc.).

R300 Apparatus and Equipment.

Under this heading come details and matters of design, as distinct from pure theory, which goes under R100. It will be noted that R100 and R300 are divided up on the same system.

R320 Aerial design.
- R322 Counterpoise.
- R324 Earth.
- R327 Artificial aerials.

R330 Valves; design, making, and particulars of.

R340 Valve apparatus.
- R341 Detectors.
- R342 Amplifiers and coupling.
- R343 Receivers (complete).
- R344 Generators: includes transmitters and also Heterodynes.

R350 H.F. generators other than valve.

R370 Receiving apparatus, apart from the valve circuits.
- R374 Crystals.
- R375 Other detectors (not valves).
- R376 Receivers (telephone), and indicators.
- R377 Recording.

R380 Components and accessories.

R381 Condensers.
R382 Coils and H.F. transformers.
R383 Resistances, grid-leaks, etc.
R384 Wavemeters and similar instruments.
R385 Keys, buzzers, and interrupters generally, also microphones.
R386 Filters.
R387 Shields, earths, insulators, etc.
R388 Oscillographs.

R400 Systems of Working.

R410 Damped and modulated waves.
R420 C.W. systems.
R430 Atmospherics, X-stoppers, secret systems, etc.
R460 Duplex and multiplex.
R470 "Wired Wireless."

R500 Applications and Uses.

R510 Aids to navigation (D.F., etc.).
R520 Aviation.
R530 Commercial working.
R540 Amateur work.
R550 Broadcasting (*i.e.*, transmission: broadcast reception is R540). This also includes time, weather, calibration waves, etc.
R560 Military and naval.
R570 Wireless control of machinery, etc.

R600 Stations: Design, Operation, and Management.

R610 Description of stations.
R620 Operation, traffic, and management.

R700 Manufacturing.

This does not cover amateur constructional details, which are found under R300.

R800 Non-Radio Subjects.

As already explained, this is reserved as a convenient space for science or other matters used for wireless work, but not themselves wireless, *e.g.*, mathematics, workshop hints, etc. They will be arranged, preferably, in Dewey order.

R900 Miscellaneous.

If the other headings are properly understood, there should really be nothing here, but . . .

The scheme outlined above will cover many of the requirements of our readers. But for the sake of completeness, and to suit those who are professionally engaged or are in training as wireless engineers, we are going to give the full scheme as we can find space for it. We will commence forthwith with a first instalment, covering R000 to R099.

In certain cases we have gone rather farther than the B.S. full scheme itself. These numbers which we have taken the liberty of inserting are marked with a star: in this first instalment, most of them are derived from Dewey itself, or from what is known as the "Brussels Extension" of Dewey.

The Full B.S. Extension.

(Numbers marked * are our own additions.)

R000 Wireless in General.

Note that the numbers 001 to 099 are also the "form division," and can be added to any number of the table, as already explained.

R001		Statistics, etc.
*R002		Quantities, costs, sale prices, etc. (This will not be used so much here as after individual numbers.)
R003		Contracts, tenders, specifications, etc. (not Patents—see R008).
R004		Designs, drawings, etc.
R005		Works executive, administration, personnel, etc.
*R006		Working instructions, maintenance, etc.
R007		Laws and regulations, arranged by countries.
	R007·1	U.S.A.
	·4	Canada.
	·5	British Empire.
	·6	France.
	·7	Germany.
	·8	Elsewhere.
	·9	International Conferences.
R008		Patent specifications.
R009		Reports, etc.
	*R009·1	On experiments.
	* ·2	On operation and traffic (log books, etc.).
	* ·3	On accidents, breakdowns, etc.
R010		Research: as a "form division," usually reserved for general considerations. Note that special research establishments come under R070.
	*R011	Definition of the science: general concept.
	*R012	Classification and special branches.
	*R013	Notes on the importance and utility of the science.
	*R015	Various theories.
	*R017	Units.
R020		Text-books, etc.
	*R021	Large and important treatises.
	*R022	General handbooks.
	*R023	Elementary works.
R030		Terminology, etc., cyclopædias, dictionaries.
	*R038	Glossaries of technical terms.
R040		Lectures, essays, technical papers, etc.
R050		Publications dealing with wireless.
	R053	Periodicals
	R055	Bibliography.
R060		Societies, institutions, etc.
	*R064	Exhibitions.
R070		Training, education, experiment.
	*R071	Courses of study.
	*R072	Research and experimental establishments.
	R073	Training of operators.
	*R074	Museums, etc.
	*R079	Examinations, competitions, etc.

R080 Collected works, tables, miscellaneous works.
R081 Tables (mathematical, etc.).
R082 Nomograms, calculating charts, etc.
R083 Humorous works.
R084 Maps.
*R085 Catalogues (commercial).

R090 History.
R090·1 In U.S.A.
R090·2 In British Empire.
R090·3 In France.
R090·4 In Germany.
R090·5 In Italy, Spain, Portugal.
R090·6 In Norway, Sweden, Denmark.
R090·7 In Asia, Africa.
R090·8 In S. America.
R090·9 Elsewhere.
R091 History of wireless telegraphy only.
R091·1 In U.S.A.
etc. etc., as above.
R092 History of wireless telephony only
R092·1 In U.S.A.
etc. etc., as above.
R097 Biography.

The next division, R100 (General Principles of Wireless) we hope to deal with in our next issue.

The Remote Control of Variable Condensers.

By Leonard A. Sayce, M.Sc., A.I.C. **[R381**

In measurement work employing oscillating circuits it is frequently desirable to be able accurately to control the adjustment of one or more variable condensers. In many such measurements the capacity of the body and the hand introduce large errors if the dial of the condenser is moved in the ordinary way, and the long ebonite rods sometimes proposed are cumbersome. In all such cases the following very simple expedient has been found to give excellent results.

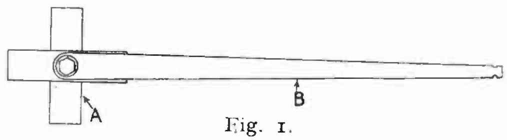


Fig. 1.

To the knob of the condenser is attached a clip (A, Fig. 1) bearing a fibre arm, B, some 15 cm. (6 in.) long. To the tip of the fibre arm a thread is attached, passing to a "winch" made of a piece of thin brass rod (C, Fig. 2), provided with a knob and turning stiffly in a cork, D. The cork may be clamped rigidly in a retort clamp. Turning the adjusting-knob thus winds up the thread and rotates the spindle of the condenser. The thread is kept taut and the spindle returned in the opposite direction by means of a rubber band, E. If the apparatus is available, the scale of the condenser is read by a telescope, F (a cathetometer is convenient) which is aligned upon a small mirror, G, fixed just above the indicating mark of the condenser scale and inclined at 45° to the vertical. The writer finds that a 6 in. diameter celluloid protractor makes a splendid scale for the purpose, for it can easily be read to $\frac{1}{10}^\circ$. The above control

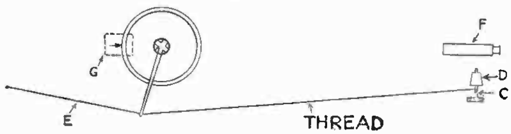


Fig. 2.

cannot move the spindle of the condenser through much more than 90°, but this is usually no disadvantage, for, if a greater range is required, the scale can be moved to its approximate position by hand—the fibre arm being free to turn stiffly—and the delicate adjustment is then made from a distance. There is practically no limit to the distance through which a condenser (or, indeed, any rotatable shaft) can be manipulated in this way.

Effective Transmission.

By Hugh N. Ryan (5BV). [R113

I MUST blame this article chiefly upon several scientifically-minded experimenters who called me to book over a certain sentence in an earlier number of this journal.

In that note I was rash enough to state that a certain amateur station in Liverpool (2ZS) was working efficiently, since he had covered some four or five hundred miles with an aerial current of ·2 ampères. Since then, many people have pointed out to me, at greater or less length, that the efficiency of a station is not in any way connected with the ratio of distance to aerial power, and still less is it connected with the ratio of distance to aerial current.

In the face of all this, what can I do but admit the truth of the criticism, and plead weakly that I used the word "efficiency" for want of a better one?

Perhaps I had better find a suitable word for future use, and what could be better than "effectiveness"? The "efficiency" of a station is, of course, strictly speaking, the ratio of the power in the aerial to the input power. But this falls rather short of the true efficiency of a station, since wireless is, after all, fundamentally a method of communication between two or more places. This being the case, we experimenters should be working at the problem of covering greater distances per unit power. Many are apt to overlook this goal, and to devote their work to obtaining technical "output over input" efficiency, regardless of whether their large aerial currents are giving them any greater range than the man with the same input and less aerial power.

The efficiency of a transmitting set, considered merely as a generator of high frequency oscillations, is undoubtedly the ratio of H.F. energy to input, but considered as a radio transmitter, its ultimate efficiency is the ratio of range to input, which perhaps does not lend itself to such accurate measurement, but is much more important, and incidentally, much more difficult to obtain.

Do not imagine that I am decrying the purely scientific method; such is not the case. By all means get as big an aerial current as you can on a given power, but make sure that the range, besides the aerial current, bears some proportion to the power.

There are many experimenters who are really interested in their range, but take it for granted that if their aerial current goes up, their range will increase. This is not so, as shown by the results obtained by various amateur stations. For instance, 2KW, 2KF, 2ZS, 2UV and myself, amongst many others, have covered several hundred miles with aerial powers of the order of ·1 watt (*i.e.*, ·1 amp in aerials with average resistances of about 10 ohms.). Yet there are many stations with some fifty times this power who are never heard at a greater distance than about 80 or 100 miles. Also, it is not unknown for the same station to obtain better ranges on low power than on full power. This happened to me about a year ago, when I used low power on 200 metres, and devoted my time to getting the best possible range on that. Just before the American tests I increased the power considerably, without allowing time to carry out sufficient work on the increased power.

The technical efficiency of the set remained about the same. That is to say, I used about five times the input power, and obtained nearly five times the power in the aerial. But range fell off hopelessly, the distant stations who could still receive me reporting a great decrease in signal strength.

This effect is at present very noticeable in London in the transmissions of 5CX, of Colne. His signals are only just audible on one valve when his aerial current is about ·7 amp, but about four times the strength and easily readable when it is only ·3 to ·4 amp.

After saying so much about the evils of "Amp-worship," I will try to give you a few hints on how to make transmissions "effective" as well as efficient; but first let me say that I do not profess to explain the great discrepancy existing between the effectiveness of some high-power and low-power stations. It would be of enormous use to all if someone could produce a simple explanation, but I think, as things are at present, we can only improve things by careful attention to details. The various hints now given are the result of several years' experience of long-distance work on low power, not of "paper-work," and are open to any criticism which can be levelled at them.

The two most common causes of loss of useful power are harmonics and "spreading." The first is probably responsible for most of the trouble. In practice, the worst harmonic of a short wave transmitter is usually the first (this of course has a frequency of $2n$, and the aforementioned critics will tell me that 2 is an even number and the harmonic should not exist, but I am dealing now with practice, not theory). Then get someone with a receiver which will receive your first harmonic to listen for it. If he reports that it is of a strength at all comparable with the fundamental, start getting rid of it. This will be chiefly a matter of adjustment of mean grid potential, and of grid coupling. If two valves are used in parallel, and these are not matched, the harmonics are probably due to this cause. This is easily tested by removing one valve and noting whether the harmonic is lessened. If this proves to be so, use one valve and be content with a reduced aerial current rather than use both valves and waste part of your increased current in harmonics.

Now for "spreading." This is a most horrible fault, since it not only greatly reduces the range of a station, but it causes great and unnecessary interference to other stations in the same district. It is not pleasant to be jammed at any time, but when the jamming is quite unnecessary, and only caused by the bad adjustment of a transmitter, causing interference over a large ban of wave-lengths—but I had better return to the point before I am tempted too far from it, being a sufferer myself, in common with many Londoners.

The point with which we are concerned is that, if spreading is allowed to occur, range will suffer. A good, if not quite complete, analogy has been suggested by a well-known experimenter :—"If you empty a bucket of water over a floor, it won't go far, but it will make a mess locally ; if you pour it along a pipe it will go anywhere you like without any mess." This rather suggests directional transmission, but it expresses the facts well. An excellent example of this is given by 2OD. His transmissions are very sharply tuned, and seem to carry anywhere. They are not extremely strong in London, but are about the same strength at every place where I have listened to him, at distances up to about 100 miles.

Friends in Scotland tell me that he is nearly the same strength up there, and 8AB gets him without difficulty, although I have heard them working when 2OD was not so very strong in London.

Perhaps it would not be wise to take an example of the other sort ; it is sufficient to say there are stations which are not sharply tuned, and that the strength of these stations falls off greatly with distance.

The cause of spreading is not always obvious, but in general it is due to using a large power on a set designed for lower power (I know that "designed" suggests a commercially made set, but the trouble is that most of the spreading comes from the extraordinary people who buy a transmitter ready-made, and don't know what is inside the box). If a set has been made for fairly low power, and has inductances wound with thin wire with small or no spacing, spreading will usually result when high power is used. Badly smoothed A.C. or generator hum will cause some spreading, and such modulation of the C.W. should be avoided, though with care even raw A.C. can be prevented from spreading beyond the inevitable band between $(N-n)$ and $(N+n)$ where N is the radio frequency and n the A.C. frequency. There is evidently some other fundamental difference between an effective and an ineffective transmission of the same power and efficiency, but I think that the exact difference remains to be fathomed, as some of our most technically efficient stations do not get very good results in practice, and some of the people who do get very fine results seem to have struck their adjustments by experiments only, and cannot explain the great effectiveness of their transmissions.

I have myself worked Amsterdam with only ·001 watt in the aerial (·01 amp in a 10 ohm aerial) with a single valve receiver at the other end. If only I could get 1 ampere or so to behave like that ·01 amp, what range could I not cover ? Yet I am wondering whether I can span the Atlantic on 4 amps, with multi-valve receivers on the other side.

The Performance and Properties of Telephonic Frequency Intervalve Transformers.

By D. W. Dye, B.Sc., A.C.G.I. **[R342.701**

PART II.

5.—Experimental circle diagrams. Effects of capacity connected to the secondary winding.

It is clear that information regarding the effective self-inductance and effective self-capacity of the secondary winding will be obtained by observing the effect on L_p and R_p of added capacity on the secondary winding. There are two methods of carrying out these experiments and each yields information of value; we can

(A) Obtain a set of circles each corresponding to a known added secondary capacity C_2. This gives all the information available from the experiments, but is rather laborious, since, on each circle, the resonant frequency is in a different region, and so a large number of frequencies must be chosen in order to obtain points around the upper portion of each circle.

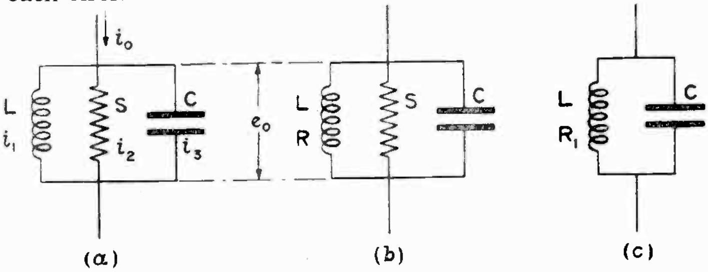


FIG. 9.

(B) We can choose a number of fixed frequencies and then find by variation of C_2 those values which give resonance on the secondary. We are, by this method, virtually finding the highest point T on each circle. This is easily accomplished experimentally by first obtaining the balance with the transformer disconnected from the bridge. Then, after connecting, adjusting V_2 to the chosen secondary voltage and disconnecting the voltmeter in the usual way, we obtain the second balance *without* alteration of M but by adjustment of C_2 and r. This method is simple to carry out and enables one to evaluate effective secondary inductance and equivalent secondary self-capacity in a direct manner.

Both sets of experiments have been made on the transformer, and are given below.

(A) Circle diagrams for various fixed secondary added capacities have been obtained, and are shown in Fig. 10. The added capacity consisted of a standard low range variable air condenser set to the successive values of 50, 100 and 150$\mu\mu$F. It was connected to the terminals SI, SO of the transformer. The four circles are distinguished by their dots to correspond to these capacities and to the case of zero added capacity. It will be seen that the circle for zero C_2 is not quite identical with that of Fig. 8. It has been found that the diameter and location of the points of the circle are slightly variable from one day to another. It is suspected that this is due to the magnetisation of the iron, since other experiments have indicated that the effective permeability and total losses of sheet materials at weak magnetisation are dependent upon the previous magnetic history of the material. For this reason it is desirable when making these observations, to complete a series at one occasion if information is sought on the relative diameters of the circles. With regard to the circles of Fig. 10, it is interesting to trace the effect of the factors operating. Reverting to Fig. 9 (*a*) it is seen that alteration of C should not have any effect on the diameter of the circle, which for this case is equal to S. But of course it is not C that we are varying, but C_2 across the secondary.

The introduction of the R term also in (b) will explain the reduction in diameter with increasing capacity, and the diameters can be used as a means of evaluating the effective R of the transformer, which may include a part equivalent to some of the iron losses and also a part due to secondary resistance.

We have, as in (7) :—

$$R_p\,(max) \doteqdot \frac{S_1L_1}{L_1+R_1S_1C_1} \doteqdot S_1\frac{R_1S^2C_1}{L_1+R_1S_1C_1}$$

If we take the difference ΔR_p in diameter of two circles corresponding to total equivalent primary capacities C_a and C_b we have

$$\Delta R_0(max) = \frac{L_1S_1^2R_1\ (C_a - C_b)}{L_1^2+L_1S_1R_1(C_a+C_b)}$$

(neglecting products of small quantities

$$\text{or } \Delta R_0(max) = \frac{R_1S_1^2\ (C_a - C_b)}{L_1+R_1S_1\ (C_a+C_b)}$$

Arranging for R, this becomes

$$R_1 = \frac{L_1}{S_1}\cdot\frac{\Delta R_p}{S_1(C_a - C_b) - \Delta R_p(C_a+C_b)} \quad \cdots \quad (17)$$

The secondary added capacity when referred to the primary winding will be approximately multiplied by σ_0^2, where σ_0 is the ratio of the secondary to the primary turns. In this particular transformer $\sigma_0 = 3{\cdot}5$ and $\sigma_0^2 = 12{\cdot}25$. If we take the extreme circles we have $\Delta R_p = 63\,000$; $C_a = 826\,\mu\mu F$ and $C_b = 825 + 12{\cdot}25 \times 150 = 2660\,\mu\mu F$.

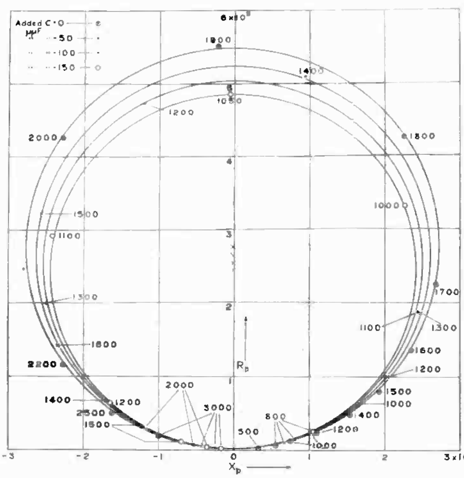


FIG.10.

From these quantities and the known values of L_1 and S_1 (in this case 8·8 and 582 000 respectively) we find $R_0 = 1060$. The direct current resistance is 1 000 ohms, so that this corroboration may be considered very good in the light of the fact that the effect of R is only in the nature of a correction.

If the values of L_1 and C_1 are deduced from one of the other circles it is found that the apparent C_1 has changed by an amount very nearly equal to $\sigma_0^2 \times$ added C_2, but there also occurs a small change in L_1 which is not clearly understood but may be

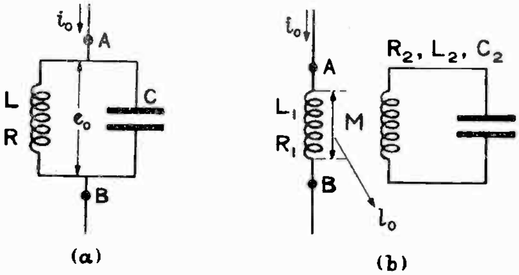


FIG.II.

due to the load placed on the transformer or to the fact that a considerably different region of frequency forms the main portion of the circle. The effective L_1 is about 1 per cent. smaller for the case of an added secondary capacity of $100\,\mu\mu F$ than for the case of no added capacity.

We may now compare two simple cases as given in Fig. 11 (*a*) and (*b*), in which S has been omitted since it may be presumed to exist as a separate shunt across AB in both cases. We will compare the R_p and L_p in these two cases.

For (*a*) we have

$$i_0(R_p + L_p a) = i_1(R + La) = i_2\frac{1}{Ca} = e$$

$$i_0 = i_1 + i_2$$

$$\text{whence } R_p = \frac{R}{(1 - LC\omega^2)^2 + R^2C^2\omega^2} \quad \cdots \quad (18)$$

$$\text{and } L_p = \frac{L\ (1 - LC\omega^2) - R^2C}{(1 - LC\omega^2)^2 + R^2C^2\omega^2} \quad \cdots \quad (19)$$

$$\text{or } (L_p - L)\omega \doteqdot \frac{L\omega LC\omega^2(1 - LC\omega^2)}{(1 - LC\omega^2)^2 + R^2C^2\omega^2} \quad \cdots \quad (20)$$

in which R^2C has been neglected.

For case (*b*) we have $i_0(R_p + L_p a) = e$

$$i_0(R_1 + L_1 a) + i_2 Ma = e$$

$$\text{and } i_2\left(R_2 + L_2 a + \frac{1}{C_2 a}\right) + i_0 Ma = 0$$

whence

$$R_p - R_1 = \frac{R_2 M^2 C_2^2 \omega^4}{(1 - L_2 C_2 \omega^2)^2 + R_2^2 C_2^2 \omega^2} \quad \ldots \quad (21)$$

and

$$(L_p - L_1)\omega = \frac{M\omega M C_2 \omega^2 \,(1 - L_2 C_2 \omega^2)}{(1 - L_2 C_2 \omega^2)^2 + R_2^2 C_2^2 \omega^2} \quad \ldots \quad (22)$$

The expressions for $(L_0 - L_1)\omega$ in the two cases are of similar type and become identical if we put $M = \sigma_0 L_1$, $C = \sigma_0^2 C_2$ and $L_2 = \sigma_0^2 L$, where σ_0 = Ratio of secondary to primary turns.

It is seen therefore that as far as the effective primary resistance and reactance circle diagram is concerned the effect of capacity connected across the secondary winding is twofold.

Mainly, the points corresponding to given frequencies are shifted round the circle in an anti-clockwise direction so that the resonant frequency is lower, therefore for frequencies below this the impedance is greater whilst for frequencies above the resonance the impedance is less than it was before, *i.e.*, the performance of the transformer is improved for low frequencies but made worse for high frequencies.

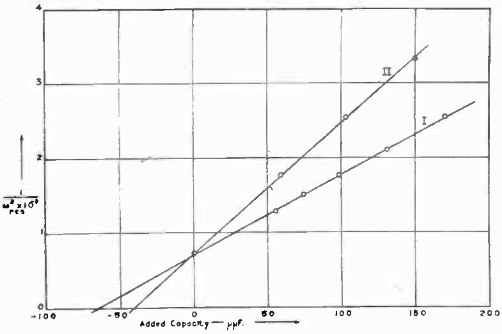


FIG. 12.

The second effect of added secondary capacity is to slightly reduce the diameter of the circle, but the effect is of small consequence unless the added capacity is large.

We will now consider the results of experiments using the resonance method (b) of adjusting C_2 and r (see Fig. 6) to obtain a balance at various frequencies without alteration of M from its zero setting. By this means we keep the effective L_0 equal to zero. (This method of finding resonance of an oscillatory circuit of large damping is far more sensitive than any methods whereby a maximum voltage or current is obtained in the circuit when brought to resonance. A glance at the curve for L_p on Fig. 7 will show how rapid is the rate of change of this quantity at the resonant point). Fig. 12 (I) shows the straight line obtained when $1/\omega^2$ (resonance) is plotted against added secondary capacity C_2. The points are seen to lie on a good line which passes through the C axis at a value of C equal to $-64{\cdot}5\mu\mu$F. This quantity therefore (with a plus sign), corresponds to the virtual effective self-capacity of the secondary winding—it must be corrected by about $-1{\cdot}5\mu\mu$F for the leads connecting the small variable condenser to the secondary winding. The slope of the line gives the true effective secondary inductance. It is in the present case equal to 107 henries. The true primary inductance was shown to be equal to 8·68 henries. The ratio of the two inductances is 12·33 and the square root of this is 3·515. The ratio of turns is 3·50. It is seen therefore that the true inductances of the windings are very closely in the ratio of the squares of the numbers of turns.

If we multiply the virtual effective secondary capacity of $64{\cdot}5\mu\mu$F (as found from the line) by $12{\cdot}25 = \sigma_0^2$ we get the equivalent primary capacity of $774\mu\mu$F. The total effective primary capacity was seen to be $825\mu\mu$F. The difference of $50\mu\mu$F may be considered as the true primary capacity and is probably not very much in error. The accuracy of this deduced value of C_p cannot of course be considered very high, since an error of only $1\mu\mu$F in the virtual effective C_2 of $63\mu\mu$F will produce an error of $12\mu\mu$F in C_p. In any case the primary self-capacity is of very little practical consequence. The secondary capacity has been called a "virtual" effective capacity because the value deduced includes the effect, referred to the secondary terminals, of the mutual capacity between the open ends of primary and secondary. This matter will be referred to later when discussing the measurements on the effects of added mutual capacity.

When using this bridge method of determining resonant frequency by variation of C_2, we also observe r at the same time, and from it we can immediately deduce the diameter of the circle. For formula (7) may be written

$$\frac{1}{R_p(max)} = \frac{1}{S} + \frac{R_1}{L_1}\sigma_0^2 C_2 \quad \ldots \quad (23)$$

and if therefore we plot $\frac{1}{R_{pmax}}$ against "added C_2" we should get a straight line whose slope equals $\sigma_0^2\ R_1/L_1$ and whose intercept at a value of C_2 equal to

$$-\frac{825}{\sigma_0^2}\ \left(=-67{\cdot}5\right)$$

should give S.

The lower line of Fig. 13 shows the results of a series of such observations and indicates that equation (23) is fairly well satisfied. The slope of this line is equal to 1 620, giving R_1 the value about 1 150 ohms. It

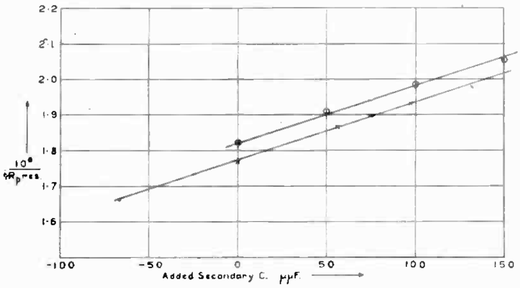


FIG.13.

was previously assumed that R_1 was equal to the direct current resistance of the primary winding, but it is clear that the copper losses in the secondary winding must appear as an increase in the effective resistance of the primary. The secondary D.C. resistance is very nearly 4 000 ohms. The equivalent of this referred to the primary may be expected to be nearly equal to $4000/\sigma_0^2 = 327$ ohms, thus giving an expected total effective value of 1 327 ohms. The agreement between the calculated and deduced values of R_1 whilst not very close, may be considered satisfactory in view of the uncertainties involved in this deduction and the many factors operating.

On Fig. 13 another line is also drawn. The points on this line are those corresponding to the actual diameters of the four circles of Fig. 10. It will be observed that the slope is practically the same as that of line R, but that the line lies considerably above it. The variation from one day to another in the diameter of a circle has been remarked upon and is not fully understood. The observations by adjustment of C_2 were made on a different occasion from that on which the four circles were obtained. The parallelism of the lines, however, indicates that the general theory holds and that only the shunt resistance S is variable from day to day. The matter is of no consequence from the standpoint of performance of the transformer.

Effects of added mutual capacity.

The experiments on added mutual capacity (between the ends PI SO on Fig. 4) were made in precisely the same manner as those for secondary added capacity. The same standard variable air condenser was used connected to PI SO and a similar set of four circles were obtained. The points refer to a secondary terminal voltage of 2·0 in every case. They are shown in Fig. 14.

It will be seen that the circles are very similar to those corresponding to added secondary capacity. The points corresponding to any particular frequency are moved round in an anti-clockwise direction and the diameter is reduced as before.

It will be observed that the effects of added mutual capacity are more marked than those of added secondary capacity.

If we take the simple case represented by Fig. 15, it may easily be shown* that the effect of mutual capacity on effective primary impedance is exactly similar to that of

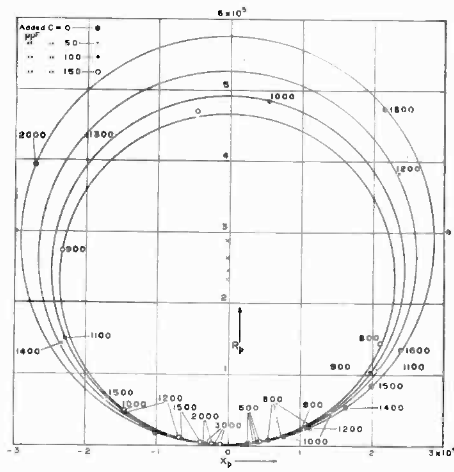


FIG.14.

secondary capacity and that it can be represented as an equivalent secondary capacity having the approximate value

$$C_2\ (\text{equivalent}) = C\ (\text{mutual}) \times \left(1 \pm \frac{1}{\sigma_0}\right)^2 \quad (29)$$

* See Note 1 at end.

It is interesting to note the significance of the value and sign of σ_0. If the transformer has a large ratio, $\frac{1}{\sigma_0}$ will be small and the equivalent secondary capacity will be nearly equal to the mutual capacity. Again, if the direction of the windings is such that the primary and secondary voltages are approximately in the same phase (*i.e.*, M and σ_0 are negative), then the effect of mutual capacity is less than that due to the same capacity across the secondary. If primary and secondary voltages are in opposite phase, so that the potential difference across the condenser is greater than that across the secondary, mutual capacity produces a greater effect than secondary capacity. In a 1 : 1 transformer having the common point such that M is negative the effect of mutual capacity is negligible, since $\left(1-\frac{1}{\sigma_0}\right)^2$ is zero.

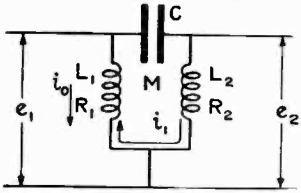


Fig. 15.

The expression for L_p including the effect of mutual capacity looks somewhat complicated,* but in the case of a good transformer the term

$$(1-k^2)\left[L_2C\omega^2\left(1\pm\frac{1}{\sigma_0}\right)^2-1\right]$$

is of little importance, since k is of the order 0·98 and the part in square brackets is considerably less than unity.

To a close approximation therefore

$$L_p \doteqdot \frac{\frac{L_2}{\sigma_0{}^2}\left(1-L_2C\omega^2\left[1\pm\frac{1}{\sigma_0}\right]^2\right)}{R_t{}^2C^2\omega^2+\left[L_2C\omega^2\left(1\pm\frac{1}{\sigma_0}\right)-1\right]} \quad .. \quad (30)$$

If we further treat the mutual capacity case in the same manner as that of secondary capacity, by determining the values of C_m corresponding to resonance, we shall expect to find a straight line connecting $1/\omega^2$ (resonance) and added C_m, having a slope equal to $L_2\left(1\pm\frac{1}{\sigma_0}\right)^2$ and an intercept equal to $\left(1\pm\frac{1}{\sigma_0}\right)^2$ times that obtained by the line for added secondary capacity. The line actually obtained from the resonances with various mutual capacities is shown on Fig. 12 (II). It is seen to be of greater slope than the other line, and must, of course, intersect it at the point C=0.

The actual slope was found to be 175·5 henries. Dividing by the slope of (1) (=107 henries) we get $(1+\frac{1}{\sigma_0})^2=1{\cdot}640$, whence $\sigma_0 = 3{\cdot}57$.

To be strictly accurate, we should have included k in the mutual term, *i.e.*,

$$\text{Effective } L=L_1+L_2+2M=L_2\left(\frac{1}{\sigma_0{}^2}+1+\frac{2k}{\sigma_0}\right)$$

instead of $(1\pm\frac{1}{\sigma_0})^2$.

Taking $k=0{\cdot}98$ and $\sigma_0=3{\cdot}50$ we get

Eff. $L=107(1+0{\cdot}082+0{\cdot}560)=175.6$, an agreement which is remarkably good.

(The measurement of k will be discussed later.)

The intercept on the C axis of the line (II) of Fig. 12 is at $-40\mu\mu$F which, allowing 1·5 for the leads and multiplying by $(1+\frac{1}{\sigma})^2$ gives $-63{\cdot}2\mu\mu$F, a value very close to the value -63 given by line (I) of Fig. 12.

It is seen, therefore, from these experiments that the effects of secondary and mutual capacity are interpretable in terms of one another and of the ratio and direction of the windings (as shown by the approximate theory also).

As a result, it is not possible to separate the true effective mutual capacity and the true effective secondary capacity of a transformer by this method. It seems unlikely that any experiments will suffice to effect a separation unless a complete series of measurements is taken using all four of the possible ways of connecting primary and secondary windings together. If the connection between primary and secondary is charged, other mutual capacities will of course be brought into operation.

No attempt has been made in the present investigation to carry out this complete analysis, involving at least six capacities.

An easy way of separating the effective mutual and secondary capacities for the case of one particular common point between primary and secondary is, however, open to

* See Note 1 at end.

those who construct transformers; that is to wind two transformers precisely similar in every respect, except that the direction of winding of the secondary of one of them is reversed as compared with the other. If the geometry of the windings of the two transformers is identical, then the only quantity changed will be the sign of σ_0.

We may consider the measured effective C_2 as made up in one case of

$$C_2 \text{ eff.} = C_s + C_m \left(1 + \frac{1}{\sigma_0}\right)^2$$

and in the other case,

$$C_2 \text{ eff.} = C_s + C_m \left(1 - \frac{1}{\sigma_0}\right)^2.$$

The values of C_2 eff. obtained on the two transformers will then differ by an amount equal to $\frac{4 C_m}{\sigma_0}$, thus allowing C_m and C_s to be separated.

(c) *Effect of a shunt resistance across the secondary winding.*

Under some conditions, the grid-filament circuit of a valve has not an extremely high resistance. Also it is not uncommon for a resistance of one or two megohms to be used as a shunt on the secondary winding for the purpose of diminishing distortion. It is interesting, therefore, to analyse the effect of such a resistance. Experiments were

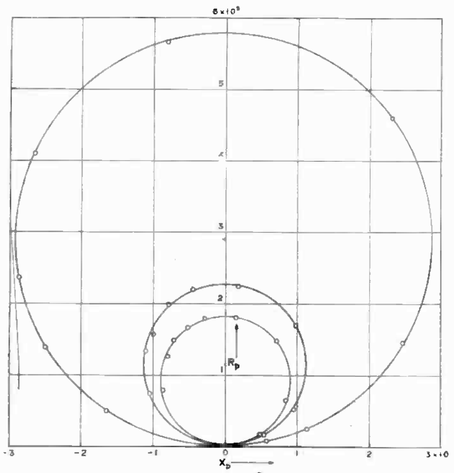


FIG.16.

made using two grid leaks connected in turn by short leads to the secondary winding. The effective resistance of each was measured at a number of telephonic frequencies by shunting the leak across an air condenser of known value. The change in capacity and power-factor of the condenser was measured by a Carey-Foster bridge. The effective resistance and effective capacity of

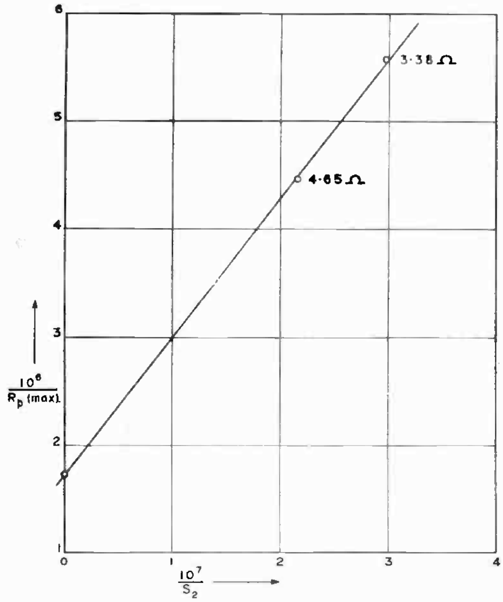


FIG.17.

the leak were thus determined. The changes with frequency were small, the capacity also was only a very few micro-microfarads.

In Fig. 16 are shown three circles correponding to secondary resistances of ∞ 4·65 megohms and 3·38 megohms respectively. It is immediately seen that the effect on diameter is very marked. This reduction in diameter doubtless accounts for the greater stability and improved performance of transformers when used for telephony and music.

It will be observed that the impedance for low and for high frequencies is not much affected by a secondary shunt of 3 megohms, the main effect being on the impedance in the resonant region of frequency. Since, even with the shunt, the impedance at resonance is still of the order of 175 000 ohms, a large fraction of the available alternating voltage in the anode circuit will still be received on the primary of the transformer.

If we plot $1/R_p max$ against $1/S_2$, as in Fig. 17, we get—as might be expected—a straight line, of which the slope is found to be 12·50.

The square root of this is equal to 3·53, a result of σ_0 in close agreement with the true value of 3·50.

(*d*) *Effect of magnitude of secondary induced electromotive force.*

Since various stages of amplification are concerned with considerably differing magnitudes of voltages, it was considered desirable to try the effect of varying the magnitude of the applied voltage.

This was carried out as follows : from the circle obtained for a constant induced voltage of 2·0 a few points of frequency were chosen so as to be fairly well distributed round it. At these frequencies observations were taken of X_p and R_p for various values of secondary voltage set by the help of the low-reading electrostatic voltmeter.

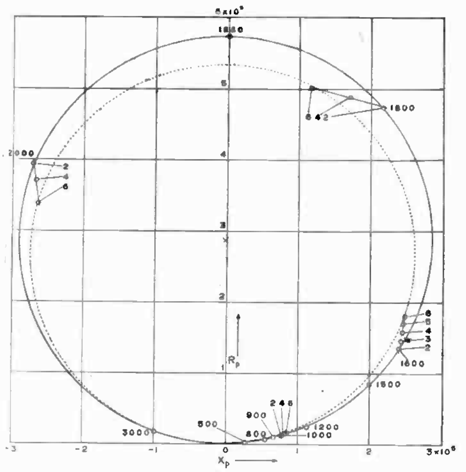


FIG. 18.

The results of these observations are shown in Fig. 18. A number of interesting deductions can be drawn from the location of the points. The effect of the increased magnetisation necessary to produce an increased secondary voltage is to shift the points round in an anti-clockwise direction, doubtless due to increased permeability as the flux density rises. This effect is smaller the higher the frequency ; this is no doubt due to the fact that the portion of the $\mathcal{H}\mathcal{B}$ curve explored at a higher frequency is moved down into a lower region of $\mathcal{H}$ and $\mathcal{B}$ at the higher frequencies, for the same range of voltage. Although the points on the curve for one frequency are more widely separated at the upper region of the circle, the corresponding change in effective L_p is nevertheless smaller. The explanation is, of course, that the scale of frequency is very much opened out over a large part of the circle and closes in towards the zero and ∞ points.

The next point to be noticed is that the circle joining the 6-volt points is smaller in diameter than that joining the 2-volt points. The explanation is that the hysteresis losses in the iron, at low densities, vary as a higher power of $\mathcal{B}$ than 2, consequently, as $\mathcal{B}$ diminishes the shunt resistance representing the total losses will increase. The indication is that over a very large range of amplification of secondary voltage, the amplification given by the transformer will not change much, and hence distortion due to variation in intensity should not occur on account of any variability in the constants of the transformer. As will be seen later, the circle may be profoundly modified by variation of applied voltage when a valve is connected to the secondary winding.

(*e*) *Effect on primary impedance when the grid-filament circuit of a valve is connected to the secondary winding of the transformer.*

The foregoing experiments must, of course, lead on to an examination of the behaviour of the transformer when performing its normal duty of supplying voltage to the grid-filament circuit of an ensuing valve.

The author has not had time to experimentally penetrate very far into the complicated region exposed by this problem, but it seems probably that the method of attack is a sufficiently powerful one to yield results of considerable value in analysing causes and effects associated with the various factors operating.

Only a very few experiments have been made, but the results are of a surprising nature, and show that profound effects may be produced depending upon the conditions in the attached valve circuit.

Three cases are given below and are shown in Fig. 20. The experimental arrangements were as in Fig. 19.

The bridge proper is identical with that of Fig. 6, but the arrangements for applying a known voltage to the transformer primary are somewhat different in order to enable smaller voltages to be conveniently measured. For this purpose a non-inductive resistance

R_2 was used to enable small currents to be measured by the help of the electrostatic voltmeter V. Of this current (from 2 to 5 milliampères) the major portion passes through the shunt T. The terminal voltage on S can therefore be made a convenient fraction of that on R_2. The ratio will not alter appreciably due to the variations in the bridge, since it is almost non-inductive, and except in certain cases the shunting effect of the transformer primary across S is small.

(*b*) Similar to (*a*) but with constant primary alternating voltage to give a secondary voltage of 0.5 r.m.s.

(*c*) Grid at —4 volts and a secondary induced voltage of 2 volts r.m.s.

(*d*) Grid at 0 volts and a secondary induced voltage of 0·5 volt r.m.s.

A most remarkable variety of results was obtained, as shown in Fig. 20. For the purpose of comparison the normal circle with no connections on the transformer secondary is also shown, dotted. The other three circles are dealt with in order of their diameters, beginning with the smallest.

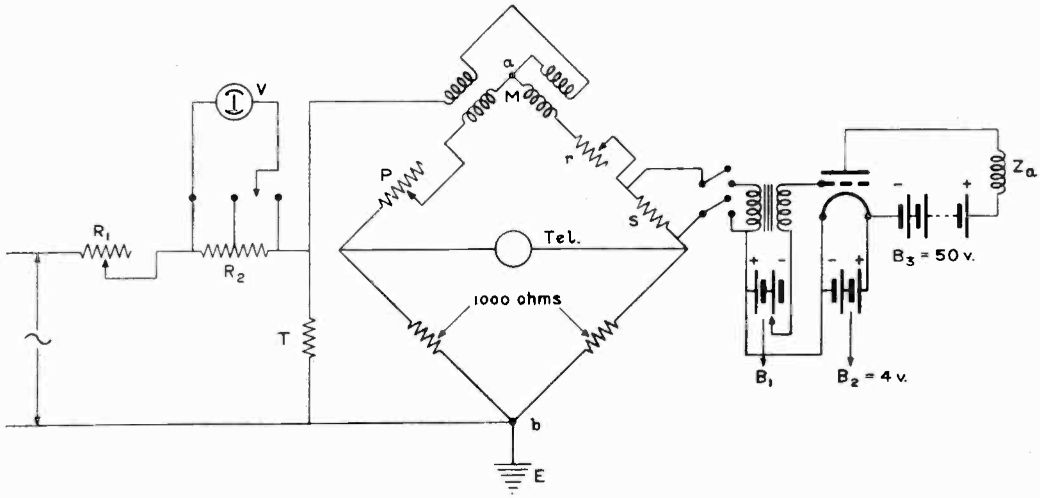


FIG.19.

The valve arrangements are indicated on the right of the diagram. The connections were such that a common point existed between primary and secondary windings of the transformer. The battery B_1 was for the purpose of maintaining the grid of the valve at a definite negative potential with respect to one end of the filament. The load Z_a in the anode circuit consisted of an inductance coil without iron. Its inductance was 5 Henries and its resistance about 1 000 ohms. The self-capacity was small (about $30\mu\mu F$). It was placed at a considerable distance from the transformer, and was turned to a position of zero mutual inductance with respect to it. The following trial cases were taken over a range of frequencies from 500 to 3 000 cycles per second :—

(*a*) Grid at —2 volts steady potential, and a constant applied primary alternating voltage of ·57 volt r.m.s., corresponding to a secondary voltage of 2.

The following remarks are considered by the author to explain to some extent these results.

(*a*) *Applied Volts* 2, *Grid Volts* —2.

The circle is very small and somewhat distorted.

Since the applied alternating voltage on the grid has a r.m.s. value of 2 it will cause the grid to become positive during a part of the cycle, so that a heavy load is thrown on the transformer secondary which almost short circuits it during this part of each cycle.

(*b*) *Applied Volts* 0·5, *Grid Volts* —2.

The grid is always considerably negative with respect to the filament, and consequently the true internal grid-filament resistance is extremely high. Further explanation is needed, however, of the fact that the diameter of the circle is *greater* than that with open secondary. It is believed that the explanation lies in the nature of the load in the anode circuit. Miller* has shown that under certain conditions the input impedance of a valve can consist of a negative resistance and a capacity in series, in the case of an inductive load in the anode circuit. It may be that the increased diameter of the circle is a manifestation of this effect.

(*c*) *Applied Volts* 2, *Grid Volts* —4.

The circle is again large, although the applied alternating voltage has a r.m.s. value of 2. This is possible on account of the increased negative potential of the grid, which maintains it negative throughout the alternating cycle.

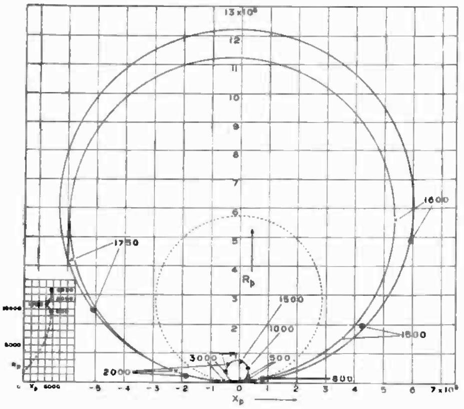


FIG 20

A remark may be permitted here regarding the conditions which should be observed if full use of the transformer is to be made.

If it is desired to obtain loud signals or speech, such as to necessitate the application of a few volts to the grid of a valve, then, in order to give the transformer an opportunity to keep a high primary impedance, it will be necessary to apply a considerable negative potential to the grid. Under these conditions, however, the valve will require a high anode potential in order to operate over the steep straight portion of its characteristic.

If it is not desired to use high anode voltage, then a large negative potential cannot be applied to the grid, and a step-up ratio on the transformer cannot be made use of at a loud-speaking stage on account of the heavy load placed on the secondary winding.

(*d*) *Applied Volts* 0·5, *Grid Volts* 0.

The impedance of the transformer no longer gives a circle diagram, but remains almost constant and of very small value. (It is so small as only to be seen on close inspection of Fig. 20 as a tiny sloping line near the origin.) The values obtained have been plotted on a much larger scale in the left hand corner of Fig. 20. It is seen that the impedance varies in a somewhat irregular manner, and is so small that it is doubtful whether any gain over a simple resistance or inductance coupling is made in spite of the step-up ratio of the transformer, owing to the smallness of the primary impedance.

These results call for much fuller investigation than the author can at present give them. The measurements under the heading (*b*) are difficult owing to the smallness of the energy available in the bridge. It has been found necessary to carry out the tests represented by the large circle at night under conditions of great quietness and steadiness; doubtless with some experimenting a stage of amplification could be applied to the bridge telephone without impairment of accuracy, so that the measurements could be made without special external conditions.

The possibility of increased diameter of the circle as a result of the conditions in the anode circuit of a valve probably has its counterpart in the howling noises occasioned by self-generation of currents of telephonic frequency. It is clear that the addition of a shunt resistance of one or two megohms on the secondary winding will effectively prevent the diameter of the circle from becoming infinite under conditions where otherwise distortion or howling might occur. No great loss of amplification will result from the use of a shunt resistance of 2 megohms, since this will still allow the circle to have a diameter of over 100 000 ohms in a normal transformer.

Another very convenient method of reducing the diameter of the primary impedance circle is to wind one or two turns of No. 18 or 20 S.W.G. wire round the

* Dependence of the Input Inpedance of a Three Electrode Vacuum Tube upon the Load in the plate Circuit. J. M. Miller. *Bulletin Bureau of Standards*, No. 5351. Vol. 15, 1919-20, p. 367.

outside of the secondary and to short circuit this tertiary winding either directly on itself or through a low resistance. Howling or incipient howling causing distortion may be prevented in this manner. The beneficial results which sometimes result from shrouding are probably due to the shroud acting as a closed tertiary winding in this manner and not to magnetic screening.

We must pass on to the consideration of the second part of the function of the transformer as mentioned in Section 2, namely, the effective voltage ratio.

ERRATA.—In the first part of this article, published in the September issue, one or two printer's errors unfortunately crept in. In column 2, page 695, the brackets in the denominator of formulas 3 and 4 should have been squared thus: $S^2(1-LC\omega^2)^2$, and not $S^2(1-LC\omega^2)$ as printed. In equation (13) in column 1, page 697, the part under the square root should have been

$$\sqrt{S^2-4X_2^2}, \quad \text{not} \quad \sqrt{S^2-4X.}$$

(To be continued.)

Note 1.—The Effect of Mutual Capacity.

We have

$$i_o(R_p+L_p a)=e_1=(i_o-i_1)(R_1+L_1 a)-i_1 M a$$

$$(i_1-i_o)(R_1+L_1 a+Ma)+i_1\left(R_2+L_2 a+Ma+\frac{1}{Ca}\right)=0$$

$$i_1(R_2+L_2 a)+(i_1-i_o)Ma=e_2$$

whence

$$R_p+L_p a=\frac{(R_1+L_1 a)\left(R_2+L_2 a+\dfrac{1}{Ca}\right)-Ma(R_1+L_1 a+Ma)}{R_1+R_2+L_1 a+L_2 a+2Ma+\dfrac{1}{Ca}}$$

it will be found that

$$R_p=\frac{R_1\{(M+L_2)C\omega^2-1\}^2+R_2C^2\omega^2\{R_1(R_1+R_2)+(M+L_1)^2\omega^2\}}{(R_1+R_2)^2C^2\omega^2+[(L_1+L_2\pm 2M)C\omega^2-1]^2} \quad \ldots \quad (24)$$

and

$$L_p=\frac{L_1+C\omega^2\left[(L_1L_2-M^2)\{(L_1+L_2\pm 2M)C\omega^2-1\}-L_1(L_1+L_2\pm 2M)+(R_1^2L_2+R_2^2L_1-2R_1R_2M)C-\dfrac{R_1^2}{\omega^2}\right]}{(R_1+R_2)^2C^2\omega^2+[(L_1+L_2\pm 2M)C\omega^2-1]^2} \quad \ldots \quad (25)$$

Except at very low frequencies $R_1(R_1+R_2)$ is negligible compared with $(M+L_1)^2\omega^2$. Thus $R_1=1000$, $R_2=4000$, $M=\pm 30$, $L_1=9$ and let $\omega=2000$. Then $R_1(R_1+R_2)=5\times 10^6$ and $(M+L_1)^2\omega^2=1600\times 10^6$

We get therefore

$$R_p \doteqdot \frac{R_1\{(M+L_2)C\omega^2-1\}^2+R_2C^2\omega^4(M+L_1)^2}{(R_1+R_2)^2C^2\omega^2+[(L_1+L_2\pm 2M)C\omega^2-1]^2} \quad \ldots \quad (26)$$

$$L_p \doteqdot \frac{L_1\left[1+C\omega^2\left\{\dfrac{(L_1L_2-M^2)^2}{L_1}([L_1+L_2\pm 2M]C\omega^2-1)-(L_1+L2\pm 2M)\right\}\right]}{(R_1+R_2)^2C^2\omega^2+[(L_1+L_2\pm 2M)C\omega^2-1]^2} \quad \ldots \quad (27)$$

or in terms of L_2

$$L_p \doteqdot \frac{\dfrac{L_2}{\sigma_o^2}\left[1+L_2C\omega^2\left[(1-k^2)\left\{L_2C\omega^2\left(1\pm\dfrac{1}{\sigma_o}\right)^2-1\right\}-\left(1\pm\dfrac{1}{\sigma_o}\right)^2\right]\right]}{(R_1+R_2)^2C^2\omega^2+\left[L_2C\omega^2\left(1\pm\dfrac{1}{\sigma_o}\right)^2-1\right]^2} \quad \ldots \quad (28)$$

in which $M^2=k^2L_1L_2$ and $L_2=\sigma_o^2L_1$.

The Perfect Set. [R370

Part I: The Crystal Set.

This is the first of a series of articles dealing very thoroughly with a subject of great importance both to the advanced experimenter and the ordinary listener.

WE have adopted an ambitious title; and in justice to ourselves we must beg for a certain journalistic licence, for the perfect set is obviously an impossibility. The perfect set technically, even if it could be achieved, might be far from perfection when account is taken of cost and convenience.

What we really wish to do in this series is to take the old familiar types of set, with well-known circuits, and show a few points in which, by careful design, performance may be improved, both as regards strength and purity.

Starting then with the simplest set—the crystal—what can we do for it? One point immediately strikes the designer: since the crystal set depends for its results entirely upon energy received from the transmitter, and not upon its release from a local store as in the valve set, efficiency is more important than in any other set. Curiously enough, none of the vendors of commercial sets seem to appreciate this point: from their point of view, the crystal set is something to sell to a customer who has little money and therefore, needs no consideration. The writer is quite prepared to wager that by taking proper care the range (or signal strength) of a crystal set can be increased to at least 50 per cent. more than that of the average purchased set.

How is this to be done? Well, first, before going into detail, let us look at the general design. The crystal set comprises, in principle, three parts: an aerial circuit to transfer energy from the passing wave to the detector; the crystal, to transform H.F. energy from the aerial into L.F. energy for the phones; and the phones themselves to convert it into sound. Now it is a cardinal principle that in all such transformations of energy, the various parts must be suited to one another: one does not use a high gear for a steep hill, or a goods engine for an express train. Electrically, the rule is that when a circuit is supplying power, but is also unavoidably wasting some of the power, the best result is got when the waste power equals that passed on. This may seem at first unsound, or difficult to grasp. But let us apply it to a simple case. In Fig. 1 we have shown a dynamo giving a voltage E, which is sending current through a resistance R. Now, the smaller the resistance, the larger the current, and as the power is given by the current *squared* and multiplied by R, we find that decreasing the resistance to half its value will give twice the power; for we have twice the current multiplied by half the resistance.

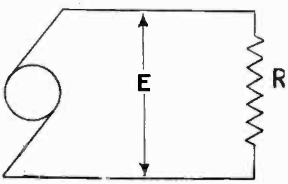


Fig. 1.

But now suppose that the dynamo itself has a resistance. Then halving the load resistance no longer doubles the current. For example, with a 12-ohm dynamo and an 8-ohm load, the *total* resistance is 20 ohms, and if the voltage generated is 20 volts the current is 1 amp, and the power in the load $1 \times 1 \times 8 = 8$ watts. If now we reduce the load to 4 ohms, the total is 16 ohms, and the current $20/16 = 1\frac{1}{4}$ amps. The power is $\frac{5}{4} \times \frac{5}{4} \times 4 = 6\frac{1}{4}$ watts: the decrease of resistance has caused an actual decrease of power. In this case the maximum useful power is developed by a load of 12 ohms: total resistance 24 ohms; current $\frac{5}{6}$ amp, useful power $\frac{5}{6} \times \frac{5}{6} \times 12 = 8\frac{1}{3}$ watts.

This golden rule of equal resistance for maximum useful power should never be forgotten in wireless work. We can at once find two applications for it in the crystal set. It would seem that the aerial, crystal, and phones should all have the same resistance. But this of course is not exact. We must consider not the resistance in each case, but the *apparent* resistance or effective resistance.

The actual value of this in the case of an aerial, a crystal, and a pair of telephones is most decidedly not a matter that we can go into in an elementary, non-mathematical article of this kind. But it can be stated clearly that the resistance of the average galena crystal is too low for the ordinary aerial circuit of to-day, and also too low for the telephones in common use. On the other

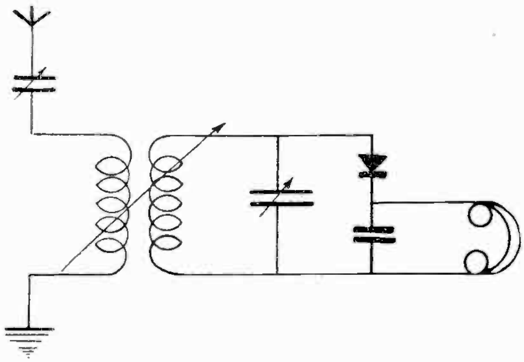


Fig. 2.

hand, galena is a good crystal, and the difficulty as regards the aerial circuit is easily overcome. We can regard the problem as that of supplying a low-resistance load from a rather high-resistance source. The obvious solution is that which we already use for low-resistance phones off a high-resistance valve—a transformer. We can use an actual transformer, as in the well-known "loose-coupled" circuit of Fig. 2, in which case the low resistance crystal is best suited by a fairly small secondary and large condenser (say a $\cdot 001 \mu F$ condenser, and coil to suit). Or we can use a tight-coupled transformer, tuned on one side only, as in Fig 3*a* and *b*, the latter being often miscalled an "aperiodic aerial," which it isn't.

But except when we particularly want great selectivity at the expense of signal strength, when loose coupling is the thing, the simplest method is to get the effect of a tight-coupled transformer by using an "auto-transformer," which in practice means no more than using an aerial coil with a variable connection to the crystal. In its simplest form this goes back to very old times, when a favourite circuit used a long single-layer coil with two sliding contacts, as shown in Fig. 4—and, we might add, there are many worse schemes. If we want to use up-to-date apparatus, a simple scheme is to employ a variometer and variable condenser, as in Fig. 5. It is obvious that various settings of the variometer may be tuned to the same station by adjustment of the variable condenser; and one particular setting will give the best results of all. But this is rather a troublesome method, though free from the great disadvantage of Fig. 4—short-circuited turns. This can also be overcome by taking tappings from the coil to two switches.

The simplest method of all, though not the most efficient, depends on the assumption that with an average aerial and an average crystal, the best tapping point for the crystal will be about half-way up the coil. The crystal is, therefore, connected to the middle of the variometer, as in Fig. 6—an alteration which will be a great improvement in almost any bought crystal set.

Leaving this problem for a moment, let us consider the phones. It was stated above that the usual galena was too low in resistance to suit 2 000-ohm phones. Here, again, the obvious solution is a transformer, but an

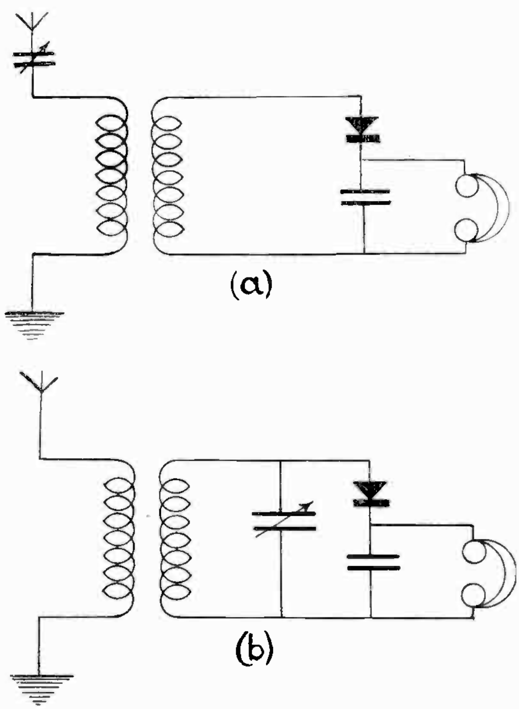


Fig. 3.

iron-core telephone transformer has two disadvantages. Firstly, its primary, like the phones it displaces, is usually designed for a high-resistance valve circuit, and to wind a correct one is not a light task; secondly, such a transformer usually wastes quite a lot of power. Unfortunately, the phone windings themselves cannot be altered. But there is one simple modification which *can* be tried: the two ear-pieces can be connected in parallel instead of series, reducing the resistance from 2 000 ohms to 500. This will usually produce a surprising improvement.

Apart from these questions of balance, there are the matters of practical design from the efficiency point of view; and here there is an important point: a gain of 5 per cent. in output is not perceptible to the

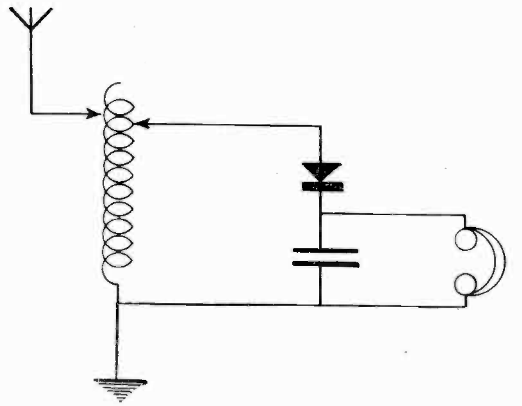


Fig. 4.

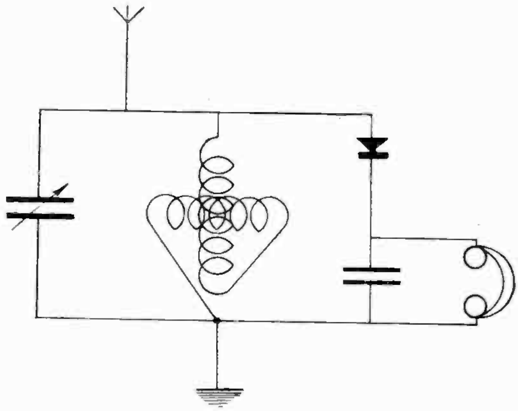


Fig. 5.

ear—even 10 per cent. will only be noticed by the experienced. But five gains of 5 per cent. give a total increase of 28 per cent., which is easily perceptible. So that if theory and experience say that such and such a modification gives improved efficiency it is worth doing, even if no obvious improvement seems to result. The two directions in which constructional design can improve matters are the diminution of (1) ohmic resistance; (2) dielectric losses. A third point is convenience, which is also a very important matter.

Coming down to practical design, what are we going to do about the coil? Mr. F. M. Colebrook, who has studied the question pretty fully, favours large square coils of bare wire, with clips for contacts. But this can hardly make a compact or pretty set. Undoubtedly, the square coil is the most efficient, for it can be arranged so that each turn is only in contact with solid matter at four points. The basket coil has many adherents, but it suffers from this: that where the turns cross one another, the insulator between them (cotton as a rule) is one prone to set up quite a surprising loss. The coil with an absolute minimum of solid matter is probably that built like a miniature frame aerial. Two pieces of ebonite of the general shape of Fig. 7 are cut, and fitted together to form a cross: the wire is wound in the slots. The most effective order of winding is a rather peculiar one, and is given by the numbers in Fig. 7. One turn is wound on the front, then two on the back, after which the turns go two in front and two behind.

It is well known that there is a best size of wire for such coils. The actual best size varies with the type of coil and the frequency; but for broadcast waves is probably 18 to 20 S.W.G. Stranded wire is only useful if (A) every strand is fully circulated, (B) the strands are plaited or most carefully twisted, (C) very great care is taken to make soldered contact to *every* strand. As our coil is to be tapped this is impracticable. Theoretically, silver plated wire would be an advantage. Actually, bare wire or enamelled is quite all right: tinned wire is not quite so good. A coil of about 50 turns is likely to be sufficient if the diameter of the inside turn is about 2 in.

Now as to tuning. It has always seemed to the writer that the simplest method is to tune the aerial circuit by a condenser. The adjustment of the crystal circuit, however, must be by a tapping on the coil. A clip means that the coil must be exposed, and as the crystal adjustment is not a very sharp or sensitive one, it seems reasonable to use a multi-stud switch. It is extremely

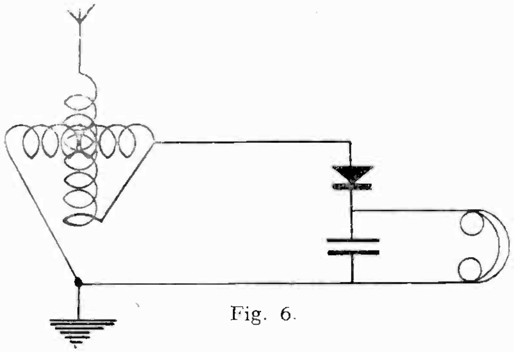


Fig. 6.

unlikely that the best result will be given by much less than half the coil, so if 50 turns are used seven tappings, including 50, 45, 40, 35, 30, 25, 20 turns, will suffice. Undoubtedly, a switch with its tappings does not form such an efficient scheme as a short flex lead and a clip: but the loss need not be large if care is taken.

The tuning condenser, however, must not be dismissed without thought. The home-made condenser is at a disadvantage because aluminium plates are used. These are *always* covered by a film of transparent oxide, which re-forms immediately, even if it is removed. Hence, it is by no means easy to ensure really good contact, especially as solder will not adhere. If possible, use a condenser with brass or zinc plates and ebonite ends, or if metal ends are used, see that the insulating bushes are *large*.

The detector itself merits consideration. Assuming that galena is to be used, the important thing (granted that the insulating parts of the detector are of ebonite and not erinoid or such material) is a stable and fine adjustment. There are many detectors available now in which the contact point has a screw adjustment, which is the first step. But this is not enough. Few detectors employing a ball joint can be called stable. A better type is that in which the crystal cup and the point holder have cross movements so that every point of the crystal can be reached without a ball joint. There are several such on the market.

A very important point in any crystal set is to have two entirely separate detectors with a switch. It is useless to try and adjust a detector with no standard of comparison: by using two and testing each against the other, one can find the really sensitive points. This tip alone may be worth 25 per cent. in signals. Fancy detectors with multiple cups, etc., miss the point; the two detectors must be entirely independent.

Also, there is the potentiometer question. The writer has tested, on the average, two or three crystals a week for the past year (most of them galena under various names), and there was not one, within his recollection, which would not have been improved by a small voltage—about ·1 to ·2 for most of the galenas.

A useful hint is to stretch a piece of fine chiffon or silk net over the crystal, so that the point works through the mesh and is thus held in position. For those who can use it properly, Woods' metal is undoubtedly superior to springs, etc. for holding the crystal owing to the excellent contact made by it.

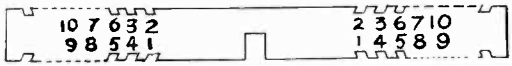


Fig. 7.

Lastly, do not omit a condenser across the phones. If this is not used, one depends on the capacity of the phones and cords to by-pass the high-frequency currents. This sometimes causes quite heavy loss. Another disadvantage is that it increases the tendency for the tuning to be affected by the nearness of the hand to the condenser, owing to leakage through the body from the hand to the phones. If the phones are shunted by a condenser of ·002 or so, both sides of them will be practically at earth potential, and if care is taken to make the moving plates of the condenser also on the earth side, this effect will not be noticeable.

The time has now come when we can begin to lay out the actual detail design of a good crystal receiver, and this is where we stop. It is not our purpose to give detail designs, for we hold that this is the branch where personal taste should hold sway. Any set built on the principles we have outlined will do well, if the common precautions of wireless construction are taken. In our opinion there is too much written about detailed construction these days, and not enough about principles; and we have endeavoured to fill in some of the gaps in the latter division.

High-frequency Resistance. [R240

By J. H. Reyner, A.C.G.I., B.Sc., D.I.C.

A FACTOR which exercises considerable effect on the working of a wireless circuit is the high-frequency resistance of the component parts. There are two classes of high-frequency resistance—one due to the ordinary physical effects at higher frequencies, and the second class which is due to defective construction, such as partial short circuits between turns of a coil, poor insulation in condensers, etc.

The increase of circuit resistance as the frequency is increased is to a large extent unavoidable. There are several ways of regarding the phenomenon, but, without going into considerable detail, it may be mentioned that, as the frequency increases, there is the well-known skin effect, and also eddy current losses in the material of the coil or condenser itself absorb an appreciable amount of energy. The result of this is to increase the effective resistance of the circuit, and the high-frequency resistance may be many times as great as the direct current resistance.

The increased resistance effect is chiefly noticeable in coils, and various methods are adopted to combat it, the trouble taken depending on the seriousness of the ultimate effect on the circuit. For example, in receiving units employing reaction the effect is of little consequence since the increased resistance can be compensated for by an increased reaction; in transmitting circuits on the other hand, every effort is made to keep the H.F. resistance down.

The second case, however, where the high-frequency resistance is not accounted for by the physical laws just referred to, is a more serious matter, and the author has found H.F. resistance due to defective construction responsible for many snags in the operation of receivers. In one case the circuit refused to function properly right from the start, the tuning being blunt and the results bad. It was found that the wire used in winding the coils had poor insulation, which was accentuated by bad wax. In another case the coils gradually developed a high-frequency short after some months of use. As a result methods were devised for checking the H.F. resistance, and the test proved very valuable.

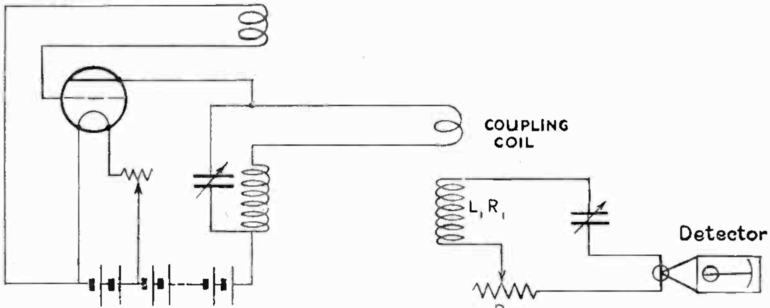


Fig. 1.

Methods of Measuring H.F. Resistance.

There are two methods in common use for this class of measurement, but unfortunately both of them necessitate the use of apparatus not usually in the possession of amateurs.

It has been pointed out, however, that in receiving circuits, it is only the "unauthorised" H.F. effects which cause serious trouble, and fortunately there is a simple method of detecting such faults.

Simple Routine Test.

Consider a simple circuit, as in Fig. 1. When the test circuit is tuned to the oscillator, maximum current flows on the circuit. If a brass or copper disc is placed near the coil, the current immediately drops to a very small value, due to eddy current losses in the disc.

If a suspected coil is brought near the main coil, a similar effect will happen if the coil is faulty, while no diminution will result if the coil is "O.K." This applies in all cases unless the natural frequency of the suspected coil is the same as or near to the frequency in the test circuit, in which case the latter may be altered to some totally different value.

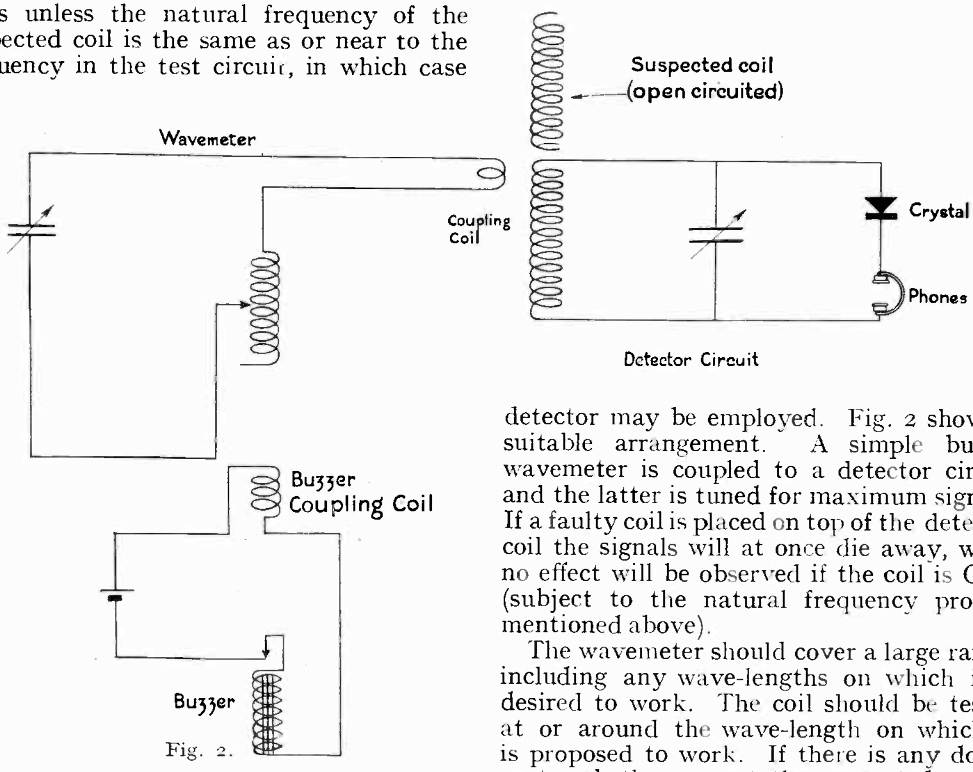


Fig. 2.

Suitable Amateur Circuit.

For amateur purposes it is not necessary to use a valve oscillator, and a crystal detector may be employed. Fig. 2 shows a suitable arrangement. A simple buzzer wavemeter is coupled to a detector circuit and the latter is tuned for maximum signals. If a faulty coil is placed on top of the detector coil the signals will at once die away, while no effect will be observed if the coil is O.K. (subject to the natural frequency proviso mentioned above).

The wavemeter should cover a large range, including any wave-lengths on which it is desired to work. The coil should be tested at or around the wave-length on which it is proposed to work. If there is any doubt as to whether or not the suspected coil is resonating with the test circuit, readings should be taken at two widely differing wave lengths.

This method has the merit of simplicity, and, even if infrequently used, will effect a large saving of time and worry.

Valves, French and English. [R330·09

IT is interesting to compare typical modern French valves, as exemplified by the two tests which follow, with the result of similar tests on British 60mA types. It will be noted that there are distinct differences in the general performance.

Métal.

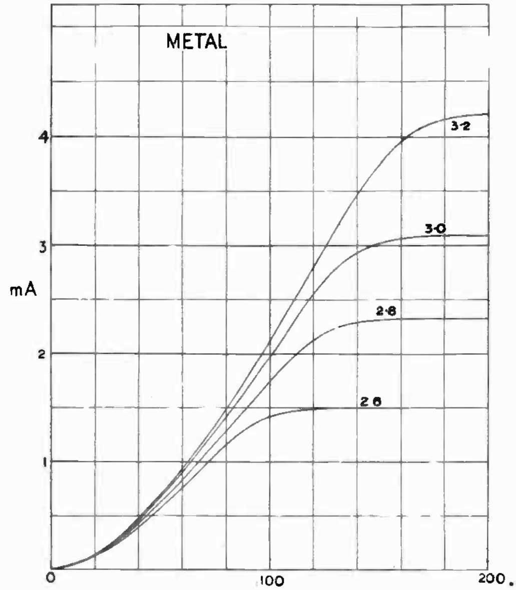
This sample was handed to us for test by the Gerrard Radio Stores, 15, Little Newport Street, W.C.2, who are handling it in this country. In outside appearance it is in no way out of the ordinary; but the electrodes are arranged horizontally, as in the "R" valve, instead of vertically as in the case of most British ·06 valves.

There was no definite information as to rating, so the valve was tested at 2·6, 2·8, 3·0 and 3·2V on the filament. As will be seen from the table below, the filament took rather less than its rated current.

MÉTAL.

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 $\left(=\frac{I_s}{\text{Watts.}}\right)$
V.	mA.	mA.	Ω.			
2·6	48	1·5	50 000	12·8	3·2	12
2·8	52	2·3	48 000	12·8	3·4	16
3·0	54	3·1	46 000	12·8	3·6	19
3·2	56	4·2	44 000	12·8	3·8	23

We note also that the "filament efficiency" (mA of saturation current per watt input) was low, 23 being not a high figure for a filament of this type.



The saturation current itself, 4·2mA at 3·2 volts, fits in with these other figures, and leads us to believe that the filament is of a higher resistance than in similar British valves, so that more than 3V is really advisable. Under such conditions better figures would be obtained for output and efficiency.

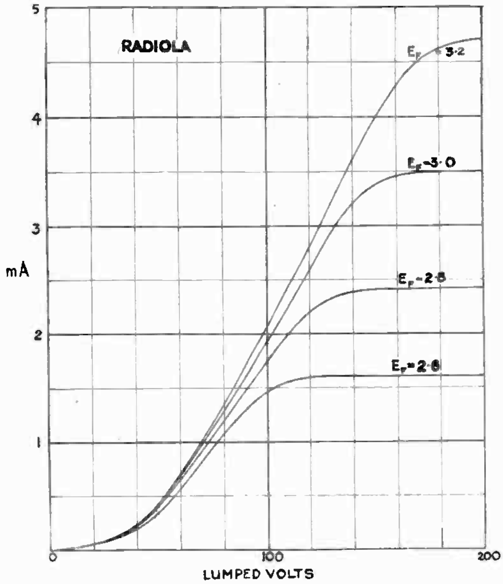
As regards amplification, the valve is very good. It has a high μ (12·8) and although the anode impedance is naturally high compared with British valves of lower μ, the power amplification factor $\frac{(1\,000\mu^2)}{R_a}$ is quite high, even at this low filament heat.

The valve is not particularly microphonic, as compared with other ·06-amp valves. Eccles lumped characteristics are shown in the accompanying curves.

Radio-Micro.

This, another French ·06 valve, is handled in this country by H. Lloyd Marshall & Co., 43, Blackfriars Road, London, S.E.1. It is arranged on very similar lines to the Métal valve noted above, with horizontal electrodes. It is easily recognisable, however, by its dumpy bulb.

Its behaviour is, generally, similar to the other



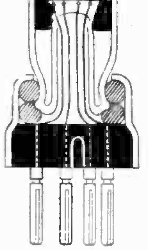
French valve tested. It would probably give its best output at more than 3V on the filament. As will be seen from the table, it has a rather lower μ and R_a, but a slightly higher output. Characteristic curves, as can be seen from the figure, show a quite exceptionally long "straight" part to the curves, so that the valve should be particularly good for the early and intermediate stages in an L.F. amplifier.

RADIOLA.

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 $\left(=\frac{I_s}{\text{Watts.}}\right)$
V.	mA.	mA.	Ω.			
2·6	52	1·6	40 000	10·0	2·5	12
2·8	54	2·4	39 000	10·5	2·8	16
3·0	57	3·5	37 000	10·5	2·9	21
3·2	60	4·7	35 000	10·5	3·0	25

G.W.I. Plateless.

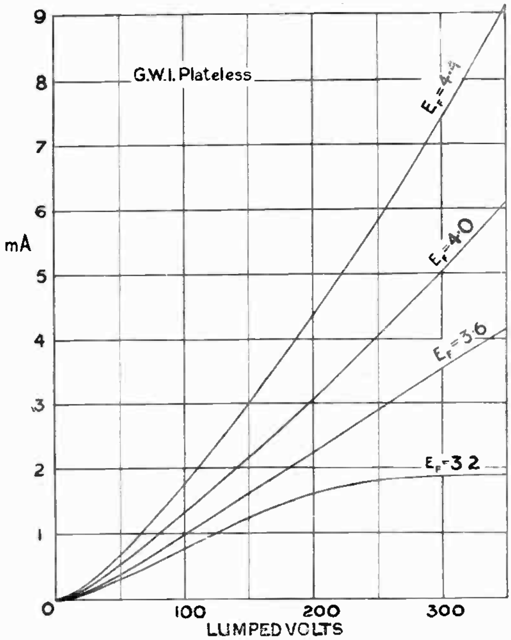
This is in many ways a most interesting valve. It is made by G.W.I., Ltd., Imperial House, 43, Grafton Street, Tottenham Court Road, W.1. The word "plateless" is, of course, a misnomer, though the valve has no anode of the usual construction. Instead, the inner surface of the glass itself is silvered, and acts as anode. The grid construction (a French patent) is also unusual: it is shown in a sketch reproduced from the maker's illustration.



The valve is a bright one, the maker's rating being 3½—6V, ·3 to ·5A. On actual test, it was found that this rating was wide of the mark, the filament current being ·74A at 3·2V and .89A at 4·4V.

Although the bulb is of a long and narrow shape, the effect of using its interior surface as anode is naturally to produce a valve with electrodes spaced rather far apart, this giving a high impedance. The magnification is also high, resulting in a power amplification factor of normal value.

It will be seen from the table that the saturation current is also exceptionally high, and it is a



consequence of the high μ and R_a that a very large anode voltage is necessary to get saturation. The characteristics are, in fact, very curious, as will be seen from our drawing; it will be seen that at 300 volts there is no sign of saturation except at 3·2 filament volts; that there is a most exceptional change of slope with increased filament heat, and that the "lower bend" of the curves is unusually sharp.

G.W.I.

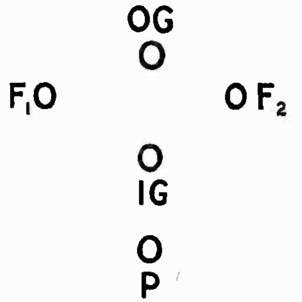
Fil. Volts. E_f	Fil. Cur. I_f	Sat. Plate Cur. I_s	Anode Impedance. R_a	Voltage Ampli. μ	Power Ampli. P $\left(=\frac{1\,000\mu^2}{R_a}\right)$	Filament Efficiency. F $\left(=\frac{I_s}{\text{Watts.}}\right)$
V.	A.	mA.	Ω.			
3·2	·74	1·9	150 000	18·5	2·2	·8
3·6	·80	6·0	80 000	14·0	2·5	2·1
4·0	·84	18	50 000	12·3	2·8	5·5
4·4	·89	25	43 000	10·5	2·8	6·2

A curious point is that if any current over 1mA or thereabouts is being passed, the bulb soon gets very hot from bombardment: quite hot enough to give a most unpleasant burn.

As will be seen from our illustration, a special method is employed to hold the valve in the cap, a ridge on the foot being gripped between two rubber rings.

A Four-Electrode Valve.

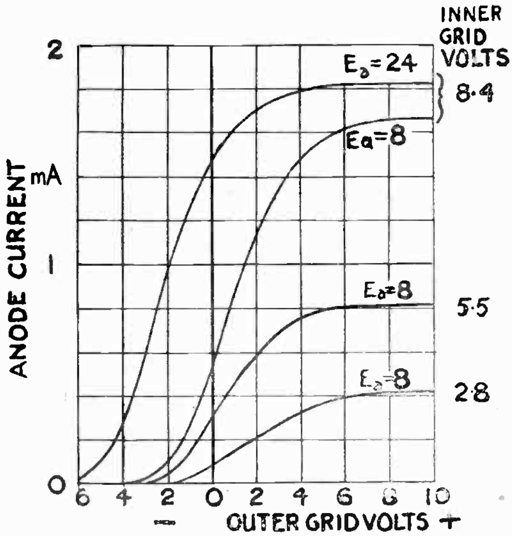
This is a French valve, supplied by the Gerrard Radio Stores, mentioned above. Our photograph shows the general arrangement, and in a separate sketch we give the type of holder required.



Sketch, not to scale, of the type of holder required for the four-electrode valve.

In testing out a four-electrode valve, it is hardly useful to apply our usual routine trials, while to provide curves for each change of variable—filament heat, inner grid volts, outer grid volts, plate volts, with the appropriate currents in each case—would take something like a complete issue of E.W. & W.E. So we have compromised by investigating the suitability of the valve for two well-known circuits of the present day: (1) its performance with low anode volts assisted by a steady positive voltage on the inner grid, with input on the outer grid; (2) its performance in the Marconi ship reflex circuit, with input to inner grid, output from outer grid, and rectification by the plate.

From the first point of view, the anode was held at +8V (4V above filament positive). Curves were then taken by varying the outer grid volts, while the inner grid was given a fixed positive voltage, different for each curve. The results are shown in Fig. 1, and show the usual type of result, the inner grid voltage having an effect like that of changing filament heat in a three-electrode valve. A fourth curve shows the effect of increased anode voltage. Working from the two curves for $E_{og}=8$V, we find $\mu=14$, $R_a=24{,}000$. The valve does not, however, give of its best in this



circuit, as better results are obtained with a pattern of lower μ and R_a.

For use in the Marconi circuit, however, the valve is much more promising. Two tests were made, corresponding to the amplification and rectification required. The first was to maintain the plate at oV, and take curves of outer grid current against inner grid voltage for various values of outer grid volts, the outer grid acting like the plate of a three-electrode valve. Results are shown in Fig. 2, and on analysis give $\mu = 18$, $R_a = 30\,000$, $P\left(= \frac{1\,000\mu^2}{R_a}\right) = 10{\cdot}8$—the latter being an exceptionally good value.

Lastly, as in this circuit the plate circuit is used as a rectifier, the current in it was tested against plate volts, each curve for different voltage on outer grid. The results in Fig. 3 show that the rectification is quite good, so that the valve should function very well in such a circuit.

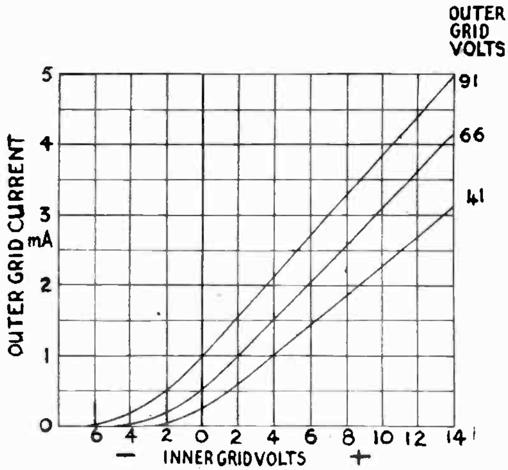


Fig. 2.

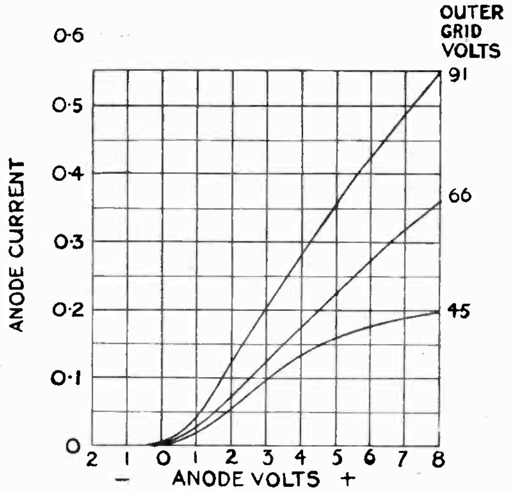


Fig. 3.

ESPERANTO FOR WIRELESS.

The necessity for the international adoption of an artificial language was particularly apparent during the past year, when amateur experimenters in one country succeeded in getting into communication with amateurs of another but found themselves debarred from intelligent conversation by linguistic difficulties. It is believed also that international communication by amateurs will become even more popular during the coming year, making the adoption of an international language imperative.

This point was long ago recognised by the American Radio Relay League, and after a thorough survey of the situation they have, with certain qualifications, decided in favour of Esperanto as its official international auxiliary language. This decision was reached on the ground that Esparanto is easily the chief of the artificial languages, having by far the greatest number of followers.

In order not to come to too hasty a decision, the League first communicated with all the national amateur radio societies of the world, and all of these that expressed an opinion in favour of an artificial language strongly recommended Esperanto.

In making public its decision, the League states that it does not regard Esperanto in its present form as necessarily a language that should come into world-wide recognition unchanged, and that it is prepared to adopt such modification of Esperanto or whatever other language may be agreed upon by an authorised international agency. The League believes it essential to the eventual success of an international language that some language of this kind becomes a world-wide working vehicle of expression, after which authorised agencies can make such rectifications as may then seem desirable.

INDUCED CURRENTS CAUSE EXPLOSION.

That wireless waves can and do produce charges of electricity in certain pieces of iron which discharge as small sparks, is the reason advanced by General Negrei, Director of the Technical Department of the Roumanian Army and Professor of Bollastics of the Bucharest Military School, for many of the hitherto unexplained disastrous explosions.

The theory is that wireless waves produce slight electric charges in such objects as iron rings broken by a small cut and not attached to or in connection with the earth. Stated plainly, these iron rings act as "condensers" to store the small amount of energy radiated by various wireless stations—actually the reception of energy by induction. The action of such wireless waves in producing induced current in iron rings is probably greatest at the meeting point of two series of wireless radiations. Under ordinary circumstances this energy would be of no serious consequence, but after a long period of charging, if a sufficiently small distance between the condenser and the ground was found, the ring would discharge its load across the intervening space by means of a tiny spark. The potential destructiveness of this spark in the event of explosive material being in the vicinity is obvious.

G.2KW. An Amateur Station.

AMATEUR radio is making such rapid progress day by day that one feels somewhat chary of discoursing at any length on apparatus made or experiments performed; yet in order that real progress shall be made it is necessary for one to become acquainted with the groundwork done by others. It is, therefore, my intention to make a few remarks on the apparatus that was used at 2 KW last winter for long-distance working.

When first acquainted with the possibilities of short wave amateur communication over great distances, it seemed as though the inclusion of several stages of radio frequency amplification was a necessity. Last winter two or three radio frequency valves were almost continuously used. Now and then signals from U2ZL and from U2CPD and the louder Atlantic coast stations were received on one and two valves, but no great effort was made to attempt regular reception with such a set. From September 5th, 1923, no radio frequency valves have been used. The set is a two-valve combination, consisting of rectifier and one stage of low frequency magnification. Whilst the addition of high frequency valves might be highly desirable, a tuned amplifier is hopeless for quick searching. We await the indication of a method of direct radio frequency amplification on low wave-lengths which will be flexible.

I am frequently asked to pass an opinion on a particular set which does not seem to be giving the results that might be expected of it. The workmanship may be beyond reproach, the materials used most expensive, yet the results are poor. The main reason for this seems to be that there is far too much material in the set. Some, though by no means all, of the super and reflex circuits form very good examples of this type of set. With shoals of switches and all the necessary wiring one would hardly imagine that the affair would be either startlingly stable or extremely efficient.

Coils preferably wound on air with single wire—not stranded—would be approaching the ideal. This would apply to transmitting coils as well as to receiving inductances. If a former is used, give ebonite and all other fancy preparations the go-by, for the loss is greater with a coil wound on ebonite than it is with a coil wound, say, on the much despised and common cardboard.* Coil holders are regular beehives of dielectric loss. Choose one with as little material in it as possible and try to think of it as an instrument rather than as a piece of furniture. It is as well to keep this fact solidly fixed in your mind: that in all our tuning circuits we are dealing with high frequencies. It is, therefore, absurd to consider only the D.C. insulation, for in so doing we are apt to forget altogether about the very much more important radio frequency component which we must cherish as carefully as we can.

Variable condensers should be designed to have as low a minimum capacity as possible. There should be no switches in high frequency circuits. All leads should be as short as possible, round wire or thin varnished copper tubing being used for wiring-up. Solder all connections carefully, removing any surplus "flux"; it is best to use resin. When choosing a low frequency transformer it is as well to remember that infinite insulation between the winding is not required. Instead, the windings should be designed to stand up reasonably

* It will be understood that these are our contributor's personal opinions. (Ed. E.W. & W.E.)

on ordinary voltages. I have found that transformers tested to 2 000 volts between the windings have burnt out when the anode voltage in use was only 50. This state of things is ridiculous. Many experimenters continue to use high resistance phones. I cannot understand why, for

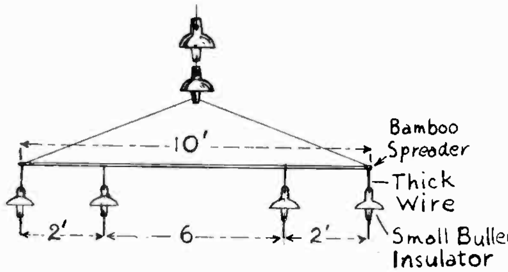


Fig. 1.

signal strength with 120 ohms Brown's A type phones with a good telephone transformer is all that can be desired.

We are now exploring the band of wavelengths from 90—150 metres, and it has been noticed that fading is practically non-existent. Signals on 100 metres are heard when signals on 200 are either absent or very weak indeed. On many occasions G.5KO has been QRZ at 2KW on 200 metres, but on 150 metres the strength increased enormously and remained practically constant. I do not think that it is merely because the radiation of the transmitting station increased, but rather that for some obscure reason there is a sort of "barrier" between the two stations. G.6RY behaves similarly, whilst difficulty is experienced in this district with the reception of Cardiff.

Though many experimenters have an idea that a low aerial is better for reception than a high one, my experience points to the contrary. The aerial at 2KW is 70 feet high at both ends. The masts are 90 feet apart, the actual aerial being 50 feet long with a 35 feet downlead. At present, of the four-wire type, the aerial wires are spaced on 10 feet bamboo spreaders, the distance between the two inside wires being 6 feet. As the current in the aerial tends to flow on the outside, this arrangement was thought best.

Very careful attention has been paid to insulation. Low capacity insulators made by Messrs. Buller's, Ltd., 7, Laurence Pountney Hill, London, are used. These are real insulators for the transmitting amateur, and the old bits of pot generally used should give place to something of the kind. Fig. 1 shows a suggested method for the spreader. The question as to whether stranded wire is better than a single wire is, I know, a vexed one. On the whole it would seem advisable to leave stranded wire out of one's calculations, because the doubtful advantage to be gained is negatived if one wire is left disconnected. The lead-in is a four-wire fan and will be taken through a special porcelain insulator mounted in a plate-glass window in the wall. Arrangements are being made for this very necessary alteration.

The counterpoise or earth-screen, at present in the form of a fan, consists of eight wires 60 feet long. The lead-in is an eight-wire cage, the wires being spaced with aluminium hoops 1 foot in diameter. The wires are supported at the further

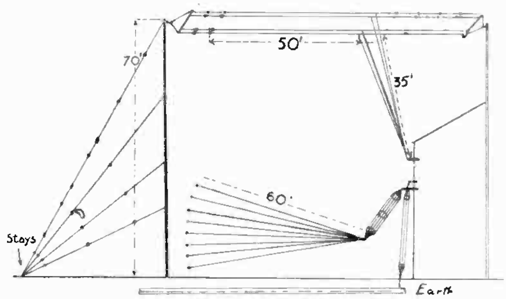


Fig. 2.

end by means of two clothes-props, accidentally acquired in the cause of science! The area at present covered by the counterpoise is approximately 500 square feet, about 700 feet of No. 18 S.W.G. hard drawn copper wire being utilised. A six-wire cage serves to connect the wires buried underneath the aerial with the set. Bunching of wires should always be avoided where radio frequency currents are being dealt with. After the many weeks spent last summer in laying wires three feet in the earth I have found that the results as far as transmission is concerned are very poor. Reception on counterpoise is also quite as good as with the earth and results are constant. The earth is used for transmissions on rare occasions and even though the counterpoise is used as an "earth-screen" very poor efficiency is obtained. Fig. 2 shows a sketch of the radiating system.

The change over switch is mounted on two ebonite rods, thus reducing its capacity to earth. The transmitter is connected up as indicated by Hartley, inductive coupling of the primary and secondary circuits being used.

Whilst being an excellent circuit for low impedance valves and an aerial circuit of low resistance, the circuit is not nearly so popular here as in America. I have found that with proper adjustment one could wish for nothing better. Two Mullard type o/150 valves are used normally, though they are temporarily out of commission. The writer has obtained excellent results with them as well as with the Mullard type o/20 valve, for lower power work.

The present circuit diagram is given in Fig. 3 together with values of condensers, etc. It is quite possible to use an Auto-coupled Hartley circuit, though considerable difficulty has been met with at 2KW when testing with this arrangement. Interference was caused by harmonics, key-clicks and other forms of frightfulness calculated to strike terror into the heart of a B.C.L. The lower diagram on Fig. 3 shows the method of keying.

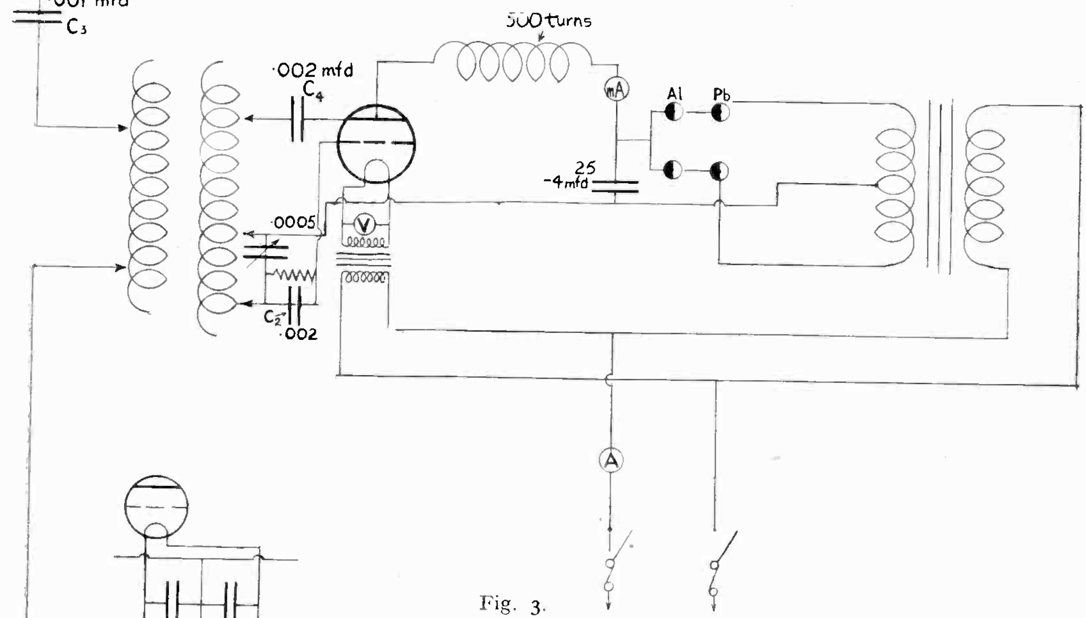


Fig. 3.

A Sullivan hot-wire meter reading 0—10 amps is used for observing changes in aerial current. I will put it that way because a hot-wire instrument can very rarely give an accurate reading at the high frequencies used by the amateur.* The goal of most of us seems to be to wreck the instrument by sending the needle off the scale. The fact that one is obtaining an aerial current of 10A does not of necessity prove that the aerial amps are being used to the best advantage. It may happen that there is an iron roof or some other metallic body in the vicinity tuned to the transmitting wave-length. It is not even sound practice to ask for reports, because they are always so conflicting. The only sure remedy is to find out something of your aerial characteristics before you camp on any definite wave-length.

The two inductance coils are wound in the form of a spiral on ebonite arms. The aerial coil consists of 17 turns, there being 27 turns on the closed circuit coil. Copper strip ½ inch wide is used instead of wire, the spacing being $\frac{7}{16}$ inch between the turns. Contact to these inductances is made by means of special clips. All such contacts are at present variable. The condenser C_1 is of the order of ·000 5μF.

* Unless carefully placed at a voltage node in the aerial. (Ed. E. W. & W. E.)

C_2 is a Dubilier, type C.D. 158, tested to 5 000V. C_3 consists of two type 577 Dubilier condensers of ·000 5 μF. each, connected in parallel and placed in series with the aerial for 100 metre work. C_4 is home made. An ex-army 1μF. condenser was taken to pieces and the mica (·002 inch thick) carefully examined. Seven sheets were fastened together to form one sheet of dielectric for C_4. Trouble was experienced with other condensers, as they had a nasty habit of breaking down. This condenser should be tested to a voltage of five to ten times the applied D.C. voltage, so that it may stand the radio frequency potentials across it. The actual voltage to which this condenser will have to be tested to fit a certain set of conditions may be easily calculated. The grid-leak, of Zenith manufacture and tapped in values of resistance from 1 000 to 20 000 ohms, is of the vitreous type. The higher the grid-leak value within limits, the greater is the efficiency of the set, because the input current is reduced. When a filter is used the A.C. component is much weaker with a grid-leak of high resistance.

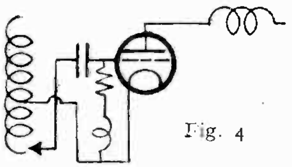


Fig. 4

Sometimes it is found advisable to connect the grid-leak as shown in Fig. 4. Though not practicable in the Colpitts circuit, both the Hartley and the 1DH circuit may be altered in this way. It is claimed that the current in the anode circuit is reduced and the aerial current increased. Assuming that the grid-coil in the 1DH circuit is tuned and the grid-leak connected across the grid-condenser in the ordinary way, we find that the grid-coil is acting as the tuned choke at the same time as it is functioning as the tickler coil. It is therefore difficult to see how any definite advantage may be gained by making the alteration with the 1DH circuit.

Now, in the Hartley arrangement, things are slightly different, for if the grid-leak is placed directly across the grid-condenser then the portion of the coil between the grid tap and the filament tap certainly is not tuned to the working wave-length. Thus it would seem that the use of a separate choke and condenser with the Hartley circuit would be an advantage, but with the 1DH circuit no definite advantage would be gained. We might still prefer to tune the grid portion of the coil in Fig. 4 with a variable condenser and so again present a similar state of affairs as in the 1DH circuit (Fig. 5).

The anode choke coil is a lattice wound affair of 500 turns of 26 S.W.G., D.C.C. wire. After winding, the coil was placed in a warm oven for some time to dry thoroughly. Upon being taken from the oven it was immersed in liquid paraffin wax and allowed to cool and set hard. Next the coil was cut out of the wax, and after being bound up with empire tape it was mounted in position.

The filament rheostats are wound with No. 16 S.W.G. bare resistance wire and the springs mounted on special fibre formers. It would be better to regulate the brilliancy of the filaments by means of either a choke or resistance in the primary circuit of the transformer.

Besides the aerial ammeter, which is by no means the most essential instrument, voltmeters reading 0—15 volts are provided for observing the exact potential across the filaments (V). An ammeter reading 0—10 amps is placed in the main supply so that the exact current may be known. This was found of high importance when using the chemical rectifier. A G.E.C. 0—250 milliammeter indicates the current in the anode circuit. This meter is most essential, for by it the efficiency of the set may be determined. A meter reading 0—50mA. is provided as a means of indicating the grid current.

It will be noticed that power from the transformer is conveyed to the anodes of the valves by the parallel method of feeding. The circuit is so arranged that the risk of burning out the filament transformer is minimised. By using the series method of feed, great R.F. strains are put on the windings of the filament transformer with the result that blue smoke issues from the transformer and bad language from the mouth of the irate experimenter.

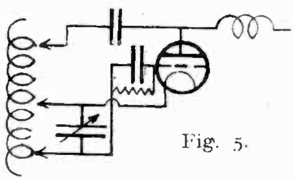


Fig. 5.

The power transformer is of home construction. The iron laminations are in the form of L pieces. The formers for the wire are made with thin leatheroid or presspahn, ebonite flanges being glued to one end; the other end piece is fitted, but left unglued so that the sections may be slipped on. The best way is to make a wood former the size that the core is to be when built up. When all is set, the former with one bobbin on it is mounted in the lathe. Half the primary turns, 600 in all, are wound on, each layer being insulated with varnished silk. Adhesive tape is next bound round the coil and then mica sheets are fastened down all over the surface of the tape. A little cotton will hold the mica in place and sheet after sheet may be put on while the cotton is wound round to hold them in position. I have nearly $\frac{1}{8}$ inch mica between the primary and secondary windings. These operations are repeated with the other bobbin. The secondary of the transformer is wound with 4 000 turns of No. 26 S.W.G., D.C.C. wire, as this gauge will allow of overloading the transformer to a certain extent. Instead of winding the 4 000 turns on in one piece, ten sections are wound consisting of 400 turns each. They are $\frac{5}{16}$ inch wide. A former was made with a perimeter equal to that of the primary bobbin. After rigging up a bath of paraffin wax with a Bunsen underneath it, the wire is passed under a brass rod fixed beneath the surface of the melted wax. The level of the wax is kept just high enough

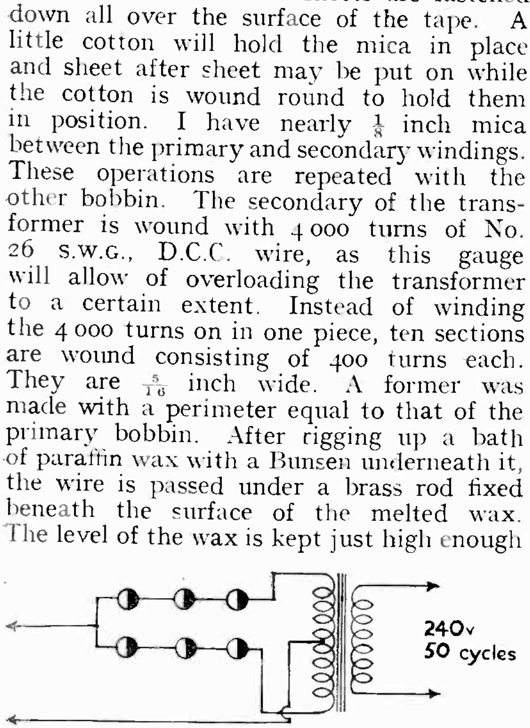


Fig. 6.

to allow the wire to run through it. After numerous unsuccessful attempts the operation was a complete success.

When sufficient sections have been wound they may be built up, care being taken to connect the windings in the same sense as the primary. In connecting up the sections it is advisable to place between each a piece of varnished silk or some other insulating material, such as micanite. When both coils have been built up in this way, the flanges are glued on and, when set, the iron laminations may be put into place. The transformer in question has, at present, enough secondary turns to give only 1 300V, after allowing for the potential drop in the rectifier.

One bobbin has also itself a centre tap so that either half or full voltage may be obtained. This is a great advantage as the same transformer may be used for low power work. Whilst not ideal in many respects this method of construction seemed the simplest at the time.

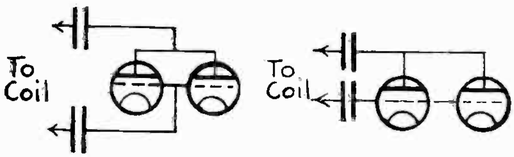


Fig. 7A. Fig. 7B.

The filament transformer is built up in the same way, it being capable of giving a current of 10A at about 12V. There are 3 000 turns of 26 S.W.G. D.C.C. wire on the primary and 150 turns of No. 12 D.C.C. wire on the secondary. Had the supply of iron been unlimited at the time much more would have been used, with the consequent reduction of primary turns. A centre tap is provided both on primary and secondary so that condensers of ·02μF. (which are two (·01 mfd.) type 577 Dubilier condensers connected in parallel) may be connected across the two halves as a protection device. Keying is accomplished as shown. It is always as well to see that the portion of the key nearest the operator's hand is at earth potential. I am not in favour of keying in the primary lead of the power transformer, for sudden surges are liable to be set up by this means. It may happen that "key thumps" are inflicted on your neighbours. Assuming that some effort has been made to render the note of the C.W. variety, these are most annoying. Not only on the proper wavelength, but over a range of hundreds of metres do they bang into one's ears. This is at present one vital reason why transmission on the low waves is impossible during broadcast hours.

With both valves in use, taking an anode current of a 120 to 150mA, the aerial current on 170 metres is 4 to 5A. When on 115 metres the aerial is around 2·5A, but on occasions it has reached 4A. At present with one 100W valve the aerial current on 120 metres is 1·5 to 2A, and on 170 to 190 metres 3 to 3·5A. Consequently, considerable increase is expected when the two valves are again put into use on full voltage. With one 0/30 the aerial current is 0·4A on 120 metres and nearly an ampère on 170 metres, this on an input of 10 to 15W.

The rectifier for converting the 50 cycle supply to D.C. is of the orthodox electrolytic type. Built on the lines of Mr. E. H. Robinson's collection of cells, but designed to pass a heavier current, the thing has up to now given very good service. Mounted on an insulated floor with a low capacity to earth are forty cells, twenty in each leg, of the high tension leads. The aluminium has a submerged area of 40 sq. cm., as also has the lead. Pickle and jelly jars are used to hold the electrolyte, which is a half saturated solution of pure ammonium phosphate. About 4 lb. of the salt were used for 50 cells. Distilled water was not used, as the town water is fairly pure

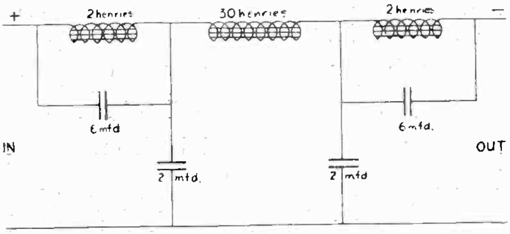


Fig. 8.

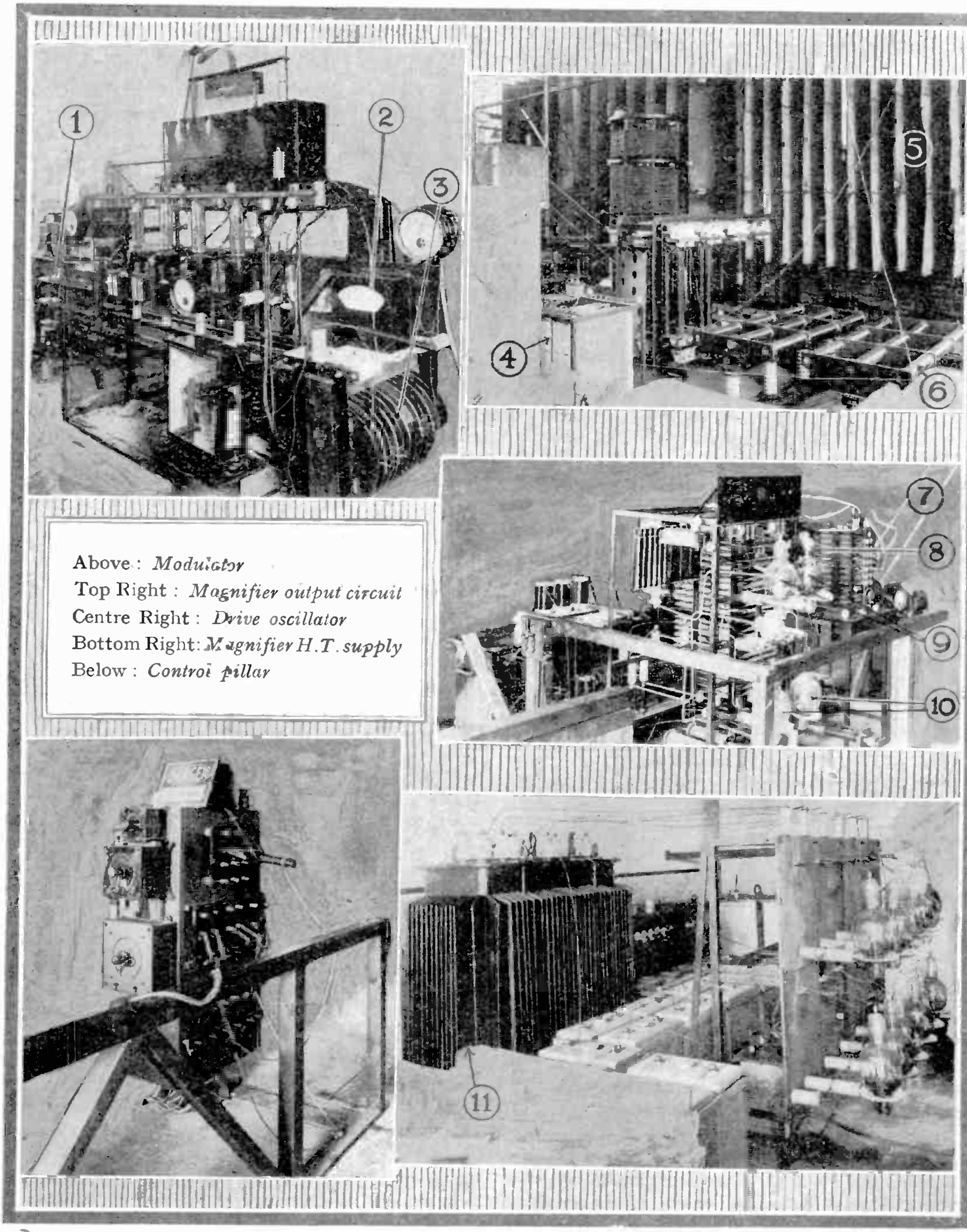
Great care was taken in the cleansing of the electrodes.

I do not think that sufficient attention was paid to the nitric acid bath. With some aluminium strips this bath was omitted, with the result that they had to be recleaned. Upon putting a few hundred volts across the rectifier the needle of the ammeter in the primary circuit did a war dance. By using the switch as a kind of tapping key for a few moments the current was reduced to two ampères. Left running for a few minutes it dropped to ·5 ampères. After two days it was noticed that some cells refused to rectify, but there are no refractory cells. It should be pointed out that when a centre-tapped transformer is used the connections for the rectifier are as in Fig. 6. In Mr. Robinson's article we see that the positive lead is taken from the centre tap. This is obviously the negative lead. Each night before actual transmission is commenced it is advisable to cut down the voltage across the transformer and turn on the current for a moment or two. The rectifier passes a good many ampères for a few seconds, but the current quickly drops. The set may now be put into operation. For this reason I fail to see the point in carefully "forming" the rectifier when first put together because it seems to require "forming" every night.

When preparing to transmit, turn on the filaments, next the high tension. When preparing to listen the H.T. should be switched off first, then the filaments—gradually. The rheostats shown in the diagram are for final adjustments only. All connections should be soldered and made as short as possible, the high frequency circuits being wired with copper tubing. Make the filament leads of very thick wire, placing the condensers as near the valve terminals as possible. If two valves are to be used in parallel it has been found that on occasion no addition is made to the original aerial current obtained with one valve. The chief cause for this is probably that the grid leads are of different lengths and so the valves are not pulling together. Fig. 7A shows the proper way of connecting the grids together, while Fig. 7B shows the wrong method. Upon adding an extra valve to a single valve transmitter the aerial current should be increased by 50 per cent.—and the power in the aerial doubled. By the way one does not radiate amps!

The filter, or smoothing unit, has not yet been constructed, but will take the form shown in Fig. 8. It is a combination of the "Brute Force" type and the more scientifically designed one. The 2μF. condensers are tested to 5 000V D.C. and the 6μF. condensers may be tested to a lower potential. At present 1 of 4μF. has been used across the line with pretty fair results. When operating on 100 metres I have noticed that the smoothing effect is very greatly reduced.

G.2KW has been heard on three continents; Europe, Africa and America, reported with code verified in the recent tests; signals were logged by WNP, 1BCF, 1ANA (one valve), 1BDT and since by a number of stations, including some in the fourth, fifth and ninth districts. Two-way working has been effected with 1KC and 1CMP, 1AJA and 1XAH. Through circumstances over which I have had no control, the operating hours of 2KW have been somewhat limited, and that is why more stations have not been worked.



Above : *Modulator*
Top Right : *Magnifier output circuit*
Centre Right : *Drive oscillator*
Bottom Right: *Magnifier H.T. supply*
Below : *Control pillar*

CHELMSFORD IN SECTIONS.

The following is a key to the reference number :—

1 *Modulator grid battery*
2 *Modulation meter*
3 *Speech choke*
4 *Magnifier grid-leak*
5 *Main output condenser*
6 *Magnifier H.F. choke*
7 *Drive output leads*
8 *Drive coupling coil*
9 *Drive oscillator valves*
10 *Drive rectifier valves*
11 *Magnifier H.T. supply Transformer*

Valve *v.* Crystal for Detection.

By P. K. Turner. **[R149**

IT is a curious example of lack of imagination that apparently 95 per cent. of the valve sets in use to-day for broadcast reception utilise a valve with grid-condenser and leak as detector, although this method of rectification is notorious as an almost certain cause of distortion.

It seems that this is an opportune time to try and show, in as simple a manner as possible, why it is that this method of detection is so prone to cause distortion.

For the sake of completeness we will begin by stating the action of a valve used for grid rectification, although our readers are, of course, familiar with it. The connections are as in Fig. 1, and the action is as follows: Before the arrival of signals the grid sets itself to a slightly positive potential, such that the grid current passing is exactly that which the difference between the voltages at the grid and the point A will push through the leak. Thus, if the valve gives 1 microamp grid current with the grid 1 volt positive, and a 3-megohm leak is connected to the + side of the 4-volt battery, the grid will set itself at + 1 volt, when we shall have 4—1=3 volts to push current through 3 megohms: obviously this is a stable condition. Now when the first positive half-cycle of H.F. is applied to the grid-condenser, the grid will be made more positive for a short time; there will be on increased grid current flow, and the grid and grid-condenser will be *negatively* charged. If the incoming wave is like Fig. 2a, the grid and condenser will get, *owing to the grid current*, negatively charged up according to Fig. 2b, so that its total voltage, from incoming signal and grid current, will be as Fig. 2c.

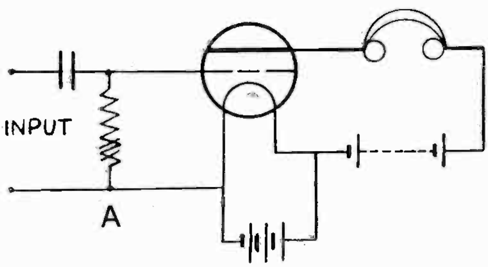


Fig. 1.

During the negative half-cycle there is no grid current, nor during the first part of the next positive cycle, so that the grid voltage will vary as shown in Fig. 3a, in which Fig. 2c is repeated. But directly the total volts reach the original free value, grid currents again flow faster than the leak can deal with them, and instead of the dotted curve at the end of Fig. 3, the grid gets more negative, as shown in the full line.

The net result is the well-known curve of Fig. 4, showing (*a*) grid voltage, (*b*) the low-frequency component of anode current.

These are for a steady carrier wave. If now the incoming signal stops, the extra charge leaks off the grid, and the plate current returns to normal.

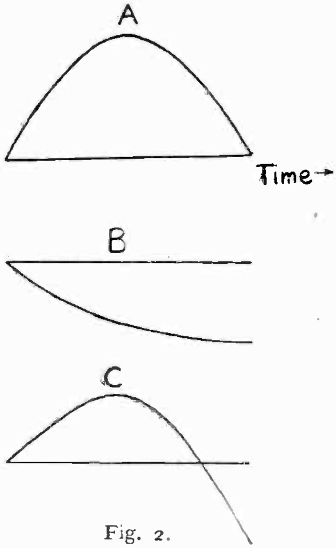


Fig. 2.

So far we have said nothing that is not absolutely familiar. Now note that although we have represented the signal as coming on suddenly, the change of plate current occurs gradually, as the grid gets charged up little by little. What controls the rate of charging up? Firstly, the amount of grid current the valve passes at any given grid voltage; secondly, the size of the grid-condenser. For, given a certain amount of grid current for a certain time, the voltage depression depends absolutely on the size of condenser: for example, if the average grid current for the half-cycle is 1 microamp, and the half-cycle lasts a half-millionth of a second, then

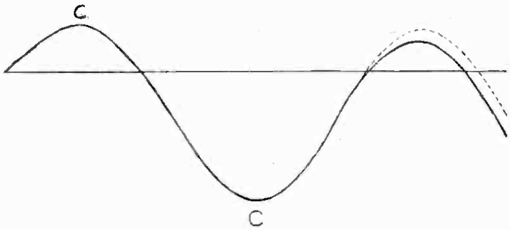


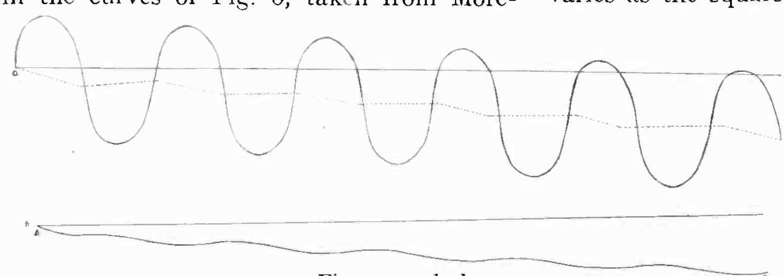
Fig. 3.

if the grid-condenser is of ·0002μF, the voltage will drop $\frac{1}{400}$ volt: if the condenser is ·0001μF, the drop will be $\frac{1}{200}$ volt.

This shows us that the shape of the first part of the plate current curve—its fall from normal—depends on the valve and grid-condenser. Similarly when the input is a modulated current, as in telephony, the shape of the plate current curve as regards its falling part (A B in Fig. 4b), does not depend only on the shape of the incoming wave, but also on the valve and the leak. If the wave is shaped as in Fig. 5a, the plate current should be of the shape of the full line in 5b; but according to the condenser and valve it might be shaped quite differently—like either of the dotted lines for example.

Secondly, as regards the remainder of the plate current curve, after B in Fig. 4a. This again depends, not on the shape of the signal current, but on the condenser and the leak. The larger the condenser and the leak, the longer it will take for the grid volts and plate current to return to zero.

An actual example of the effect is shown in the curves of Fig. 6, taken from Morecroft's *Principles of Radio Communication.* These are actual experimental curves, identical except that for curve 6 (c) the grid-leak was about three times that used for 6 (b). The actual incoming signal is shown at (a).



Figs. 4a and 4b.

Bearing in mind that any difference between the outline of the incoming signal and that of the plate current *is* distortion, we are forced to the conclusion that grid detection is a totally unsatisfactory method. Even if, by chance or skill, a variable grid-leak and condenser are adjusted to give the right shape for a note of (say) 1 000 audio frequency, they will be wrong for any other.

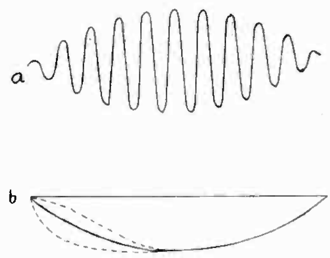


Fig. 5.

But before turning to other methods as superior we must examine them also. As it happens, the other two available methods —crystal detection and "plate rectification" by a valve—are essentially similar, and can be investigated together. It will hardly be necessary to recapitulate the action of the crystal detector: we will confine our attention to considering its response to signals of various strength, which is easily shown to be the criterion as to distortion. It is very commonly stated that the characteristic curve of the crystal is such that the output varies as the square of the signal strength; *i.e.*, a signal of half strength is reproduced as a note of quarter strength. This is approximately true for weak signals, but is not so for strong ones.

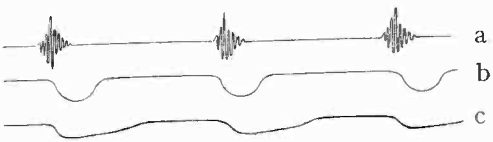


Fig. 6.

Take for example an imaginary crystal such as that whose curve is shown in Fig. 7: there is no reverse current and a constant resistance. It is easily seen by scale drawing that the output is proportional to input. But with a curve such as Fig. 8, the "square" law is true (with a good crystal the "reverse" current is negligible in either case). Now, the curve of an actual crystal is in the majority

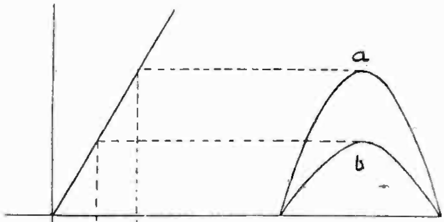
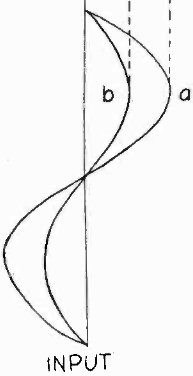
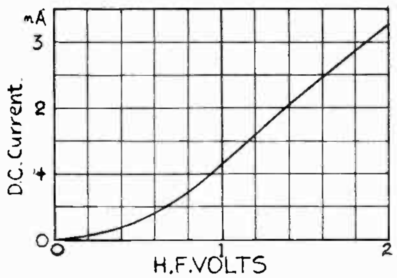


Fig. 7.



of cases more or less like that of Fig. 9. It begins with a curved portion, but this is soon followed by something approaching, quite closely, a straight line. It can be proved that, as a result of this shape, loud signals will result in an output proportional to their strength, though weak signals will not. But better, perhaps, than mathematical proofs are experimental results, and we have again drawn on the invaluable Morecroft for Fig. 10, which shows the telephone current produced by a given H.F. input. It will be seen that for all inputs greater than about ·5 volt the graph is practically a straight line, and there



will be no distortion due to the detector. This curve was for a Penikon detector of high resistance: we shall not be far wrong in assuming that for a galena we could depend on the absence of distortion for inputs greater than about ·2 or ·3 volt.

Lastly, what about using a valve with plate detection, *i.e.*, no grid-condenser? This is easily dealt with by remembering the general appearance of a valve characteristic. The bend at the foot of the curve is by no means sharp, and the minimum input to avoid distortion is

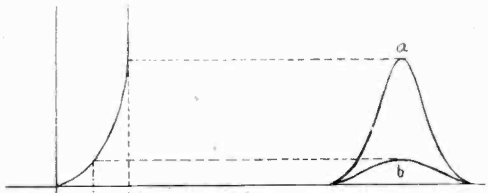
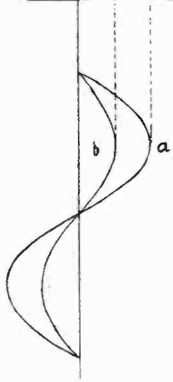


Fig. 8.



much larger. In point of actual fact, an ordinary valve used in this way is wasted: if one is determined on a valve detector, one such as a "Q," specially designed for the purpose, should be used.

Such a valve has one advantage over the crystal. Its input resistance is very high, and it damps the input much less. But, as has been pointed out several times during the last few months, much of the damping effect attributed to the crystal is simply due to using a low resistance crystal in a circuit designed for one of high resistance. The methods suggested by Colebrook and others (recapitulated in *The Perfect Set*, p. 22) avoid this trouble.

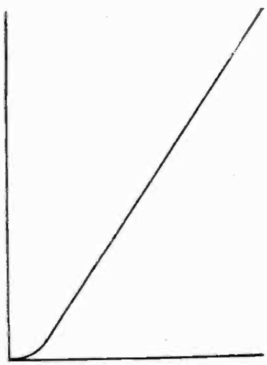


Fig. 9.

Summarising, these are the conclusions to which the writer is forced: perhaps some reader can refute them. They apply, of course, only to apparatus intended for the distortionless reception of music.

(1) The use of grid-condenser and leak is not permissible;

(2) A crystal is the best method;

(3) The input must be made at least ·3 volt (and preferably more) by H.F. amplification if necessary;

(4) Undue damping can be avoided by proper design.

On Some Properties of Low-Tension Discharge Tubes.

By James Taylor, B.Sc.

In the following article the author considers the volt-ampère characteristics and their practical application, and describes the employment of "Osglim" lamps for the detection of wireless waves.

Abstract.

THE article deals with the volt-ampère characteristics of low-tension discharge tubes and gives an interpretation of the different portions of them.

It is further shown how the peculiarities of the characteristics have been applied practically, in their use as current rectifiers, relays and voltage-transformers.

Some experiments on the use of the "Osglim" lamps for the detection of wireless waves are described.

Introduction.

One low-tension discharge tube at least, in the form of the "Osglim" lamp, is now very well known and widely used by wireless enthusiasts. There are certain properties, common to all gas discharge tubes in which the cathode and anode are not more than a few mms. apart, which are well illustrated in the case of the neon lamp, and make it of use in wireless practice.

When the electrodes of a discharge tube of this type are connected to a potential difference sufficiently high, a discharge passes, and a glow—the so-called negative glow—restricted under ordinary conditions to the cathode, and spread over both sides of it, ensues. It is found that no discharge will occur till the potential applied to the lamp attains a certain value termed the upper critical voltage V_c, but that, if the discharge is once initiated, the potential difference may be reduced to a very much lower value, called the lower critical voltage V_b, before the discharge ceases.

The Volt-Ampère Characteristics.

The volt-ampère characteristics for the tubes are extremely interesting. If a discharge tube of the above type is connected in series with a battery of sufficiently high voltage to drive the lamp, a variable high resistance R, and a microammeter, and an electrostatic voltmeter is shunted across the tube terminals so that the potential across it may be measured, a complete volt-ampère characteristic for the tube may be obtained by progressively diminishing the value of R and taking the corresponding readings of the microammeter and voltmeter (see Fig. 1 for diagram of the circuit).

In the case of the "Osglim" lamps it is necessary to remove the ballasting resistances from the caps before experimenting with them. It is, however, possible at the present time to obtain lamps of this description without the usual ballasting resistances in their caps (they are made specially for

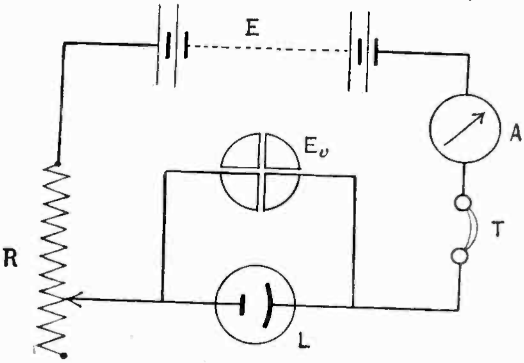


Fig. 1.

wireless purposes). The ordinary 240 volt mains provide a convenient voltage for driving the lamps, but it is preferable where possible to use a battery source of potential, free from the voltage fluctuations which almost always occur on main supplies.

The resistance R may conveniently have the initial value of one or two megohms.

When the complete volt-ampère characteristic is determined it is found to be of the general form shown in Fig. 3 (the current scale of the portion A to D is magnified for the sake of clearness). It comprises several distinct portions as shown.

If a telephone is included in the circuit, it is found that when conditions correspond to the portion of the characteristic to the right of E, the current is regularly intermittent in nature, and gives rise to a high note in the telephone. From E onwards to the right the characteristic is negative, that is a *decrease* of the voltage across the lamp terminals gives rise to an *increase* in the current through the lamp.

The present writer regards this regular intermittency of the discharge tube current as, purely and simply, a manifestation of the ordinary "flashing" phenomenon of the lamp. It ought to be mentioned here that this view is not generally held.

The "flashing" of the neon lamp is well known and has been described in a previous issue of this journal,* so that it is not

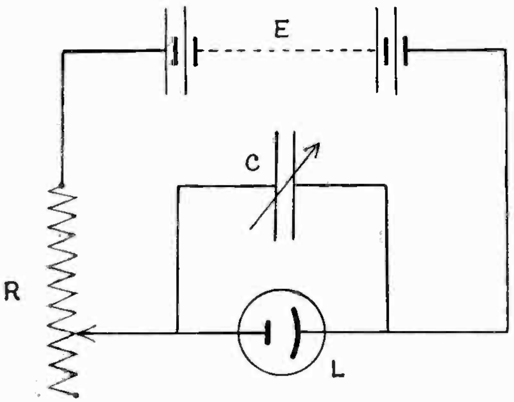


Fig. 2.

necessary to enter into the matter very fully.

When a capacity C is shunted across the terminals of the tube, and it is connected through a high resistance R to a source of voltage E (see Fig. 2), a regular "flashing" or lighting up of the lamp occurs at intervals, the time of flash, or more correctly the time taken for the condenser to charge up from the lower critical potential to the upper critical potential and to discharge through the lamp down to the lower critical potential again, being directly proportional to C and to R.† As the value of the capacity is diminished the time of flash becomes less, and the series of periodic clicks, as heard in the telephones, merges into a low note, which increases in pitch with decrease of C, until finally in some cases the pitch of the note increases above audible frequency.

It is therefore extremely probable that the regular intermittency of the current through the lamp, corresponding to the part of the characteristic to the right of D, is a limiting case of the ordinary flashing with C and R in circuit: C being due to the residual capacity of the circuit leads, the electrodes, and the electrostatic voltmeter.

It is apparent, then, that the voltage across the tube, as measured by the electrostatic voltmeter, is merely the average voltage over the whole time period of flash and charge, and the current is the average current over the period.

This view is supported experimentally by several facts. There is a portion of the characteristic curve from B to C where the voltage is almost stationary with change of current: the voltage at this part of the curve is evidently the limiting average voltage over the whole period, when the time of charging of the circuit capacity becomes great compared with the time of flash or luminous period.

To the right of this portion the energy transference through the lamp becomes very small, since R is large, and the telephones indicate a grating irregularity of flash. Beyond this again the current becomes regular but the discharge is non-luminous (the ordinary Townshend current in gases).*

As the circuit resistance is decreased, the characteristic is traversed from A towards D: there is no discontinuity, the voltage decreases continuously as the current is increased by reduction of R, and the note in the telephones rises in pitch. At the point D, however, a discontinuity occurs, the note in the telephones falls somewhat and then terminates abruptly, the current through the discharge tube becomes steady, and the voltage across the terminals falls in value (by as much as 20 or 30 volts in the case of some discharge tubes in which the filling gas is air, but usually less than this).

At this point the area of the electrode illuminated by the cathode negative glow becomes considerably less, but the intrinsic luminosity is much greater. The current through the lamp also increases abruptly by several microampères at this discontinuity point.

* Robinson. EXPERIMENTAL WIRELESS, Vol. I., No. 1.

† Taylor and Clarkson. *Journ. Sci. Inst.*, Vol. I., No. 6, p. 174.

* Shaxby and Evans. *Proc. Phys. Soc. Lond.* Vol. 36, Pt. 4, p. 259.

It has been shown that there is a critical resistance for the discharge tubes, below which no "flashes" can be maintained.

It is easily seen that if the quantity of electricity flowing from the battery E, through the high resistance R, to the lamp terminals, in a certain time, is equal to or greater than the quantity discharging across the lamp in the same time, then no flashes can take place and the current will become continuous in character. The highest value of R, consistent with the maintenance of flashing in the circuit, has been shown to be

$$R_c = \frac{E - V_b}{k(V_b - V_a)} \quad \ldots \quad \ldots (1)$$

where E is the voltage of the battery, V_b the lower critical voltage, k the "conductance" of the lamp, and V_a approximately the cathode fall of potential.*

It would appear that the point D is the critical resistance point for the circuit, and that here the current changes abruptly from the periodic to the steady state. Evidently the part of the characteristic between D and E cannot be obtained except fortuitously, since, at D (in the flashing state) the voltage reading is some definite average between V_b and V_c, that is, greater than V_b, and at E the voltage is steady and, as will be shown, is of the value V_b, the lower critical voltage.

When the discharge through the tube becomes steady, the circuit, in accordance with a perfectly general law (the Law of Minimum Potential Energy), will adjust itself to carry the maximum current under the existing conditions. This state is obviously obtained (since the current $i = \frac{E - V}{R}$) when the potential across the tube is as low as possible, that is of the lower critical voltage value V_b. At D consequently, the lamp will adjust its potential and arrive at the point E, so that the potential across its electrodes is V_b.

As was stated above, at E there is only a fraction of the cathode area illuminated and taking part in the conduction of the current through the lamp. Now the "conductivity" of a discharge tube is (under the present conditions) directly proportional to the area of the part of the cathode illuminated by negative glow.

* Taylor and Clarkson. *Proc. Phys. Soc. Lond.* Vol. Pt. 4, p. 269.

As the circuit resistance is further decreased, the circuit still continues to carry the maximum current $\frac{E - V_b}{R}$, and the tube increases its conductivity to carry the additional current by augmenting the area of cathodic surface utilised in discharge.

From the point E on the characteristic, to the point F, where the full cathode area is employed, the voltage across the tube is of the lower critical value. The extent of this vertical portion of the characteristic is considerable when the tube is of large cathode area—in the case of some air discharge tubes operated at about 480 volts the present writer has obtained a range of as great as 30 milliampères for this portion.

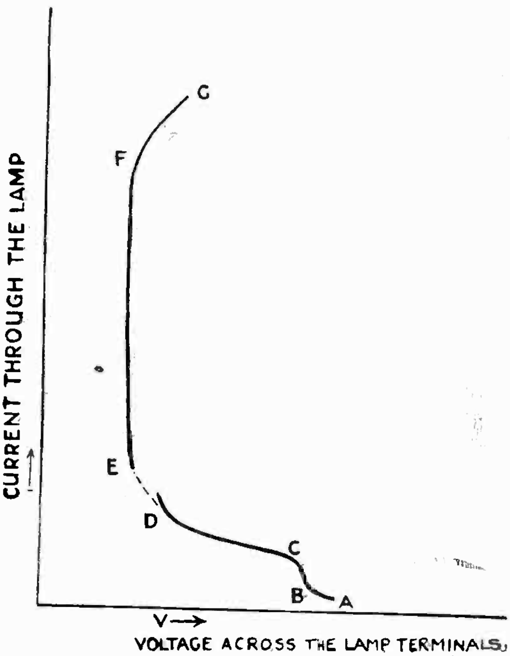


Fig. 3.

At F the slope of the characteristic begins to diminish, and the voltage across the lamp commences to rise steadily.

For this part of the characteristic it has been shown by J. W. Ryde that the following equation holds :—

$$i = \frac{E-e}{\frac{1}{AM}+R} \quad \ldots \quad \ldots \quad (2)$$

where A is the area of the cathode, and e and M are constants. The present writer obtained a very similar relation from theoretical considerations.

Practical Applications of the Properties of the Low Tension Discharge Tubes.

Current Rectification and Voltage Transformation.

It may be seen from equation (2) that the conductivity of the lamp is dependent upon the area of the cathode used, consequently if (as in the case of the "Osglim" lamp) one electrode is of large area and the other of small area, the tube will possess the property of unilateral conductivity to an extent depending on the difference of the electrode areas, that is to say, it will pass a much larger current when the electrode of large area is used as cathode than when the electrode of small area is used as cathode.

This property of discharge tubes has been known for a great number of years, and led to their adoption for the purposes of rectification. One of the original uses was for the partial rectification of the high tension current from induction coils. At a later date a variety of these tubes was used commercially, on a limited scale, in Germany, a considerable time before the "Osglim" lamp came on the market. In December, 1915, and later in 1919, F. Schröter published papers on glow discharge tubes.* These tubes had the usual two electrodes, and the filling gas was helium, argon or neon at pressures between 1 and 3 mms.

Fused alkali amalgams were used as cathodes. These metals liberate copious supplies of electrons when bombarded by the positive ions of the discharge, and so possess low cathode falls of potential, which enable the discharge to start at a much lower voltage than normally and give rise to greater currents than those usually obtained. On the other hand, the anode was of iron, a metal of high cathode fall, and no great property of liberating electrons under ionic bombardment : this efficiently prevents any large back current passing when the potential across the electrodes is reversed.

These tubes were fairly efficient in the rectification of alternating current. The efficiency depends, of course, on the material of the electrodes, the effective area of the electrodes, and the filling gas. It is stated in one of the papers that the efficiency in the rectification of alternating current was some 40 per cent. The same author utilised these tubes in connection with the "Problem of Voltage Transformation," for the Hydra Co. of Charlottenburg.

The voltage across the lamp must, under all conditions, be at least of the value V_b, and, as is seen from the graph of the characteristics, the potential will remain at this value over a range of currents represented by the part of the characteristic from E to F. Consequently when the lamp is connected to a high voltage through a resistance, it will subtract a constant value from the main voltage and thus transform down the potential across the resistance to much smaller value.

In a case given by Schröter, there was a potential fall of 190 volts across the discharge tube and of 30 volts across the series resistance. The low voltage circuit, which consisted of a bell, an accumulator, or such like, was placed in parallel with the circuit resistance. "The applications given comprise lighting of signal lamps, ringing of bells, and charging of accumulators."

Notwithstanding this advance, it was still impossible to use such tubes for any purpose where constancy and precision were necessary.

Discharge tube work had, from its very initiation, suffered from grave disabilities which it had not been found possible to overcome. The discharge tubes were always constructed in glass vessels, which were, as a rule, in close proximity to the actual discharge, consequently an accumulation of electrical charge (space charge) on the sides of the vessel occurred and resulted in serious and erratic interference with the normal course of the tube phenomena. Moreover, under the action of the intense bombardment by positive ions, the surface of the cathode became modified in nature, and progressive change of the cathode fall of potential and the conductance of the tube took place.

Lastly, and perhaps the most disturbing effect of all, a "clean up" of the gas in the tube, resulting in a pressure progressively

* F. Schröter. *Elektrot. Zeits.* 36, pp. 677-679, Dec. 30, 1915; also pp. 685-687, Dec. 25, 1919.

diminishing from the initial value, occurred ; this "clean up" is most probably due to the absorption of the filling gas by the electrodes and the glass vessel.

Recently, however, two American experimenters have overcome these disabilities in a most remarkable and ingenious manner, using a principle, known to scientists for many years, and termed the "short path" principle.*

The "Short Path" Principle.

Sir William Crookes appears to have been the first to observe the fact that when two metallic electrodes are placed very near together in a gas at a reduced pressure (so that there is only a few mean free paths of the gas between the electrodes), it is very difficult to get a discharge to pass between them, even at potentials very much higher than those normally required to initiate the discharge. If, however, there are longer paths available between the electrodes, the discharge will take place along these with comparative ease. When only "short paths" are available between the electrodes, they are able, under certain conditions, to withstand voltages of a few thousands before discharge between them takes place.

The Application of the "Short Path" Principle.

The above principle has been applied by Bush and Smith to the production of discharge tube rectifiers ; the following may be amplified by a reference to their paper quoted above.

If two cylindrical electrodes A and B, as shown in Fig. 4 are placed in a glass vessel so that no long paths are available, no discharge will pass, even though there is a considerable potential across the electrodes. If now a small hole is made in the electrode B say (see Fig. 5) and B is used as negative electrode, the interior of the cylinder B will now act as cathode and long paths are available for the discharge, so that a fairly large current will flow : the tube is thus free from extraneous influences which cause the behaviour to be erratic. It was found in addition that certain grades of carbon, when used as electrodes, eliminated almost entirely both the clean up effect and the effect due to the modification of the electrode surfaces.

* V. Bush and C. G. Smith. *Am.I.E.E.J.* 41, pp. 627-635.

Tubes of this description with a filling gas of helium at a pressure of 2 mms. and electrodes at a distance of 1 mm. apart, act as very efficient rectifiers of alternating current.

The tube will take currents of many milliamps, on a 500 volt circuit, when operated with the electrode in which a hole is pierced, as cathode, but gives a reverse current of 1·5 milliamps only when subjected to a voltage as high as 1 000 in a reverse direction. The efficiency of the tube as a rectifier is due to two causes. In the first place there is the difference of electrode area. When the pierced electrode is employed as negative electrode, the full inside area of the hollow cylinder is utilised as cathode, whereas in the reverse case the area of the cathode is the much smaller portion of the electrode opposite the hole only.

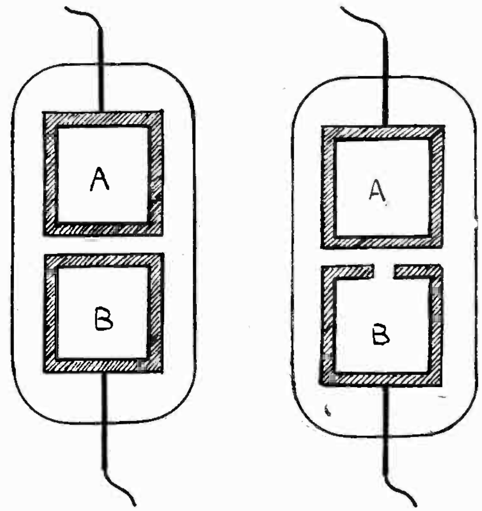


Fig. 4. Fig. 5.

This provides a certain one-sidedness of conductivity, but it is not solely, or even largely, responsible for the efficiency of the device as a rectifier. The explanation of the efficiency as a rectifier is found, according to Bush and Smith, in the persistence of the positive space charge within the hollow cylinder.

As is well known, the preponderent part of the potential fall across the tube takes place at the cathode (cathode fall of potential). Consequently when the solid electrode is employed as cathode, the electric field within the hollow cylinder will be very small, the motion of the heavy positive ions will be very slow and they will persist over the length of time required for the potential across the tube terminals to be reversed when current of ordinary commercial frequency or greater is being rectified.

In rectification of alternating current therefore, the pierced cylinder when used as anode will act as if it were solid, the paths will almost all be "short" and the tube will conduct hardly at all.

These rectifiers are remarkably steady in their action.

An example is given of one of the tubes carrying a current of 10 milliampères from a storage battery, and the variations in the current were barely audible even when amplified by a two-stage thermionic amplifier.

The above principles were also employed in magnetic rectifiers: these tubes consisted of electrodes in the form of concentric cylinders, built up on the short path principle, so that no current could pass, even though high voltages were employed to effect this.

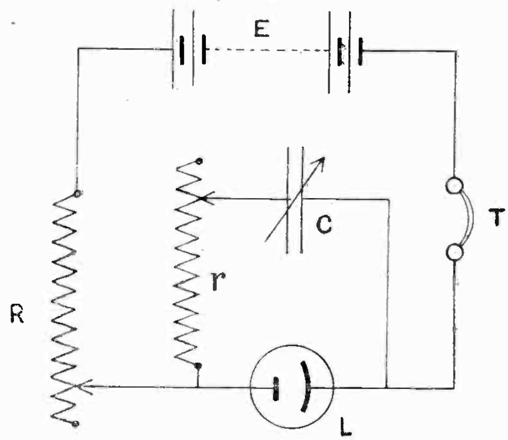


Fig. 6.

A small magnet is attached to the outside of the tube so that the lines of force run along the annular space between the two electrodes. Under the action of the forces due to these lines of magnetic force, the ions of the discharge tube describe curved paths and will thus cease to be "short," consequently a current will flow through the tube. The intensity of the magnetic field required to enable the discharge to start is critical in nature and depends on the diameter of the electrode used as cathode. It is obvious therefore that the magnetic field may be made of such a value that the current will flow only when the electrode of large diameter is employed as cathode. These types of tubes provide very efficient rectifiers and possess the advantage of very long life.

The Anson Relay is another application of the properties of the low tension discharge tube, but it is now so well known as to make a description here redundant.

Application to the Measurement of Capacities and High Resistances.

In a previous article by Mr. Clarkson and the present writer,* a description of the methods for the utilisation of the tubes for the measurement of capacities and high resistances was given, so that a further detailed description is not required.

If a capacity is shunted across a neon lamp which is connected to a charging voltage, through a high resistance, as was previously shown, "flashing" occurs. The time of flash is directly proportional to the magnitude of the capacity and the high resistance in the circuit. These relations can evidently be utilised directly for the measurement of capacities and high resistances.

In the case of very small capacities, a method is employed whereby beats are obtained between two circuits flashing at note frequencies, and the capacities are compared in this way.

Experiments on the Use of the Neon Lamp for the Detection of Wireless Waves.

In some early experiments on the flashing of discharge tubes, the writer made use of a circuit as shown diagrammatically in Fig. 6. E is the charging voltage, R the circuit resistance (variable megohm), L the "Osglim" lamp, C the capacity shunted across the tube electrodes, and r a further resistance control (variable 10 000 ohms resistance) in the condenser circuit.

Experiment showed that increase of r had the effect of "speeding up" the flashes, but that the area of the cathode employed in the flashing became less; as r was increased however, a point was reached at which the discharge became steady and R was evidently the critical resistance value for this arrangement.

Now if C is a small variable capacity (an aluminium vane variable condenser for

* Taylor & Clarkson. *Journ. Sci. Inst.*, V. 1., No. 6, p. 174.

example), and r is varied, the note in the telephones changes rapidly and it is possible to "run up the scale" by keeping C fixed and increasing r (alternatively by keeping r fixed and varying C). When r attains a certain value the note stops suddenly and a steady discharge ensues.

As a rule for this latter position the discharge is in a *sensitive condition* and small disturbing causes make the discharge variable or intermittent, the intermittency stopping when the cause is removed. Thus, touching the anode terminal with the finger produces a very marked change in the nature of the discharge for the duration of the touch.

As a matter of interest, experiments were made to find out whether the arrangement could be used as a detector of wireless waves. The waves were generated by a small Hertzian Oscillator (that is, an induction coil with capacity and inductance across its sparking points). The following circuit was finally adopted for the reception. It would respond to the waves from the oscillator at a distance of some 20 yards away, by a vigorous flickering of the discharge, the flickering terminating abruptly when the oscillator was not working. Fig. 7 gives the circuit employed. The arrangement is essentially the same as that of Fig. 6, except that an inductance l* is included to give the usual tuned-in circuit, and X is a variable grid-leak connected from the lamp anode to earth, as shown.

As a rule R was made of the order of 0·7 megohms, after which r was adjusted till the sensitive position was attained. If then C and L were adjusted properly, a very noticeable disturbance of the previously steady lamp current was observable, and a flickering, together with a rumbling in the telephones, was produced.

The variable grid-leak to earth from the anode very much increased the efficiency of the arrangement and gave rise to much stronger signals.

The correct interpretation of these interesting effects appears to be as follows. The adjustment of the two circuit resistances brings the lamp to the point corresponding to E on the characteristic (see Fig. 2). If at this point an increase in the voltage across the lamp terminals is produced by the incoming oscillations there will be very little effect on the discharge tube current, but if a small decrease in the potential occurs a very noticeable change in the current through the tube will occur, owing to the steepness of the slope of the characteristic curve in this direction. The action is of a trigger nature, for very small changes produce large effects in the nature of the discharge.

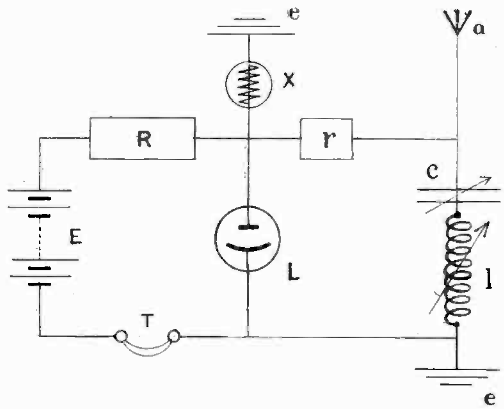


Fig. 7.

Very similar experiments may be carried out at higher potentials with air discharge tubes.

The present writer has not been able, so far, to detect disturbances due to the local broadcasting, etc., in this manner, diversion of the work into other channels having prevented fuller investigation into the matter, but it appears to present a possibly fruitful field for wireless experimenters.

A different method of utilising the neon lamp for the detection of wireless signals has been given by Robinson in Vol. I., No. 1, of EXPERIMENTAL WIRELESS.

* * *

The writer wishes to acknowledge his indebtedness to Mr. A. Bulman, of Armstrong College, to whom the diagrams of the circuits are due.

* The variation of l, the inductance in the circuit produced very little effect, since the form of the wave departs so radically from the simple harmonic form and comprises a very large range of wave-lengths.

On Crystals and Crystal Testing.

IN our last issue we gave a short note on the methods adopted in our routine tests of valves sent in for report. We must now do the same for crystals.

The basis of judging a crystal is, of course, the characteristic curve showing current against a steady applied voltage in either direction. Such a curve, however, cannot be reproduced very well, as in the case of any decent crystal the "reverse" current is too small to be shown on it. A simple way of getting over this is to draw a curve showing the ratio of the currents in the "pass" and "stop" directions for any applied voltage. In the curves below, the "stop" current is expressed as a percentage of the "pass" current.

There are one or two tricky little points even in drawing the characteristic, if one is to show a fair comparison between different crystals. First, up to what range of voltage shall the curve be taken ? Looking at any of the curves below, it is obvious that if the part from 0 to (say) ·3 volts were enlarged to the same size as the whole curve at present, the bend of the characteristic would not appear nearly so sharp, and a false impression might be derived. Similarly, if we compare the curves of two crystals of different resistances, drawn to the same scale, the curve of the high resistance one would be lower on the drawing, and its bend would again appear less sharp, although it might be just as good a rectifier.

This difficulty we get over as follows: the power put into a crystal is proportional to EI, where E is the applied voltage and I the current. So we extend our curves for crystals of various resistances to points representing equal powers, *i.e.*, if a galena of 500Ω resistance to D.C. at 1 volt has its curve shown up to 1 volt, then a carborundum will be extended until EI=·002, which might occur at say E=2, I=·001, or R=2 000.

In actual practice all ordinary galenas, of resistance 200Ω to 700Ω or thereabouts, are shown up to 1 volt.

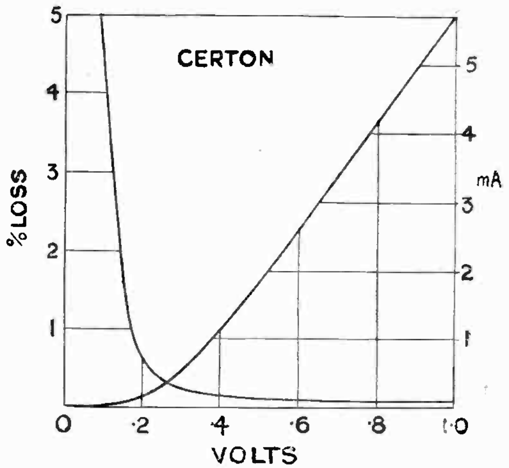
Again, to get over the apparent flatness of curve due to high resistance, all curves are drawn within a rectangle of the same shape, *i.e.*, the current is drawn to a different scale in each case, so that its value at the largest voltage shown, whatever it may be, is represented by the same height on the paper.

Lastly, a note is added as to the type of crystal, and the percentage of points found sensitive on trial. It will, of course, be appreciated that the curves represent the results of one test on one sample. They may or may not be typical of average results.

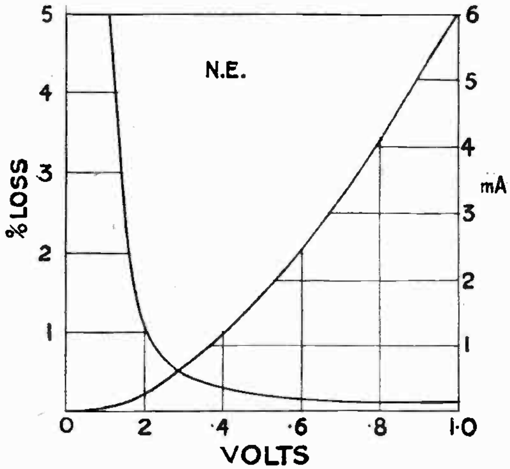
Two Impandex Crystals.

These were sent in by the Impandex Trading Co., Ltd., 5, Victoria Avenue, Bishopsgate, E.C.2.

One of them, known as Certon, is a normal galena in appearance. Its rectification loss was exceptionally low, being only ·07 per cent. at 1V, and remaining below 5 per cent. at 0·1V. The resistance at 1V will be seen to be 1750. All the points tested were good, and the crystal seemed to enjoy heavy input in a reflex circuit.

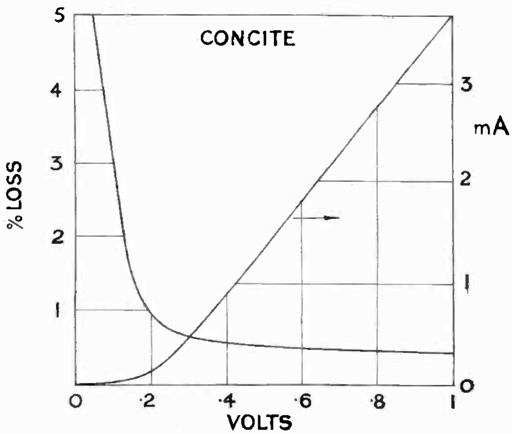


The second crystal has suffered an unintentional insult in its name. This is NE●, which we believe is intended by the makers to be a pun on "any spot." Of course the average reader will read it as "No Earthly." The crystal is a very large-grained galena, and as usual in this type there is a tendency for the contact point to slip on the polished surface. But when a steady point is found quite good results are obtained, as will appear from the curves. The crystal shows very low loss for the larger voltages especially. Points tested were 60 per cent. fair, 40 per cent. good. The resistance at 1V was 160Ω.



Concite.

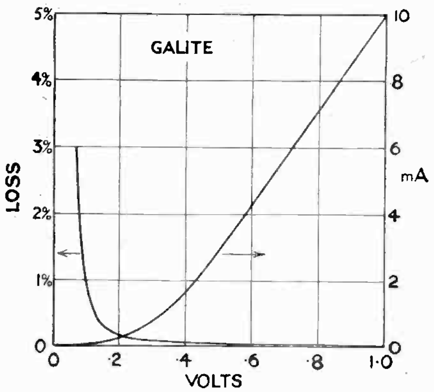
This is a galena of normal appearance, sent for test by Messrs. Conradi & Braun, of 52, Theobalds Road, W.C.1. As shown by the curves herewith, the rectification loss is low—about ½ per cent. for medium voltages. Like most galenas, the bend



occurs at about ·2 volt, and a potentiometer would be an advantage—a point not always appreciated. The curve above the bend is nice and straight, so that there is likely to be proportional rectification for fairly large inputs. The resistance is fairly high, being about 270Ω at 1V. Of the points tested 40 per cent. were good, 60 per cent. fair.

Galite.

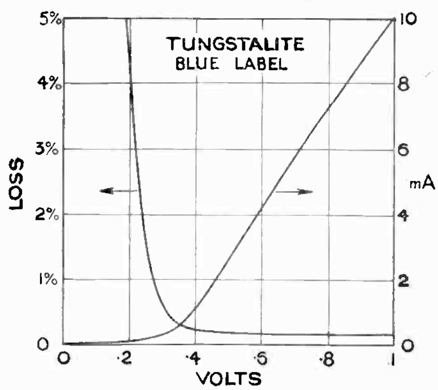
Another typical galena in appearance, submitted by M. A. Gardiner, of 84, Grosvenor Road, N.5. The curves show an exceptionally good rectification, the loss being actually less than ·02 per cent. at high voltages, and only 3 per cent. at the lowest voltage tested. The pass resistance is quite low, being 100Ω at 1V. All the points



tested were very good, though not all of them were of the exceptional quality of the curves. On large input, in a reflex circuit, there was a loss of efficiency estimated at 20 per cent.

Tungstalite Blue Label.

This is a synthetic galena made by Messrs. Tungstalite, Ltd., 47, Farringdon Road, E.C.1. It has the great advantage of being unaffected by grease, or the heat of ordinary solder. Its test performance was good, as our curves show, though it is obvious that a potentiometer voltage of about ·3



would give better signals. As usual in synthetic crystals, there are not so many highly sensitive points as in picked natural specimens, the figures being, as regards all points tested, 20 per cent. very good, 20 per cent. good, 40 per cent. fair, 20 per cent. indifferent.

A Method of Obtaining A.C. for Transmission.

Of particular interest to those possessing D.C. supply. **[R355**

By J. K. Jennings, B.Sc., and B. L. Stephenson (5IK)

THE problem of obtaining the high voltages required for transmission presents some difficulty, especially where D.C. lighting supply only is accessible. In the authors' case it was very soon found that the 200 volt D.C. supply, while providing an excellent source of H.T. for low power work, was totally inadequate for use with the larger types of transmitting valves. It was therefore decided to try out several methods of obtaining a high voltage from the D.C. mains, and a "Voltage Raiser," similar to that described in No. 5 of EXPERIMENTAL WIRELESS, was first constructed. A four-stage machine was used, each condenser bank being of 18 microfarads, and consisting of waxed paper dielectric condensers of various values built up in parallel. During preliminary tests considerable trouble was experienced with the rotating contacts, which were of laminated copper strip. These were therefore replaced by ordinary carbon motor brushes, which were more satisfactory, in that they did not wear the face of the distributor segments, and consequently less noise was experienced. It was found, however, that the voltage on no external load was much less than the 800 volts which was to be expected, and, in addition to this, the output on load was very rough and irregular. Both faults appeared to be due to leakage in the condensers, so it was decided to make certain alterations to the arrangement of the distributor segments in order to charge the condensers twice per revolution of the charging brushes, and also to eliminate the 90° dead space on the original distributor. Accordingly, a new distributor was built up to the theoretical design shown in Fig. 1.

In this, opposite segments are connected together, thereby allowing each condenser to be charged twice per revolution. Owing to the elimination of the 90° dead space the sizes of the segments had to be very carefully arranged so that no shorting occurred during rotation.

In order to ensure this, each pair of segments had to be of rather different sizes and considerable experimenting was necessary before the final position of the brushes was fixed. As might be expected, the voltage now obtained was higher, and the output much smoother than in the first case. This

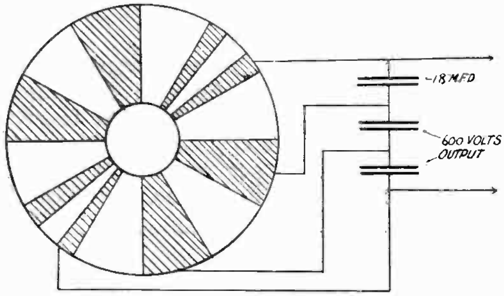


Fig. 1.

arrangement was therefore used for some time at 5IK and gave quite good results. It still had a number of mechanical defects, however, so it was decided to abandon it and try some other method of obtaining H.T. It was considered desirable, if possible, that this should be A.C. in order to give greater flexibility. The arrangement about to be described was ultimately arrived at because of its simplicity and low cost, the fact that the motor which had originally driven the distributor brushes could again be utilised being taken into consideration.

The method employed is one well known in electrical work and consists in converting low voltage D.C. to low voltage A.C. by means of an inverted rotary converter. The A.C. thus obtained is brought to a transformer and stepped up to the required voltage. This can be then rectified either by a chemical rectifier (see No. 3 of EXPERIMENTAL WIRELESS) or by a mechanical rectifier suitably mounted on the shaft of the converter. The output from the rectifier can of course be smoothed if desired before application to the plate of the valve. The general arrangement will be seen from Fig. 2. It will be readily understood that this is extremely simple and straightforward and possesses many of the advantages of actual A.C. supply. The power which can be obtained depends entirely upon the size of the converter, and it was found that a large size fan motor was capable of supplying 40 watts rectified and smoothed H.T. to the valve. The cost of running is comparatively low, for in the above case the motor took about 200 watts from the D.C. mains. Most of the loss here is due to the chemical rectifier, which takes considerable current to operate it satisfactorily.

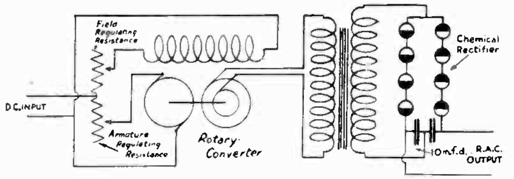


Fig. 2.

It is now proposed to give a detailed description of the plant in use at the authors' station, including the method of conversion of the motor to a converter, and the design and constructional details of the transformer. The power output from the plant is up to 50W at 800V rectified and partially smoothed 50 cycle A.C.

The Rotary Converter.

The rotary converter is an adapted fan motor, the original machine being series wound for 200V D.C. and having a normal input of 50W continuous rating. It was of the totally enclosed type, and as the output required from it would necessitate a considerable overload it was deemed advisable to drill holes in the end plates so as to give increased cooling. It should be understood however that a single phase converter gives 85 per cent. of the output of the same machine run as a D.C. generator, for the same degree of heating. The reconstruction of the machine necessitated the taking of two tappings from opposite segments of the commutator of the motor to sliprings, and the alteration of the field from series to shunt, inserting the necessary resistances which will be discussed later. There was no room inside the machine for these sliprings, and to overcome the difficulty one segment was connected to the shaft, and the tapping from the other was taken out in insulating sleeving through a hole drilled down the centre of the shaft. This lead was connected to a contact stud mounted on an ebonite disc attached to the end of the shaft. The A.C. output brushes were then arranged to run one on this stud and the other on the shaft; Fig. 3 will make this clear.

Operation of the Converter.

Considering the case of a D.C. motor with tappings from opposite segments of the commutator to sliprings, as shown in Fig. 4a, it is clear that in the position of the armature indicated the voltage between the rings will be the same as that of the applied D.C. In Fig. 4b where the armature has rotated through 90°, the armature windings being symmetrical, the voltage difference between the sliprings will be zero.

When the armature has rotated through another 90°, the voltage across the rings will again be equal to that of the D.C. but of opposite polarity. Thus, an alternating E.M.F. is set up between the rings, and this can be considered as being of sinusoidal form. The maximum value of this E.M.F. will be the same as the D.C. voltage, and the R.M.S. voltage will therefore be

$$\frac{\text{D.C. volts}}{\sqrt{2}}$$

It should be borne in mind that with an inverted converter an inductive load, such as transformer load, will cause a weakening of the field and consequent speeding up of the machine, and this will cause increased reactance of load and still further speeding up. By suitable adjustment of the field

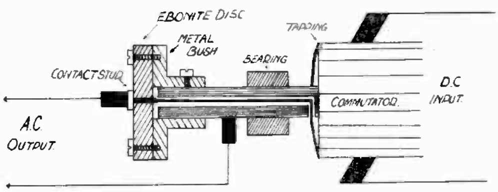


Fig. 3.

current, however, this effect can be minimised so as to cause no trouble. For this reason it is necessary to use a resistance, of value determined by experiment, in series with the field. The frequency of the A.C. produced

$$= \frac{\text{Revs. per minute} \times \text{No. of poles}}{60 \times 2}$$

so that in a bipolar machine the frequency is the same as the revolutions per second.

The details of the machine used are :—

Resistance of field $=250\Omega$.
Normal load current $=0{\cdot}25$A.
Volts drop in field $=250\times0{\cdot}25=62$V.
Voltage on armature $=200-62=138$V.

It was found that an increase in field voltage to 100 gave greatest stability of the converter, and on 200V supply a series resistance of 250Ω was therefore required. In the case of the armature the voltage could safely be increased to 150V, and as the armature current to the converter on load would be about 1A a resistance of 50Ω was inserted.

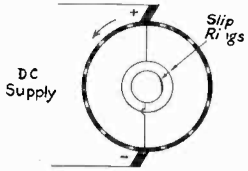


Fig. 4a.

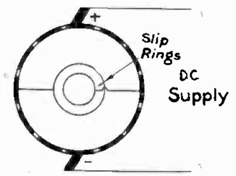


Fig. 4b.

Under these conditions the speed of the machine on no load was 3 000 r.p.m. and the A.C. frequency was therefore 50, the voltage being

$$\frac{150}{\sqrt{2}}=105\text{V A.C.}$$

From these remarks it will be clear that for a different machine or in the case of a different supply voltage, suitable resistances can be selected.

The Transformer.

The transformer is designed round a rectangular laminated iron core, built up from thin iron strip one inch (2·5 cms.) in width. This could be cut into lengths; in the case under consideration two different lengths were required. Three sides only were built up at first, thereby leaving space for the windings to be inserted later. The strips were cut into lengths L and L_2 and assembled as shown in Fig. 5.

The first layer is shown by dotted lines and the second layer by thick lines. The third is then similar to the first and so on. This forms a complete magnetic circuit. When laminations have been built up to the required thickness they are held together by clamping one side (AB) between two strips of iron of about the same width as the laminations. It will be found that ribbed iron, such as that used for angle brackets, is very convenient for this purpose. The method of holding these strips together is shown in Fig. 6.

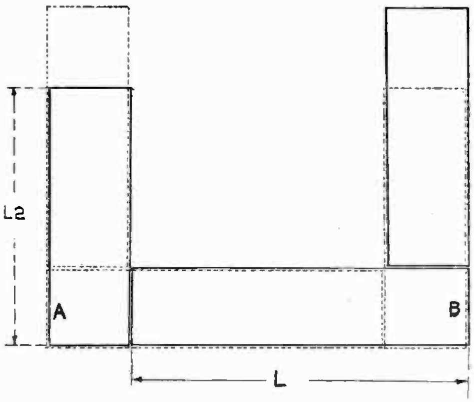


Fig. 5.

The primary and secondary coils are wound separately on formers made from sheet presspahn, and are slipped over opposite arms of the core. The open end is closed up by further strips (employing the same method of jointing as before) and is then held by a second clamp.

Design of Transformer.

Requirements: Output $=80$ watts (sufficient to cover rectification losses, etc.).
Secondary voltage $=800$.

Supply available from converter : 105 volts, 50 cycles (no load).

Owing to the comparatively high resistance of the armature winding, the voltage on load will drop considerably and we will therefore assume the voltage to the primary

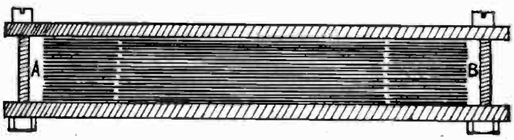


Fig. 6.

to be 90V. Further, assuming that the efficiency of the transformer is 80 per cent. the input required will be

$$\frac{80\times10}{8}=100\text{W},$$

and the approximate current will be

$$\frac{100}{90}=1{\cdot}1\text{A}.$$

It is convenient to take the depth of winding to be 1 cm., and it is found that a current density of 550A per sq. cm. will not cause any overheating. The sectional area of the wire is then $\frac{1\cdot1}{550}$ sq. cm. and this equals $\frac{\pi d^2}{4}$ where d is the diameter.

Therefore

$$d=\sqrt{\frac{1\cdot1\times4}{500\times\pi}}=0\cdot05 \text{ cm.},$$

and this is 24 S.W.G. approximately. This size of wire is not unreasonable, and will be adopted for the present.

The number of turns required and the necessary flux are found from the following :—

The voltage produced in a coil of N turns by an alternating flux of maximum value Q_m at F cycles is given by :—

$$E=4\cdot44\ FNQ_m\times10^{-8}$$

In our case therefore

$$90=4\cdot44\times50\times NQ_m\times10^{-8}$$

i.e., $$NQ_m=\frac{90\times10^8}{4\cdot44\times50}=\cdot4\times10^8$$

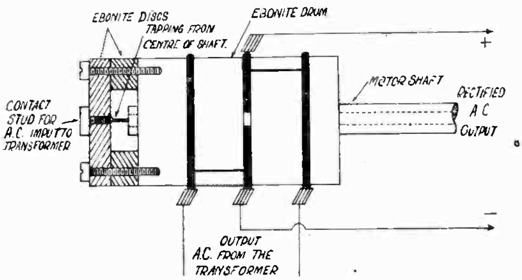


Fig. 8.

From this it will be seen that it is possible to have either a large number of turns and a small flux or vice versa. The amount of iron needed, however, depends on the flux to be carried, and for greatest efficiency it is desirable to have the iron and copper losses approximately equal.

For a trial we will assume the number of turns to be 1 000 and take the depth of winding as being 1 cm. Then, if we wind the coil layer for layer and allow ·03 cm. for the D.C.C. insulation, we have :—

$$1000=\frac{1}{\cdot086}\times\frac{L}{\cdot086}$$

where L=the length of the coil.

In this L=7·4 cm. which, for constructional reasons, is rather large. We shall therefore increase the depth of winding to 1·6 cm. so that the length of coil will now be 4·5 cm. Now the flux

$$Q_m=\frac{\cdot4\times10^8}{1000}$$

and taking a flux density B=9 000 lines per sq. cm. we have the area of iron needed

$$=\frac{Q_m}{B}=\frac{\cdot4\times10^8}{1000\times9000}=4\cdot4 \text{ sq. cm.}$$

As the standard width of the iron stampings is 2·5 cm. we have :—

The thickness of stampings to be built up

$$=\frac{4\cdot4}{2\cdot5\times\cdot9}=2 \text{ cm.}$$

(An allowance of 10 per cent. is made in the above equation for paper, varnish, etc., on the stampings.)

Secondary Winding.

Voltage required=800.
Primary voltage=90.

The number of turns on the secondary will therefore be $\frac{800}{90}\times1\,000=9000$ approximate.

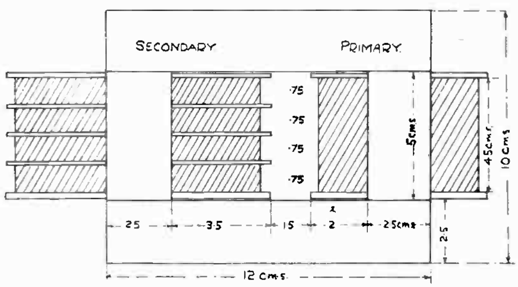


Fig. 7.

The secondary current is ·1A and the current density can be taken as 400A per sq. cm.

The area of the wire is $\frac{\cdot1}{400}$

and the diameter is therefore

$$\sqrt{\frac{\cdot1\times4}{400\times\pi}}=\cdot015 \text{ cm.}$$

This is 38 S.W.G., but for mechanical reasons it is advisable to use 36 S.W.G. D.S.C. (·029 cm. diameter over D.S.C. insulation).

Owing to the high voltage it is necessary to divide up the winding into four sections and the details of the bobbin are given in Fig. 7. It will be seen that the total width of winding is 3 cm., so that the depth will be

$$\frac{9\,000 \times \cdot 029 \times \cdot 029}{3} = 2 \cdot 5 \text{ cm.}$$

but owing to the narrowness of the sections (·75 cm.) we shall allow a depth of 3 cm.

Complete Data for Windings.

	Primary.	Secondary.
Size of wire	24 S.W.G., D.C.C.	36 S.W.G., D.S.C.
Number of turns ..	1 000	9 000
Length of wire required	550 feet	6 250 feet
Size of former ..	2·5 × 2 cm. (to fit over iron section)	2·5 × 2 cm. (to fit over iron section)
Outside dimensions of winding	5·7 × 5·2 cm.	8·5 × 8 cm.
Width of bobbin ..	4·5 cm.	4·5 cm. (divided up into four sections each approximately ·75 cm. in width).

Fig. 7 shows the main dimensions of the transformer.

To check the previous figures it will be advisable to estimate the various losses in the transformer.

Iron loss at 9 000B at 50 cycles = ·04W per cu. cm.

Volume of iron = 180 cu. cm.

Therefore total iron loss = 180 × ·04 = 7W.

Primary resistance = 9Ω.

Therefore primary copper loss = $9 \times 1 \cdot 1^2 = 11$W.

Secondary resistance = 1 000Ω.

Therefore secondary copper loss = $1\,000 \times (\cdot 1)^2 = 10$W.

This gives a total loss of approximately 28 watts and the efficiency is therefore 100—28 = 72 per cent. This is quite good considering the small size of the transformer and the fact that it is a very economical one to make. The copper losses are rather high compared with the iron losses but iron is less expensive than copper.

We can therefore consider our preliminary assumptions to be reasonably correct.

Mechanical Rectifier.

Such a rectifier must of course be synchronous, and by far the most convenient method is to arrange the necessary apparatus on the shaft of the converter. This can be done by mounting an ebonite drum of, say, 4 cm. diameter on the end of the shaft. This drum has three grooves about 2 cm. apart cut round its circumference and rings of thick copper wire are fixed in the outer ones. This can be done by heating the rings and then slipping them over the ebonite and allowing them to contract into the grooves.

The ring to be placed in the centre groove is split in halves and shortened so as to give gaps between each half of about 1·5 cm. The arcs are then held in position by flattening their ends and putting through small countersunk screws into the ebonite, and each one is connected to an outer ring. One carbon brush is arranged to run on each outer ring and two (at 180°) on the split ring. The operation and general features will be understood from Fig. 8. The drum can be a tight fit on the shaft or it may be held in position by a flanged bush. Its correct position is such that the peak of the A.C. wave occurs at the centre of the arcs comprising the split ring. This condition is fulfilled when the centres of the arcs are opposite the tapped commutator bars. The two brushes on the split ring, in order to take off the peak, must be in the same plane as the D.C. brushes on the converter, or possibly lagging these a few degrees.

In the case of the chemical rectifier it was found that the arrangement shown in Fig. 2 gave the most satisfactory results. Each bank consists of eight cells, the current density allowed being 6 milliamps output per sq. cm. of plate. The condensers are 10 microfarads each, thus giving considerable smoothing.

Amateur Transmission.

THE most important work done by amateur transmitters on the scientific side, as distinct from the technical, has been connected with the investigation of the varying properties of different wave-lengths. In this connection the statistics collected by the American Bureau of Standards from broadcast listeners are of interest, indicating that a minimum of reception strength occurs at a distance proportional to the wave-length; about one-quarter of a mile per metre. This is borne out fully in Edinburgh, where the Aberdeen and Newcastle stations, both about a hundred miles distant, are received very poorly, while stations further south are received much louder. This result appears to be obtained in other parts of the country. One explanation given is that besides the main ether wave, a wave travels at a different speed through the outer layer of the earth, and owing to the difference in velocity causes an interference band.

On examining results obtained with the transmitter 5JX it is found that they agree with the above observations. On 120 metres a minimum should be observed at about 30 miles, and it is a fact that at times when loud signals are reported at a distance of 1000 miles, Glasgow, 40 miles distant, and Dollar, 30 miles, report poor signals. It would be interesting to know if this experience is general, and particularly as regards waves of 50 metres or less now being used by several experimenters. In the latter case it would even be practicable to mount a portable receiver on a car and make observations of strength at varying distances, care being taken to avoid such effects as local screening, etc., as much as possible.

Experiments at 5JX indicate that fading is not entirely absent on waves below 150 metres, as is sometimes stated, but that it is usually slight or altogether absent, and, exceptionally, may be very bad. Signal strength curves showing fading of 5JX have been obtained simultaneously from a number of districts, and these show that even in districts separated by a few miles, the fading varies in quite a different manner; at the same moment signals may be steady at one point of observation, and fading very pronounced at another only 10 miles away, and when fading takes place at both, the curves do not in the slightest degree correspond. It is rather surprising that this should be so, as it would be expected, according to the present theory of fading, that the phenomenon would affect a particular district in an appreciably similar manner at nearby points.

Detailed reports of signals from 5JX, whether special tests or not, are always welcomed as supplying information on these matters relating to the propagation of short wave signals. Signals are frequently sent after B.B.C. hours on about 120 metres.

Some Interesting Transformers.

The Monopole.

THE Monopole L.F. transformer, handled in this country by Mr. P. Capel, 3 and 4, Queen Street Arcade, Cardiff, is a typical example of French audacity. We are accustomed in this country to attribute much evil to the close juxtaposition of two L.F. transformers; what then shall we say to the idea of enclosing two, or even three, in the same case, with their cores parallel? Yet this is done quite successfully in this case. The secret is the use of a core with no magnetic joint at all—a closed ring—with windings, one over the other, covering the whole of it, so that leakage is *really* negligible. The sample tested was of the double type, the first 5 to 10, the second 3 to 1. We tried each part of it separately and also the two together, the method being the simple one of switching over on broadcasting, with a specially accurate type of audibility meter in use, while at the same time two independent judges compared tone.

The standards of comparison were first-class commercial transformers, each one used in the stage which it suits best. The results, as regards strength, were :—

Position		After Crystal	After Ordinary Valve	After Power Valve
Approx. Impedance	..	4 000O	25 000O	6 000O
Ratio of standard Transformer	..	4/1	4/1	3/1
5 to 1		1·2	1	1·6
3 to 1		1·1	1	1·4

The figure giving in each case comparative strength, and accuracy of test being about 5 per cent.

As regards tone, both the units gave admirable results after the crystal; but in the later stages they gave a rather high tone, a small condenser across the secondary (about ·0007) giving improved richness.

On wiring both transformers simultaneously for the first and second stages, their performance was exactly the same as when used separately: there appeared to be no interaction.

The price is low, being 24s. for the double type, which replaces two ordinary transformers.

The Marconi Ideal.

The Marconiphone Co. recently sent us some literature dealing with their new L.F. transformers, from which we gathered that they had attempted to make a practically perfect transformer by sparing no effort either in design or manufacture. The data given seemed interesting, so we have tested samples of these transformers with especial care.

We may state at once, before going into detail, that the results were exceptionally good.

The construction of the transformer is, as will be seen from our sketch, unusual. The secondary is in four sections of which the end ones apparently contain more wire than the middle ones: the primary is in three equal sections. Each section is spaced about $\frac{1}{16}$ in. from its neighbours. The core is extremely large, having a cross section of $1 \times \frac{3}{4}$ in. The number of turns is not stated, but the ratio is 2·7, 4 or 6 to 1 in the three models, which are otherwise identical. The transformer is enclosed in a light sheet-iron case.

The performance claimed by the makers is an extraordinary one. They offer the two lower ratios as suitable for valves of high or medium impedance, and the 6 to 1 for low impedance (power) valves: they do not claim perfection of quality with the 6 to 1 ratio on high impedance valves.

Curves of performance (stage step-up against frequency) are given on the guarantee card which accompanies the valves. The worst of these shows a drop of 20 per cent. (just perceptible) at 300 and 4 000 cycles, as compared with the step-up at about 1 000. Most of them show a drop of about 7 per cent. between 750 and 300 cycles, and even amplification above. These curves are apparently the Company's own tests, but the guarantee given is that every transformer will be within 5 per cent. of the curve, and it also provides for replacement in case of breakdown within 6 months.

We have dealt with these matters at greater length than our custom; we are led to do so by the fact that this is, as far as we know, the first attempt by a manufacturer to offer a close performance specification on such a tricky thing as a transformer.

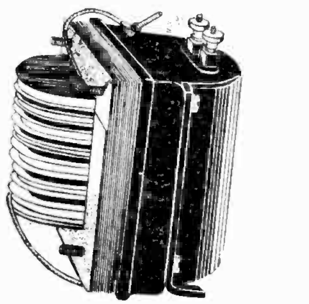
Now for results: we have already described our method, and the strength test resulted as follows:—

Position		After Crystal	After Ordinary Valve	After Power Valve
Approx. Impedance	..	4 000O	25 000O	6 000O
Ratio of standard Transformer	..	4/1	4/1	3/1
6 to 1		2	2·7	1·4
4 to 1		1·4	2	1·4
2·7 to 1		1	1·4	1·25

The quality is, we believe, better than any we have previously heard. Our standards give us a tone which sounds absolutely satisfactory; but on a very careful test we find that the Marconiphone curves are justified: there is a distinct increase of comparative strength of the extreme top and bottom notes with the Marconi when the main bulk of the music is of equal loudness in both transformers.

One result of the extremely low self-capacity must be noted: the transformer is extremely sensitive to added capacity; even a condenser of ·0005μF across the secondary causes a great change of tone in the higher ratios.

Further, the self-capacity is so low that it will not by-pass H.F. currents as it will in most transformers. Hence the transformer is difficult to use in reflex circuits. We found it impossible with our usual series H.F. and L.F. connections, and had to change over to the parallel arrangement, with stop condenser and radio-frequency choke.



The transformer is expensive—it costs 35s.—but we believe it to be of such exceptional quality as to be good value. A disadvantage inherent in its quality is the large size; it is $3\frac{3}{4}$ in. by 3 in., and $3\frac{1}{4}$ in. high overall.

Editorial Note.

We have received many inquiries from readers regarding an index and also binding covers for the first volume of EXPERIMENTAL WIRELESS & THE WIRELESS ENGINEER. *We have pleasure in reporting that these are now in course of preparation. The index will probably be included in our next issue, when particulars will be given of the binding covers.*

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.

Direct Current Measuring Instruments.

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

SIR,—With reference to the article by Mr. Leonard A. Sayce in the September issue of E.W. & W.E., I have had two Weston relays in use, one as a voltmeter and one as an ammeter, for some time, and they have given every satisfaction. Personally, I prefer to use the instruments in a horizontal position, and for this they are fitted with the usual three legs, two of which are fine-threaded screws. A circular spirit level, such as are used on cameras, is fixed to the top of the instrument. The hair springs by which the current is led to the moving contact were not removed, and whilst not quite so sensitive as the one described, the instruments gave a full scale deflection with 0·00 4 ampère, equivalent to 0·00001 ampère per division. A shunt box is used in conjunction with the ammeter, and a series resistance box with the voltmeter. The ammeter ranges are: 0·0004, 0·001, 0·002, 0·004, 0·01, 0·02, 0·04, 0·1, 0·2, 0·4, 1, 2, 4 and 10 ampères. The voltmeter ranges are: 0·15, 0·3, 0·6, 1·5, 3, 6, 15, 30, 60, 150 and 300 volts. For accurate work a number of ranges are necessary owing to the shortness of the scale.

H. H. DYER.

22, Leopold Street,
Derby.

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

SIR,—The following notes may usefully supplement my article on the conversion of Weston relays, which appeared in the September issue of EXPERIMENTAL WIRELESS & THE WIRELESS ENGINEER:—

The range of the converted relay may be extended to any desired extent by the provision of suitable shunts.

If the total current $=$ I
 the portion flowing through the instrument $= I_g$,
 the portion flowing through the shunt $= I_s$,
 Resistance of instrument $= R_g$,
 Resistance of shunt $= R_s$,
then

$$R_s=\frac{I_g\times R_g}{I-I_g}$$

The instrument itself gives a full-scale deflection for (say) 0·000 28 amp. Suppose we wish to use it as a milliammeter, for plotting valve characteristics. It would be convenient if it registered 0 to 8mA. Taking the resistance of the coil (R_g) at 350ω:—

$$R_s=\frac{I_g+R_g}{I-I_g}=\frac{\cdot00028\times350}{\cdot008-\cdot00028}=12\cdot7\omega$$

A resistance coil of this value can be made by taking 12 in. of No. 40 D.S.C. Eureka resistance wire and winding it upon a short length of ebonite rod.

Thus the converted relay can provide us with a means of measuring small or large currents of any order of magnitude. But its utility need not stop here, for it may serve as a voltmeter of any range if suitable resistances are included in series with it. Suppose, for instance, that we require to make it into a voltmeter having a range of 0 to 8 volts. We have assumed that a current of .000-28A produces a full-scale deflection, so the total resistance of moving coil and series resistance must be such as to pass this current when the voltage across them both is 8. The total resistance must then be $8 \div 000\ 28 = 30\ 000\omega$, *i.e.*, the added series resistance must be in the order of 29 700ω.

In conclusion, it may be pointed out that the movement of the Weston relay is of the finest construction, so that, if care is taken, there is no reason why the converted instruments should not give every satisfaction.

LEONARD A. SAYCE.

Sunderland.

High Frequency Resistance.

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

SIR,—Your footnote to my article on "An Experimental Determination of High Frequency Resistance" in the September issue of E.W. & W.E. anticipates a somewhat similar table of results by other experimenters which it was my intention to send you. Consideration of these figures has led me to believe that the disparity between my results and those of the formulæ is probably due to the error introduced by the ammeter, for the hot wire in this instrument is divided into four parallel paths, and the slightest lack of symmetry in the inductance of these paths will produce a non-uniform distribution of current in the wire. This will cause a larger deflection for a given current than would otherwise be the case.

I should also like to thank Mr. Edward Hughes, B.Sc., A.M.I.E.E., of Brighton Technical College, for his helpful advice at all stages of the work and for permission to use the apparatus required.

W. G. WHITE.

Brighton.

A Full Wave Rectifier.

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

SIR,—Since writing the article on the above, I have adjusted several buzzers for friends who have made up similar rectifiers, and in all but one case the buzzers operated quite satisfactorily without any magnetising current. In the odd case, the magnet was not sufficiently magnetised, but using the 32 ohm windings in parallel made the magnet too strong. It appears from this that the strength of the magnet in relation to the flux due to the operating current is important. I mention this in case difficulty is experienced in obtaining sparkless rectification. I myself have had a buzzer running quite satisfactorily with a permanent magnet for about two months.

May I call attention to a little slip in the size of the base? The thickness is given as 3¼ in., this should be ¼ in. In column four of the table P.N. should be P.M., meaning, of course, permanent magnet instrument.

H. H. DYER.

22, Leopold Street,
Derby.

A Universal Meter.

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

SIR,—In reply to Mr. E. Lester Smith's criticism of my article "A Universal Meter," I was, of course, aware that the field should be radial and also that in *pivoted* commercial instruments this condition is obtained by using circular pole pieces and a fixed iron centre. This construction does not, however, increase the sensitivity unless it is carefully constructed so that the two air gaps in series are less than the air gap in the type described. Since this type of coil has four faces to keep clear of the stationary parts instead of two, the instrument as made by the amateur would probably have a much larger total air gap than the type described. The standard of workmanship in commercial moving coil instruments is very high indeed. Most *suspended* coil commercial instruments have no iron centre and flat pale faces.

It is certainly not desirable to use a very long scale, but if this error is avoided very satisfactory results can be obtained.

I enclose a comparison of the readings on the instrument illustrated in my article and of a Weston ammeter placed in series with it. It will be seen that the combined effect of all the errors of design and construction are by no means as serious as Mr. Smith seems to fear.

I agree, however, that it would be preferable to take more than one point. The suggestion to make the curve from one point was intended for experimenters who had only one standard 1 000 ohm resistance as mentioned. I expected that those who had better facilities for calibration would use them.

Home-Made Instrument.		Weston Instrument.
Even Scale Division.	Reading ÷ 1·100	
11	·010	·010
22	·020	·020
32	·029	·030
44	·040	·040
57	·052	·050
69	·063	·060
82	·074	·070

Leicester. HAROLD E. DYSON.

Spark Jamming.

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

SIR,—Regarding Mr. R. H. P. Collings' letter in the current issue, this end of the Channel is certainly a hotbed of spark jamming. I think the chief trouble with FFU is that it radiates harmonics to a greater extent than most spark stations. Here (just by Plymouth) FFU is not nearly so bad as it is farther west. The French trawlers, however, often seriously interfere with 5PY at a distance of only half a mile from the latter. Naval buzzer sets and Rame Head are sometimes bad, and an occasional foreign liner or American cargo boat yelling for FFH, or even PCH, liven matters up. Even heart-shaped reception does not avail at times, and, of course, any form of tuning, including rejecting, is useless. The employment of a limiting valve, however, in conjunction with judicious use of loose coupling, *will* do the trick.

L. J. VOSS.

Saltram Point,
Plympton,
Devon.

H.F. Amplification.

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

SIR,—I note with interest an article in the September issue of EXPERIMENTAL WIRELESS by Mr. Lewer on the use of Low-Frequency Amplification for Long Distance Reception. I am, however, amazed at the last paragraphs, in which the author compares H.F. and L.F. for DX work. There has recently been a wave of feeling against H.F. amplification, but I am very disappointed that anyone who has done such wonderful reception as Mr. Lewer should adopt this attitude.

Some time ago H.F. was in invariable use, but now, as we drop to shorter waves, H.F. is being dropped also. When we worked on 1 000 metres we said H.F. was only just possible and not much good below that figure, we found later that this was not so. It is the same in this instance. H.F. will work as low as one cares to make it.

Consider Mr. Lewer's table. (1) Selectivity. H.F. has the advantage of cutting out local interference to a great extent and is undoubtedly a help. However, Mr. Lewer says this tends to become a disadvantage when receiving weak signals. Since we are discussing receiving C.W. in an oscillating state, I should like to know how the selectivity effects it—obviously it cannot. What happens is that the tuning is sharper and stations are liable to be passed over. The cure is obvious —use a much smaller tuning condenser, with a fine adjustment.

On 100 metres about ·0001 is the minimum desirable capacity for normal work and this is best provided by a small fixed condenser in parallel with the usual one. This flattens the tuning merely because the range with the coil is not as great, but it does not increase the selectivity. The sensitivity advantage is of course very great. The extra difficulty in tuning is not noticeable if the set is properly designed. The reaction coil needs only infrequent adjustment if correctly made and it is just a matter of practice.

The second disadvantage does not exist. To all intents and purposes everyone reacts from the detector to the aerial nowadays and the aerial resistance loss is got over as with the other method. The extra capacity in detector grid circuit mentioned is a point I fail to see, for if the set is designed there is less capacity on an H.F. set detector than on an L.F. set. The body capacity effects are easily avoidable and a set using L.F. is just as susceptible if badly designed.

Not only is H.F. a great benefit on 50 metres but it is also possible to obtain noticeable amplification of about 20 per cent., using four-pin valves, on waves between 20 and 30 metres. Using V-24 valves and a set built for the job, instead of putting in condensers and coils of slightly smaller sizes, I am positive H.F. can be made enormously worth while down to 20 metres or below.

FREDERIC L. HOGG.

Running Valves in Parallel.

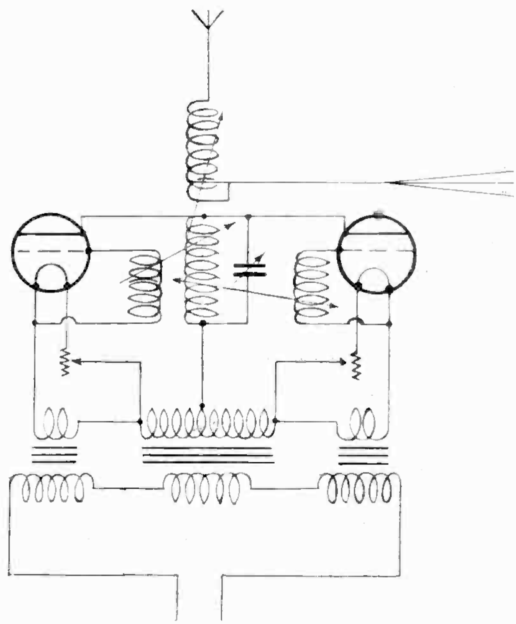
The Editor, E.W. & W.E.

SIR,—In looking over the August number of your magazine, I noticed an article on radio station G.5RZ. I also note that difficulty was found in balancing two valves when used on opposite sides of the circuit.

The writer had the same difficulty several years ago, and resolved to correct it by changing the circuit, but at the same time to rectify both halves of the wave. This was done by connecting the two plates together and running this common terminal through the helix and back to the centre tap on the transformer. The separate filament transformers which were well insulated were attached to the ends of the high tension supply. The grids were coupled inductively to the plate coil, and by placing a milliammeter in each plate circuit the two tubes could be balanced perfectly by varying the position of each grid coil separately. The diagram herewith explains this.

The writer found after a number of experiments on this that a similar scheme had been worked out in the Navy in some experimental work along the same lines.

While this scheme necessitates well insulated filament transformers, it is frequently of value where the difficulties of balancing tubes in the ordinary circuit become great.



In connection with your electrolytic rectifiers, I am wondering if you are familiar with the tantalum rectifier, employing tantalum and lead electrodes in a 10 per cent. or 15 per cent. solution of sulphuric acid. The rectifying action is much better than aluminium. A commercial form of six-volt battery charger, employing this rectifier unit, is quite popular here, and I understand that the Fansteel Company of North Chicago, Illinois, who manufacture the tantalum, are selling electrodes for high tension rectifiers for which they claim rather remarkable results. I am rather sure that a word to them from you would bring some very interesting information.

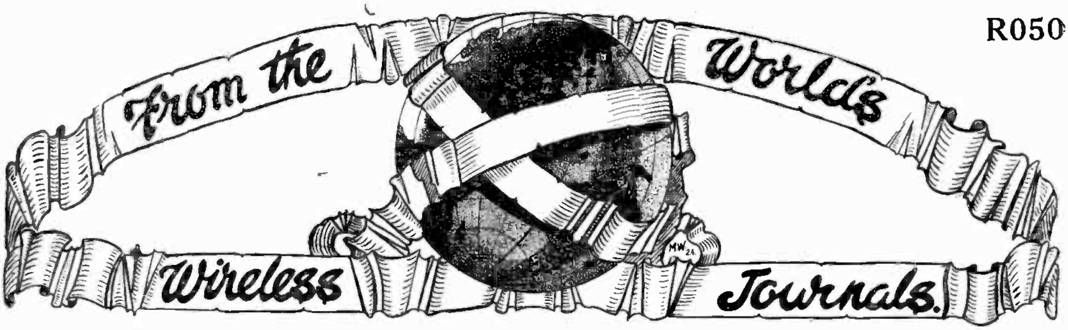
JOHN H. MILLER,
Electrical Engineer,
Jewell Electrical Instrument Co.

Chicago.

[The difficulty with regard to the tantalum rectifier, in England, has been to obtain plates: we are taking up Mr. Miller's hint, and will report results in a later issue.—ED., E.W. & W.E.]

A CORRECTION.—In the article entitled "Further Notes on Resistance-Capacity Amplification," by F. M. Colebrook, published in last month's issue, an error occurred on p. 716. The first equation was printed as $Z=R\times\frac{1}{\omega C}$. The $\times$ sign should of course have been $\div$.

R050



R100.—THEORY AND PRINCIPLE.

R110.—A NEW THEORY OF LONG DISTANCE RADIO COMMUNICATION.—Prof. G. W. O. Howe, D.Sc. (*Electn.*, *Sept.* 12, 1924).

An analysis of the propagation of wireless waves, based on an assumption of the Heaviside layer.

THE DIELECTRIC PROPERTIES REQUIRED FOR MAXWELIAN RADIATION.—A. Press. (*Phil. Mag.*, Sept.).

A mathematical analysis.

R121-2.—NODAL POINTS AND AERIAL TUNING.—P. K. Turner (*Exp. W.*, Sept.).

A simple theoretical discussion of the potential distribution along an aerial with respect to frequency and aerial length. An analysis is given showing how the harmonics of an aerial may be deduced for given aerial constants and loading values.

R148·1.—FAITHFUL REPRODUCTION IN RADIO-TELEPHONY.—L. C. Pocock, B.Sc. (*Journ. Inst., E.E.*, Sept.).

A general consideration of the transmission of articulate speech by wireless. Various types of distortion are analysed, namely, frequency distortion, amplitude distortion, faulty modulation, additive distortion and the non-linearity of the response characteristic of the human ear.

R200.—MEASUREMENTS AND STANDARDISATION.

R210.—WAVEMETERS FOR THE NEW RANGES.—S. Kruse (*Q.S.T.*, Sept.).

Description of method of calibrating a wavemeter for wave-lengths between 20 and 80 metres by using the harmonics of another wavemeter built for the 200 metre band.

R240.—AN EXPERIMENTAL DETERMINATION OF HIGH FREQUENCY RESISTANCE.—W. G. White (*Exp. W.*, Sept.).

Some measurements of H.F. currents at various frequencies by the use of a thermo-junction to measure the heating effect of the currents on a test wire.

R250.—HOT WIRE *v.* THERMOCOUPLE AMMETERS.—H. B. Richmond (*Q.S.T.*, Sept.).

A summary of the relative merits of the two types of H.F. ammeter.

R270.—TRANSMISSION EXPERIMENTS AT 8AQO.—S. Kruse (*Q.S.T.*, Sept.).

First part of an article describing some experiments to test the relative merits of the buried earth and counterpoise for transmission on various wavelengths.

R300.—APPARATUS AND EQUIPMENT.

R342·2.—FURTHER NOTES ON RESISTANCE-CAPACITY AMPLIFICATION.—F. M. Colebrook (*Exp. W.*, Sept.).

A detailed article on resistance amplifiers for speech frequencies. Careful attention is given to conditions of working, particularly to the best values of anode resistance, grid-leak and coupling condenser.

R342·5.—CONSTRUCTION D'AMPLIFICATEURS DE PUISSANCE.—P. Dastouet (*R. Elec.*, Aug. 25).

A short description of a two-stage transformer-coupled power amplifier and a resistance-coupled push-pull power amplifier for loud-speaker work. Constructional details of intervalve power transformers are given.

R342·7.—THE USE OF LOW-FREQUENCY AMPLIFICATION FOR LONG-DISTANCE RECEPTION.—S. K. Lewer (*Exp. W.*, Sept., 1924).

Some practical notes on the reception of signals using a detector valve with reaction followed by low-frequency ampification.

R342·701.—THE PERFORMANCE AND PROPERTIES OF TELEPHONIC FREQUENCY INTERVALVE TRANSFORMERS.—D. W. Dye, B.Sc. (*Exp. W.*, Sept.).

Methods are described for measuring the effective primary inductance and resistance of audio-frequency intervalve transformers.

R343.—A COMBINED TEST AND BROADCAST RECEIVER.—(*Exp. W.*, Sept.).

Details of an ingeniously designed receiver for testing all kinds of circuits and components.

R343·5.—GETTING RESULTS WITH AN ARMSTRONG SUPER. J. G. W. Thompson (*W. World*, Aug. 27 and Sept. 3).

Description of a compact super-regenerative set for short wave reception. The electrical constants of various components are given, together with some details of the performance of the set.

R370.—THE BEST CRYSTAL CIRCUITS.—W. B. Medlam, B. Sc. and U. A. Oschwald, B.A., (*W. World*, Aug. 20 and Aug. 27).

A discussion on the relative merits of different crystal circuits for reception on broadcast wave-lengths. Results are given of quantitative observations with various values of inductance in the aerial and crystal circuits.

R376·3.—THE EFFECT OF A HORN ON THE PITCH OF A LOUD-SPEAKING TELEPHONE.—E. W. Kellogg (*Gen. El. Rev.*, Aug.).

An interpretation of certain formulæ developed by Lord Rayleigh.

R382·6.—THE BASKET-WEAVE COIL.—G. W. Pickard (*Q.S.T.*, Sept.).

Note on losses and wire sizes in the Lorenz-type winding.

R386.—FREQUENCY FILTERS.—E. K. Sandeman, B.Sc. (*W. World*, Sept. 3 and Sept. 10).

An elementary consideration of electrical and analogous mechanical filters for the purpose of allowing the transference of energy at certain frequencies and the suppression of other frequencies. High-pass, low-pass and band-bass filters are described.

R400.—SYSTEMS OF WORKING.

R402.—WORKING AT 20, 40 AND 80 METRES.—S. Kruse (*Q.S.T.*, Sept.).

Some notes on reception and transmission on these short wave-lengths. Several suitable receiving circuits, as well as transmitting circuits, are given, with data of size of capacities and inductances required.

R500.—APPLICATIONS AND USES.

AIR MAIL WIRELESS EQUIPMENT.—*W. World*, Sept. 10).

A description of the transmitting and receiving equipment used on the aeroplanes of the U.S. Post Office Department.

R600.—STATIONS: DESIGN, OPERATION AND MANAGEMENT.

R610.—5XX.—(*Exp. W.*, Sept.).

A technical description of the British Broadcasting Company's high-power station.

R800.—NON-RADIO SUBJECTS.

PROPERTIES OF FUSIBLE ALLOYS. (*W. World*. Aug. 20).

A short note on the composition and properties of various well-known fusible alloys.

DESIGNING SMALL POWER TRANSFORMERS.—W. James (*W. World*, Aug. 27).

An elementary résumé of the principles involved in the design and construction of transformers for small powers at commercial frequencies.

SOUND IN RELATION TO WIRELESS.—Prof. E. Mallet, M.Sc. (*W. World*, Sept. 10).

A general explanation of the nature of sound and wave-motion in material media.

A SIMPLE METHOD OF MAKING DIRECT-CURRENT MEASURING INSTRUMENTS.—L. A. Sayce, M.Sc. (*Exp. W.*, Sept.).

A description of how ex-W.D. Weston relays may be converted into D.C. measuring instruments.

A FULL WAVE RECTIFIER.—H. H. Dyer (*Exp. W.*, Sept.).

Description of how a vibrating rectifier can be constructed from an ex-W.D. D III. buzzer.

THE PROBLEM OF HIGH-TENSION SUPPLY, IV.—R. Mines, B.Sc. (*Exp. W.*, Sept.).

One of a series of articles on high-voltage supply for power valves, etc. Induction coil and interrupter methods are described for driving high-tension A.C. from low-tension D.C. sources.

STUDIES OF ELECTRIC DISCHARGES IN GASES AT LOW PRESSURES.—Dr. Irving Langmuir and H. Mott-Smith (*Gen. El. Rev.*, Aug.).

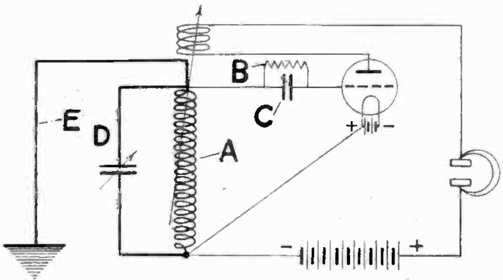
Experimental data, illustrating the use of plane collectors.

Some Recent Patents

RECEIVER WITHOUT AERIAL.

(*Application dates, January* 11 *and March* 23, 1923.)

Patent No. 217,259 of D. S. B. Shannon is intended to cover a regenerative or super-regenerative receiver wherein the grid end of the grid tuning



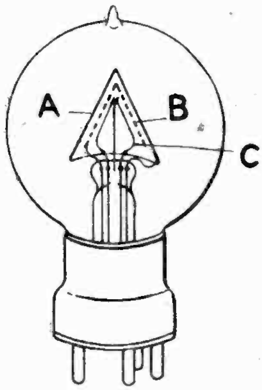
inductance is connected to earth, the lower end being connected to the positive terminal of the L.T. battery and the negative terminal of the H.T. battery. The grid-condenser C is of larger capacity than usual and may have a capacity between ·0005 and ·02m.F, while the grid-leak B has a low value of about 100 000 ohms. It will be seen that the grid of the detector has normally a slight positive bias. Presumably the capacity of the set to earth has the necessary aerial effect.

INTERFERENCE FROM IGNITION SYSTEMS.

(*Application date, February* 10, 1923.)

Reception of wireless signals on cars or aeroplanes may be seriously interfered with by short-wave damped oscillations set up in the ignition leads by the discharges at the sparking plugs in the engine. Patent No. 217,270 of V. Kulebakin covers a simple but ingenious method of eliminating these disturbances. The leads from the magnets to the sparking plugs are made of such high resistance as to be aperiodic from an H.F. point of view while being still sufficiently conductive for ignition purposes. Each discharge is thus made dead-beat and no oscillatory currents are produced. The ignition leads may, for instance, be oxidised iron chains, thus introducing a large number of contact resistances in series.

VALVE CONSTRUCTION.



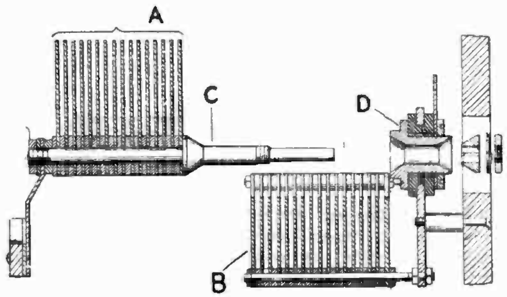
(*Application date, January* 4, 1923.)

In Patent No. 217,256 the British Thomson-Houston Co., Ltd., cover the use of conical electrode elements. The anode A and grid B are coaxial cones while the filament C may take the form of an inverted **V** or a conical spiral. The object is to provide a dome-like electrode structure while at the same time keeping the electron-emitting cathode symmetrical with respect to the other electrodes.

CONDENSER CONSTRUCTION.

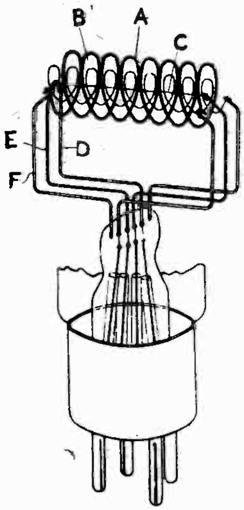
(*Convention date, February* 1, 1923.)

The main purpose of the construction illustrated is to reduce the labour of assembly by making it possible to introduce or withdraw the moving plates and shaft A as a complete unit without interfering with the fixed plates B. This is accomplished by discarding the bottom end-plate and bearing and having one substantial conical bearing C D at the top. (Patent No. 210,771, E. S. Miller.)



SPIRAL ANODE VALVE.

(*Application date, March* 19, 1923.)



Patent No. 217,647, held by T. W. Lowden, covers a thermionic discharge tube having an anode A consisting of a spaced helix of wire surrounding the cathode C, no parts of the helix being short-circuited. Electrical connection from the lead-in wire is made to one end of the anode spiral through one of the supports. This type of construction is used also in the Penton and Thorpe valves, and its exact advantages have always seemed to us rather problematical. Perhaps, however, it is simply to avoid earlier valve patents, which usually specified an anode in the form of a cylindrical sheet.

EVACUATING WATER-COOLED POWER VALVES.

(*Application date, February* 14, 1923.)

In the process of pumping hard power valves it is desirable to raise the anode to a high temperature in order to release occluded gases. This involves a difficulty with valves employing a metal anode which also forms part of the envelope and which is sealed to a vitreous portion of envelope, because the seal will be destroyed if a high temperature is applied to it. E. Y. Robinson in Patent No. 217,273 employs means for cooling the metal envelope in the neighbourhood of the seal so that although the rest of the metal envelope may be raised to a high temperature the seal itself is protected.

EARTHING WATER-COOLED ANODES.

(*Application date, March* 15, 1923.)

One of the difficulties with valves having water-cooled anodes is the insulation of the water supply if the anode has a high potential to earth. The obvious alternative, covered by E. Y. Robinson's Patent No. 217,327, is to earth the anode and allow the other electrodes to assume a high potential. If this is done the cooling water may be supplied directly from the water main. The specification describes how the anode may be made the earthed electrode in the case of various single- and polyphase rectifiers and oscillators. We should hardly have attributed sufficient originality to the idea to be the subject of a patent.

VALVE PUMPING PROCEDURE.

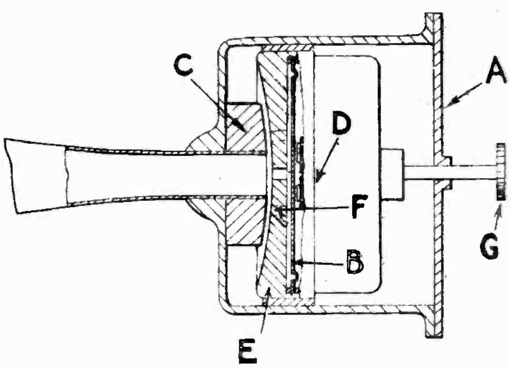
(*Application date, February* 22, 1923.)

It has been common practice for some time to perform the welding of thermionic valve electrodes in an atmosphere of hydrogen gas. The object of this is to prevent the oxidisation of the metal parts and the occlusion of oxygen in the metal itself, as occluded oxygen retards the pumping process and is detrimental to the action of hard valves. In their British Patent 216,207 Messrs. C. Seymour, B. Hodgson, H. G. Hughes and T. E. Goldup, of H.M. Signal School, carry preliminary precautions further by assembling the internal parts of the valve in an atmosphere of some inert gas such as nitrogen. The presence of nitrogen within the bulb is particularly advantageous in those operations where the glass is being subjected to the blowpipe flame. The assemblage in a nitrogen atmosphere is preferably followed by a baking in an atmosphere of hydrogen prior to pumping. The inventors state that with silica valves employing tungsten and molybdenum elements the necessary period of bombardment during exhaustion is materially reduced by the preliminary procedure referred to.

AIR DAMPING IN LOUD SPEAKERS.

(*Application date, January* 24, 1923.)

We are most of us familiar with the result of using an ordinary earpiece in conjunction with a horn as a loud speaker. As soon as we load it up sufficiently to obtain real loud-speaker strength the amplitude of vibration of the diaphragm becomes excessive and it tends to rattle against the pole-pieces or the cap of the receiver. Most properly-constructed loud speakers have larger and stouter diaphragms so that ample sound energy is obtained from a reasonably small amplitude of movement of the diaphragm. In their British Patent 214,718, however, P. L. Wostear and R. H.



Billingsley describe a construction of loud speaker which permits the use of the headphone size of diaphragm without undue distortion or loss of volume. The invention consists essentially in having a cap E very close to the diaphragm B, the cap E being perforated by a small central hole E and other small holes F surrounding it This restriction of the air in front of the diaphragm results in a damping which prevents the diaphragm from taking up excessive amplitudes. At the same time the inventors state that owing to the enhanced intensity of the air displacements at the hole D a large volume of sound is produced. Another feature of the invention is that a screw G is provided by means of which the receiver may be moved longitudinally in the outer case A to allow an adjustment of the gap between E and the washer C, thus allowing an adjustment of the air-damping and the volume of sound emitted.

ATMOSPHERIC ELIMINATION.

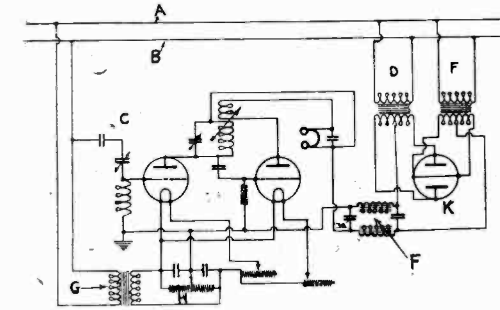
(*Convention date, February* 16, 1923.)

A method for receiving morse signals through atmospherics is described in Patent No. 211,512 of Marconi's Wireless Telegraph Co., Ltd., and R. H. Ranger. The main feature of the invention is the use of a limiting device which is saturated or paralysed by the received marking signal, or the signal plus atmospheric disturbances, but which is not paralysed by the disturbances alone during the spacing intervals. Thus the indicating device is operated by inverse morse or spacing signals. As atmospherics are of short duration and not persistent the limiting device is not ever saturated for any appreciable part of a spacing interval by the atmospherics alone. Means are described for re-inverting the inverse morse signals passed on by the limiter so that intelligible signals are produced at the final indicating device.

RECEIVERS OPERATED ENTIRELY FROM SUPPLY MAINS.

(*Application date, February* 12, 1923.)

J. Robinson and W. H. Derriman have patented "a wireless receiving set adapted to be applied to an electric light or power system so that the

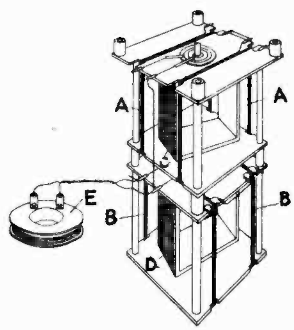


latter forms an aerial for the receiving set and supplies power for operating the receiver." We show a figure illustrating the arrangement of a set adapted to work off A.C. mains. A and B are the main wires which supply the filament lighting transformers E and G and the plate-supply transformer D. K is a full-cycle rectifying valve whose output, after smoothing with the usual combination of condensers and chokes at F, is fed to the anodes of the receiving valves. The usual form of earth connection is used, while one of the supply wires is used as an aerial, connection being made through the condenser C which keeps out the low-frequency A.C. without offering any material impedance to the H.F. currents to be received. H is the usual potentiometer arrangement, which is necessary when A.C. is used for filament heating, the purpose of which is to maintain the mean grid-filament potential constant as far as the low-frequency A.C. component is concerned.

The claims of the patent are very broad, but we cannot trace any single feature in the circuit shown which was not familiar to us before the date of application. The use of the mains as aerial through a series condenser has been common knowledge ever since the "Ducon" adapter made its appearance, and other details on the A.C. side must have been described in numerous periodicals during the last two years. The use of A.C. on the filaments of present type of receiving valve will never be a complete success, however, as there is always a considerable hum due to the low thermal inertia of the filaments. The specification referred to also describes a set adapted to be entirely operated off D.C. mains by the now well-known arrangement of potentiometers and resistances. (British Patent 215,455.)

COMPENSATION OF ERRORS IN DIRECTION FINDERS.

(*Application date, March* 23, 1923.)



C. Seymour and C. E. Horton describe in Patent No. 217,668 a means of compensating quadrantal errors such as may occur in D.F. receivers of the Bellini-Tosi type. Instead of only one search coil for both field coils there are two search coils C and D which rotate within their own sets of field windings A and B. The search coils C and D rotate together and their magnetic axes are parallel while the field coils A and B are at right angles to each other. The field windings A and B are connected respectively to two loop aerials at right angles. The windings C and D are in series with each other and are connected to the input of the receiver. The constants of either field winding may be adjusted independently of the other to compensate for any error. For instance a variable inductance E may be shunted across one of the coils.

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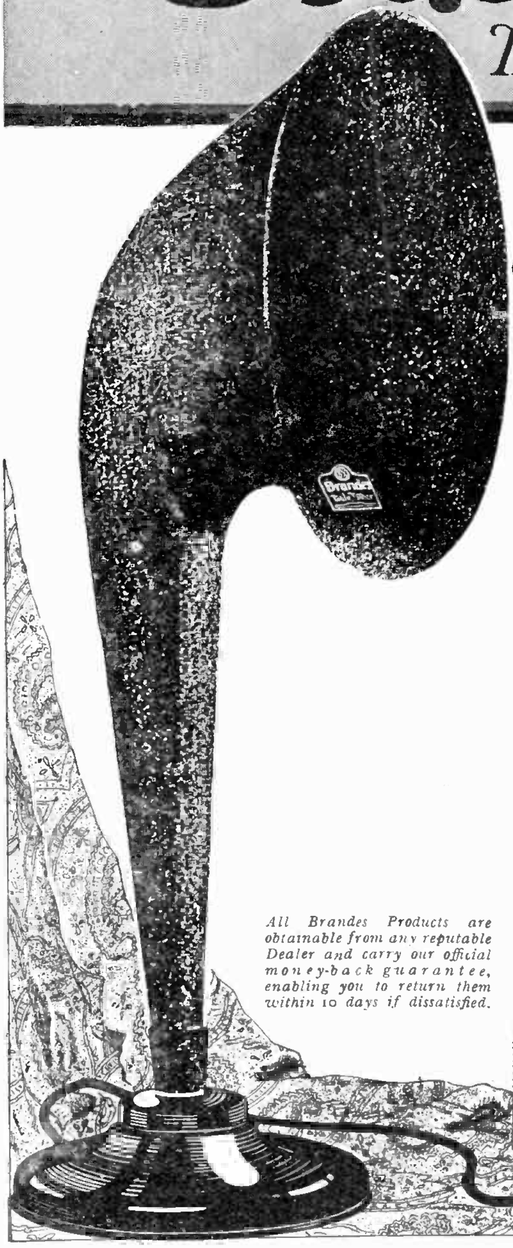

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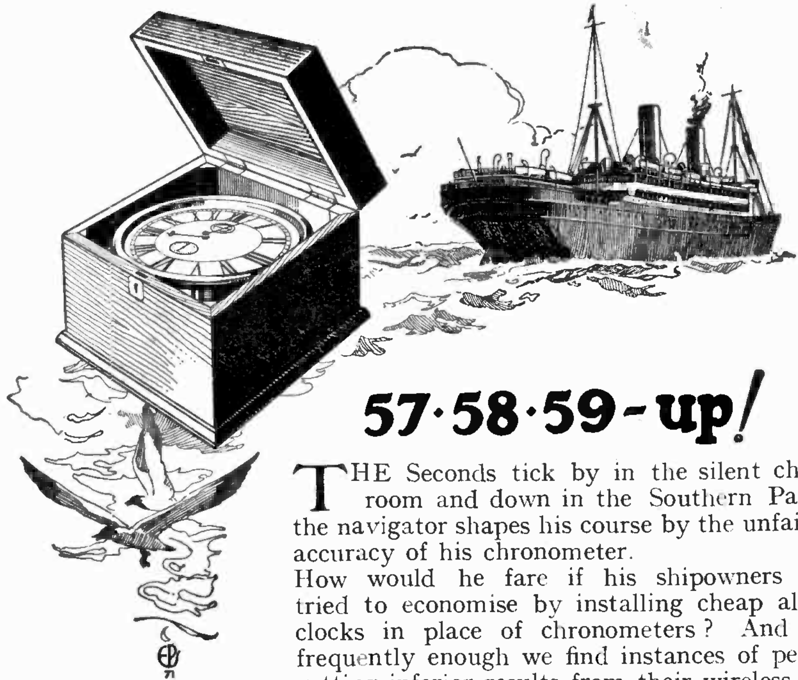

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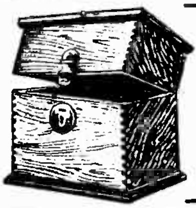

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