EXPERIMENTAL WIRELESS & The WIRELESS ENGINEER

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Editorial Views.

H.F. & L.F.

THE discussion on the choice of L.F. or H.F. amplification for short wave long distance reception has been getting almost acrimonious. But perhaps a discovery of our own may cast oil on the troubled waters. A chance remark in one of the letters gave us the clue, and the great discovery is this: that the opponents are working at cross purposes the whole time! They are sitting down to their sets with quite different ideas of what they want, and naturally they have specialised in sets that suit them.

Mr. Lewer, the originator of the "ruction," is beyond everything interested in logging stations, *i.e.*, getting the maximum number of call signals down. Naturally he wants a set tunable with the greatest ease. Mr. Hogg, on the other hand, specialises in actual communication—two-way working. He wants to get in touch with a given station in Mars or elsewhere, and work it steadily. Naturally he is not so anxious to swing all over the wave-length range every ten seconds; but he wants selectivity and good signals to avoid repetition, so he plumps for an H.F. stage.

The real lesson to be drawn is—the danger of hasty generalisation. It is unsafe to assume that the set which suits *us* best is really the *best* set for everybody.

The Square-law Fallacy.

There is a rage just now for square-law condensers. How many of our readers, we wonder, realise that in practice the square-law condenser does *not* give a "straight-line" curve of wave-length against degrees?

In making this statement we are not referring only to bad condensers, with vanes that are not cut to the accurate "square-law" curve; but to good ones also. The reason is a simple one; in no case, as far as we know, is allowance made for the zero or stray capacity. Take a numerical example. Suppose a condenser of 1 000$\mu\mu$F maximum. In a square-law condenser the condenser is designed to give 250$\mu\mu$F at 90°, while the ordinary type gives 500$\mu\mu$F at this angle. Both, as far as design is concerned, are supposed to have zero capacity at 0°. But actually we must add say 30$\mu\mu$F for stray capacity, and this throws the whole scale out.

As it happens, the effect is much more serious on the square-law condenser. The straight-line condenser still gives a straight line curve of capacity, whatever the "stray." But the square-law, which is supposed to give a straight line curve of wave-length, does not do so if there is stray capacity.

Even if the vanes were cut to a different shape, to give a straight-line law after allowing for the zero capacity, it will still be upset when the condenser is put into use, for allowance must be made for the self-capacity of the coil and the rest of the circuit.

Lest we be accused of hair-splitting, we might mention that in four wave-meters recently calibrated (provided with square-law condensers) the calibration curves were nothing like straight lines.

Do we want the Square-law?

But supposing that we did get a condenser adjusted to give a square-law on a given circuit, is it what we want?

After all, the idea of using a square law is to avoid the difficulty that an ordinary condenser is too sensitive at low angles, *i.e.*, there is too large a change in wave-length for a given movement. In the perfect square-law type, the change of wave, in meters, will be constant for a given movement. But this is not quite right. A change of five metres at 50 metres will affect signal strength as much as one of ten metres at 100 metres. What we really want is that a given movement shall give a constant *percentage* change of wave-length. For this neither the ordinary nor the square-law condenser will do; but plenty such condensers have been made, especially for decremeter work. In fact, the Americans usually refer to these condensers by the name of Kolster, who used them in the standard Kolster Decremeter.

Circuit Calculations.

The article in our last month's issue, on calculating A.C. circuits, appears to have attracted considerable interest. In a sense, Mr. Colebrook's article this month, on the Graphical Analysis of Composite Impedances, is a continuation of it, although it was written before our article.

It appears, however, that further simple explanation is needed on certain points—one reader is quite disinclined to do as we requested, and take our word for it that a condenser carries a leading current—and so we propose to give (probably next month) a further article, dealing with sine-waves, amplitude, phase, vectors and such-like mysteries.

The White City Show.

A rapid inspection of the White City Exhibition—all that we had time for before going to press—showed that although it opened with little ostentation, and did not occupy a very large space, there was an astonishing amount of novel and useful stuff for the amateur. There was not very much in the way of expensive cabinet sets to tempt the plutocrat—though the few such sets shown were very fine—but the components and accessories that we depend on were present in full force.

Crystals.

We have in hand quite a large batch of crystals for test, which would normally have been reported this month.

But we have always realised that our method of testing crystals (though better, we believe, than most methods commonly adopted) has been not entirely satisfactory, and the only thing that has prevented us from adopting a different method has been the difficulty, first of finding the correct method and second, of applying it.

The problem is, in fact, an exceedingly complex one. It is obviously desirable to apply a known H.F. voltage, and measure the resulting D.C. output. But the matter is complicated by the fact that to get the best out of the crystal one must try it with a large number of different loads in the output, and that the change of output load affects the power taken. As a result, it would take two or three hours to test a single point on a single sample.

We have therefore decided on a compromise. We propose to report the performance of a crystal *under normal conditions, i.e.*, with a load corresponding to that of an ordinary pair of phones. Preparations for such testing are now under way, but a surprising amount of work is required. The problem involves measuring radio-frequency voltages from about ·1 volt up to 1 volt, and currents of a few milliamps, as well as D.C. currents of a few microamps. This in turn necessitates the calibration of a delicate thermo-junction, the making and calibration of a Moullin voltmeter, and the construction of a stable H.F. oscillator. Certainly none of these tasks are very difficult, but they consume a good deal of time. We hope next month to have some results.

Calibration.

We regret that, although we have cleared off all wavemeter calibrations and almost all other calibration work, the checking of our instruments is not yet complete, so that we are not yet ready to receive apparatus again, except as regards the measurement of resistance and the checking of ammeters and voltmeters, which we can do.

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

Part III: R200—Measurements and Standards.

Continuing our list of reference numbers for the filing of wireless information, we now deal with the important subject of measurement. For the first time we find what appears a flaw in the B.S. extension, and in spite of our desire to adhere to an existing classification, we feel impelled to suggest a slight change, as will be seen below.

R200 Measurements and Standards.

The scope of this section is clearly indicated by its title, and no further explanation appears necessary.

R201 General methods and apparatus.

In the B.S. extension, various headings are given under 201 to 205, as follows :—

R201·2 *Use of valves.*
·5 *Shielding and earthing.*
·6 *Bridge methods.*
·7 *Oscillographs.*
R202 *Resonance methods.*
R203 *Harmonics.*
R204 *Null methods.*
R205 *Substitution methods.*

It appears to us, however, that this subdivision might cause much confusion by clashing with the general "form divisions," which are supposed to be applicable to any number : *e.g.*, R201·5 is given above as "shielding." But on the form division (see E.W. & W.E., October, 1924, p. 8) ·015 means "various theories," so 201·5 should mean "various theories on measurement."

We therefore, while giving the above numbers for completeness, suggest that they be not used, and propose to arrange similar entries in a way consistent with the "form division." R201 remains "General methods," as this is consistent. It will be noted that the divisions which follow fall in with those given under R000 (E.W. & W.E., October, 1924, p. 8) but extend them somewhat. Further, this allows the "method" subdivision to be used for any type of test : *e.g.*, R201·21, Bridge methods ; R220·121, Bridge methods for measuring capacity.

*R201·15 Formulæ.
*R201·2 Classification of methods.
* ·21 Null methods in general, including bridge tests.
* ·22 Resonance methods, including harmonics.
* ·23 Substitution methods.
*R208 Miscellaneous matters in measurement.
*R208·1 Calibration tables.
* ·2 Calibration charts.
* ·6 Standard generators for test work (special oscillators, etc.).
* ·7 Means of detection : general notes. For detecting current, voltage, etc., see below.
* ·8 Screening, earthing, and precision precautions generally.

*** These subdivisions are proposed by us as a tentative further extension.** B2

R210 Frequency and wave-length.

R211 Resonance methods.
R213 Extending by harmonics.
*R217 Absolute measurements.
*R218 Standards.

R220 Capacity.

R223 Dielectric constant.

R225 Self-capacity of coils, etc.
*R227 Absolute measurements.
*R228 Standards.

Note that measurements of dielectric loss (or power factor or phase difference) are really measurements of resistance. (See R240.)

R230 Inductance.

R231 Self-inductance.
R235 Mutual inductance.
*R237 Absolute measurements.
*R238 Standards.

R240 Resistance, damping, etc.

*R245 Radiation resistance.
*R248 Standards.

R250 Current.

R251 Current measuring instruments (ammeters, etc.).
R251·1 Hot-wire ammeters.
·2 Thermo-junctions.
·3 Current transformers.
·4 Dynamometer type instruments.
·5 The Einthoven galvanometer and similar instruments.
·6 Bolometers.
*R257 Absolute measurements.
*R258 Standards

R260 Voltage.

R261 Valve voltmeters (Moullin, etc.).
R262 Spark-gap voltage measurers.
R263 Electrostatic voltmeters.
*R267 Absolute measurements.
*R268 Standards.
R269 Voltmeters not indicated above.

R270 Signal strength measurement.

R271 Shunted telephone and similar methods.
R272 Radio-frequency comparison methods.
R273 Audio-frequency comparison methods.
R275 Modulation measurements.

R280 Properties of materials.

R281 Insulating materials.

NOTE.—We have added the following subdivision to apply either to insulating materials as a whole or to any of them :—

*·012 Special properties.
*·012·1 Volume resistivity.
* ·2 Surface resistivity.
* ·3 Dielectric strength.
* ·4 Dielectric constant.
* ·5 Dielectric losses.
* ·6 Effect of temperature, humidity, etc.

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

R281·1	Laminated insulators (Bakelite, Fibre, etc.).
·11	Phenolic types (Bakelite, Condensite, etc.).
·13	Fibre.
·2	Moulding materials.
·31	Porcelain.
·33	Glass.
·35	Rubber and ebonite.
·37	Gutta-percha.
·38	Mica.
·383	Built-up mica compounds.
·41	Textile materials.
·42	Paper and cardboard.
·43	Wood.
·44	Waxes.
·45	Pitch.
·46	Paraffin wax.
·47	Varnishes.
·48	Shellac.
·49	Oils.
·6	Resins.
·61	Natural resins.
·62	Synthetic.
·7	Minerals, etc.
·71	Quartz.
·72	Marble.
·73	Granite.
·74	Slate.
·75	Lava.
·76	Asbestos.
·77	Sulphur.
·78	Amber.
·79	Celluloid.
·8	Other cellulose esters (viscose, etc.).
·81	Oxide coatings on metals.
·82	Stoneware, vitrified clay products, etc.
·83	Casein products.
·9	Miscellaneous.
R282	Electrolytes.
*R282·1	Water.
* ·2	Sulphuric acid solutions.
R283	Magnetic materials.
*R283·1	Ordinary iron and steels.
* ·2	Special electrical steels.
* ·5	Non-ferrous magnetic materials.
R284	Simple Conductors (*i.e.*, "conductors of the first class").
R284·1	Pure metals.
·11	Copper.
·13	Tungsten.
* ·2	Alloys.
*R285	Gaseous conductors.

This is reserved for general considerations. Applications such as the valve, the arc, and the spark, are dealt with elsewhere.

R290 Other measurements.

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

The Numans Oscillator.

By K. C. van Ryn. [R344

This circuit—a new one from Holland—may be used with either single or double-grid valves, and makes an effective wave-meter.

IN valve-oscillator circuits, up to now, it has been the practice to use two coupled coils (Tickler coil), one with a centre tap (Hartley), or a single coil with a "tapped" condenser (Colpitts). For use as a heterodyne wave-meter all these circuits have the drawback of the necessary use of two coupled coils or two separate condensers, which make them difficult to handle and unsuitable for measuring purposes.

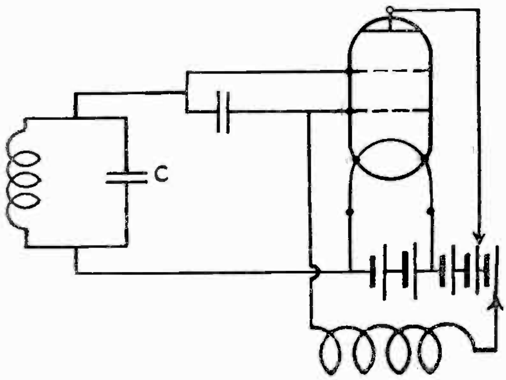


Fig. 1.

This article describes a valve circuit that sets up oscillations in *any closed circuit* containing inductance, capacity and resistance, such as an ordinary condenser and coil (wave-meter), a telephone winding, a transformer winding or an aerial circuit.

As in all usual valve-oscillator circuits we have different ways of feeding the valve. In Fig. 1 the valve is fed in shunt. Fig. 2 shows the same circuit but with series feed.

In Figs. 1 and 2 a double-grid valve is shown, but an ordinary one will do for this purpose. *The principle does not depend on any particular dimensions or on the use of a double-grid valve.*

The New System.

To explain the system we will consider first the characteristic curve of a double-grid valve, Fig. 3. In this type of valve the auxiliary grid (the one next to the filament) is kept at a positive potential, just like the anode. Auxiliary grid and anode will then each take a part of the total electron stream from the filament. Generally the auxiliary grid current and the anode current will not have the same value.

Assume that the control or outer grid is now brought to a negative potential: the electrons, which on their way from the filament to the anode have passed the auxiliary grid, will be pushed back and *partly* reach the auxiliary grid, instead of the anode.

A *negative* charge on the control grid thus causes an *increase* in auxiliary grid current. This happens in the part *bc* of the curve.

If we go on increasing the negative potential of the control grid, its field, which reaches through the meshes of the auxiliary grid, will at last become so strong that the electrons will be pushed back before having actually reached the auxiliary grid. When this occurs we observe a *decrease* of the auxiliary grid current, when *increasing* the *negative* control grid potential. We then

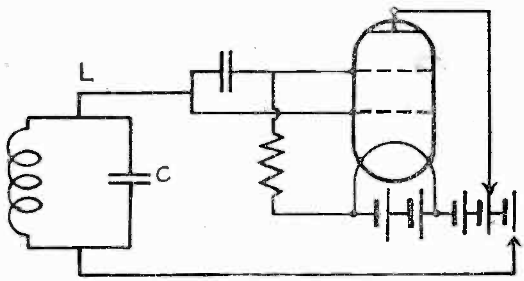


Fig. 2.

come to the part *cd* of the curve where the fluctuations of the control grid voltage are in phase with the auxiliary grid current fluctuations. We mention this phenomenon in order to explain later on some deviations that may occur.

The same phenomena take place in a single grid valve, when using the anode as a "control grid" and the grid as an "auxiliary grid." However, with ordinary makes of single grid valves, the first part of the curve is very small and therefore unsuitable for our purpose. Ordinary makes of double grid valves are better, because in this case the field of the anode can assist the auxiliary grid field to pull the electrons through the meshes of the auxiliary grid.

In the case of this oscillator circuit we want the valve to work in the first part of the curve (*bc*), where the control grid voltage fluctuations are 180° out of phase with the auxiliary grid current fluctuations. Looking at the *combination* of the two grids, we find that this forms, *as regards the closed circuit*, a negative resistance device, *i.e.*, a negative potential on the control grid, induced by the closed circuit, gives rise to an increase of the auxiliary grid current, flowing through the same closed circuit.

It will therefore be clear that any circuit containing inductance, capacity and resistance, connected between the filament and the combination of the two grids, will start to oscillate at very nearly its own frequency.

Perhaps a more simple explanation of the operation of this oscillator circuit is the following :—

The closed circuit LC forms part of the control grid circuit (acting as an input circuit) as well as of the auxiliary grid circuit (acting as an output circuit). Thus the auxiliary grid circuit feeds back to the control grid circuit by means of the common closed circuit. As a result of the phase difference of 180° between the fluctuations of control grid potential and auxiliary grid current, this feed-back is in the right direction, so that oscillations are produced. In this circuit the maximum possible coupling between input and output circuits is obtained (100 per cent.).

This is the principle of a new apparatus which opens a large field of extremely useful applications, not only for communication purposes, but also for accurate measurements.

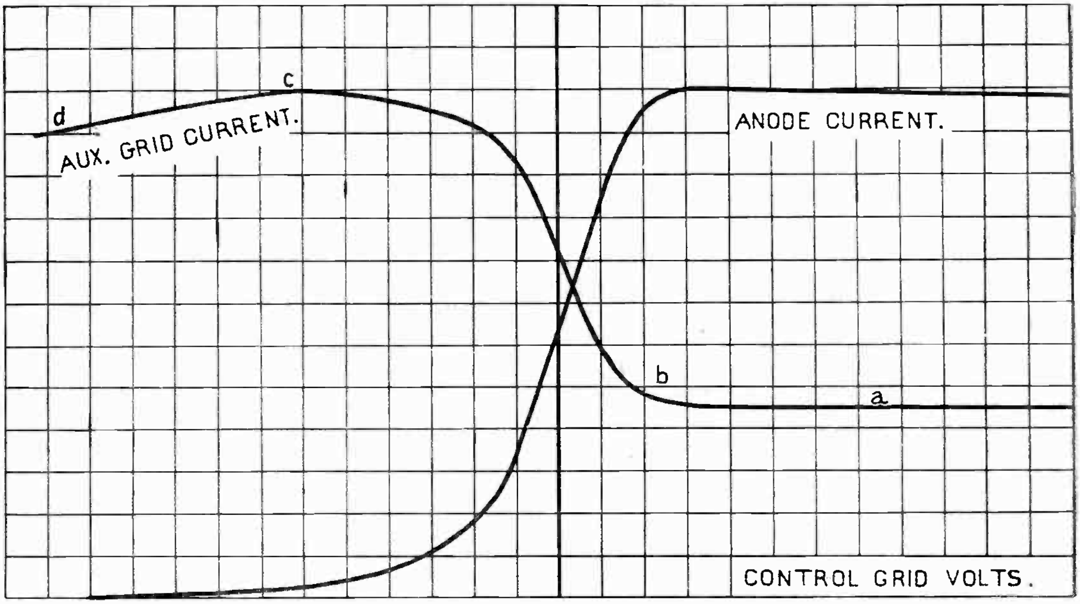


Fig. 3.

A Handy Heterodyne Wave-Meter.

We will here describe a wave-meter for very short as well as for very long waves (up to a frequency of 20 per sec.), built on this principle. The circuit of Fig. 2 is particularly suitable for this purpose, as it contains a grid condenser and leak, which enables it to be used as a receiving wave-meter also. A photograph of the instrument is shown in Fig. 4, and the practical circuit will be found in Fig. 5.

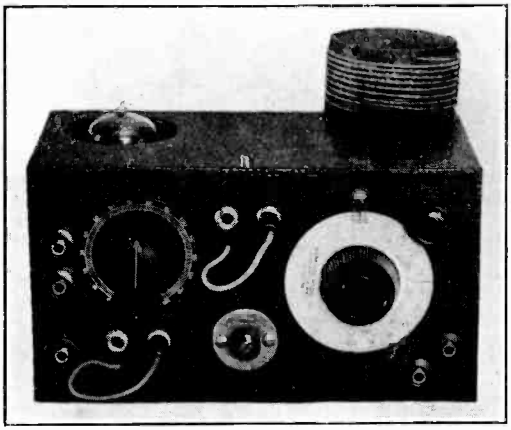


Fig. 4.

A General Radio condenser of ·000 27μF is used, with vernier adjustment, and has proved very suitable, even for wave-lengths down to 10 metres. The batteries have been shunted by a condenser C_3 of ·002μF for eliminating hand-capacity effects. Condenser C_2 is the telephone by-pass condenser (·002μF), which can be short-circuited by a plug. C_1 is a stopping condenser which, in combination with the leak R, gives rectification in the grid circuit. The value is ·0002μF. The grid leak is a Watmel (0·5—5 MO), but its value is not at all critical; it should not exceed about 1 MO.

We have used several makes of double-grid valves, such as: "Philips" (Dutch) with ordinary and dull-emitter filaments; "Heussen" (Dutch); "Telefunken" (German) type R.E. 26 and R.E. 25; "Siemens-Schottky (German); all giving equally good results.

The filament resistance is placed in the *positive* filament lead. Between filament resistance and terminal is interposed a flexible lead and plug as also across condenser C_2. The plugs are placed in such a way that, with the filament glowing, the anode can be plugged directly to the positive filament terminal. This done, the anode is always at filament potential (see later). The oscillator may be connected to the same batteries as the receiver.

Oscillation.

To find out if the wave-meter oscillates, plug telephones into the anode circuit (at C_2 in Fig. 5) and touch the grid side of the closed circuit with a wet finger.

When the filament burns too brightly, the set will howl or stop oscillating, especially when using too little high tension. On long waves the filament should not burn too brightly; with a bright-emitter filament, *red* suffices. On short wave-lengths, under 200 metres, the filament may burn at its normal temperature. The more high tension is used, the brighter the filament should be and the stronger will be the oscillations.

An explanation of this phenomenon might be the following: Oscillations will stop when the free negative charge on the control grid reaches such a value, that the valve works on a point past C in the curve of Fig. 3.

When observing the beat note with an oscillating receiver on waves longer than 500 metres, a very small change will be observed on changing the filament or high tension voltages, just as with every other heterodyne wave-meter. On the other hand absolute constancy can be obtained by connecting the anode to the filament positive. The plug system illustrated makes this possible.

This heterodyne wave-meter can be calibrated easily, using harmonics (this with full

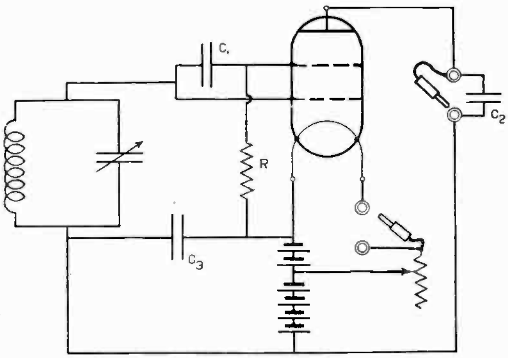


Fig. 5.

anode voltage). The "click-method" is found very handy.

In addition, this apparatus permits of making accurate measurements of capacity, self-capacity of coils, inductance and aerial constants. Low-frequency transformers can also be tested.

Short-circuited Turns as an Aid to Reception on Short Waves.

By W. E. Benham. **[R382**

In this article the author shows how, by short-circuiting one or more turns of the reaction coil, oscillation on short waves is made easier. Further to the author's explanation of this we give an alternative one in an Appendix.

Introductory.

SHORT waves have been found efficient by amateurs. Shorter waves have been and are being found more efficient still. Last year it was 100 metres, this year it is 50 and even less. No sooner do we find KDKA on 66 metres than we learn that WGY has contented itself with 15·8; and in this headlong rush down the wave-length scale, many are left behind.

In low-wave reception everything (except mechanical essentials) must be sacrificed to efficiency. Special attention must be paid to all wires carrying high frequency currents, and thick wire should therefore be used, not only in the aerial and grid circuits, but also in the plate circuit. The phones, high tension and even accumulator should be shunted by condensers.

Spacing of wire on the aerial coil is very necessary, and a low capacity valve should be used; a soft Dutch valve however seems to answer the purpose very well. The grid-condenser should preferably be of air dielectric: in fact as little dielectric as is compatible with mechanical considerations should be used in the construction of the receiver.

Damping.

Why all the above cautions? The one word "Damping" provides the answer. On long waves the damping reduces mainly to the high frequency resistance of conductors in the receiver, in particular the aerial coil. On short waves losses due to dielectric absorption, eddy currents on neighbouring objects and capacity losses in one form or another become serious. These losses can be reduced, but not eliminated. They have to be compensated for by transfer of energy from the plate to the grid circuit of the valve. When the energy so transferred is equal to or greater than the energy lost by damping, oscillation occurs.

Conditions for Regeneration.

In order that the energy fed back into the grid circuit may be sufficient to overcome damping, there must be a sufficient field: in the case of the reaction coil this means sufficient "ampère turns." Now the "ampère turns" of a reaction coil reach a maximum when the coil is tuned to the same wave-length as the aerial circuit; but simplicity in tuning being highly desirable in short-wave work, it is unwise to tune the reaction coil as well as the aerial circuit, especially as this produces in the set a very unstable condition of oscillation. It is found that tuning is easiest when the reaction coil is tuned to a wave-length just below that being received. The field in the reaction coil is then somewhere near the maximum value.

The number of turns is very critical on short waves, and it is advisable to have tappings every two turns on a coil 3 in. in diameter. It is hardly necessary to point out that the use of tappings, being a rough method of tuning, is not nearly so laborious as tuning the coil exactly for any wave-length. One tapping will serve for quite a large range of tuning, and once this range has been found by trial for each tapping, the right tapping for use with any wave-length is known.

Now on shorter waves the field in the reaction coil tends to become less, while there is more damping to be overcome and to make matters worse there are fewer turns in the grid circuit available for coupling. Hence the main difficulty in getting the receiver to oscillate on short waves.

The Grid Coil.

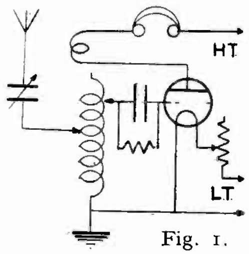


Fig. 1.

A device for increasing the grid turns available for coupling is due to Hartley, who included a number of turns in the grid circuit whose function is to increase the mutual inductance between plate and grid circuits, and so collect more energy. As these grid turns are to be aperiodic however, they cannot be increased indefinitely. The arrangement is shown in Fig. 1. This circuit oscillates nearly as easily as a loose-coupled circuit, and is simpler to operate. The lower wave-length limit of either circuit is reached when the turns in grid and plate circuits are too few to provide the necessary coupling.

Decreasing Wave-length.

If the turns in the reaction coil could be increased without altering the natural wave-length, oscillation would be easier. This can be done by short-circuiting one or more turns of the reaction coil. When any current flows in the coil, the short-circuited turn acts like the secondary of a transformer, and a large induced current is set up in it. This current in turn sets up a magnetic field which is always opposed to that set up by the coil itself. Since the inductance of a coil is measured by the magnetic field to which it gives rise, the apparent inductance is decreased.

It will at once be asked: "What is the gain in field strength if the field due to a given inductance (apparent or otherwise) is always the same?" In other words, we may obtain the same inductance by doubling the turns and short-circuiting the end one, but the field produced is no greater, hence no more energy is handed back to the grid circuit.

The explanation of this lies in the fact that the induced and inducing currents are out of phase. For large frequencies they are very nearly 90 degrees out of phase. The result is that *at a given instant* the induced and inducing currents are going in opposite directions, and the fields set up will actually assist one another. At a given instant the induced current has not been caused by the simultaneous main current, but is due to that current an instant before. So that it is still true to say that the fields due to inducing and corresponding induced currents oppose one another, while the fields to the synchronous inducing and induced currents assist one another.* Since the short-circuited turn acts like a separate circuit, we may regard it as such for purposes of examination. If L_1 be the actual inductance of the main coil, L_2 that of the single turn, M the coefficient of mutual inductance between the two, R_2 the resistance of the single turn, and $\omega = 2\pi n$, where n is the frequency, then the apparent inductance of the main coil is

$$L_1 - \omega^2 M^2 L_2/(R_2^2 + \omega^2 L_2^2).$$

Since ω is very large and R_2 is small, we may neglect R_2^2 in comparison with $\omega^2 L_2^2$. The apparent inductance is then

$$L_2 - \frac{M^2}{L_2}$$

While the apparent inductance is diminished, the apparent resistance is increased. R_1 being the actual resistance, the apparent resistance is

$$R_1 + \frac{\omega^2 M^2 R_2}{R_2^2 + \omega^2 L_2^2} = R_1 + \frac{M^2 R_2}{L_2^2}$$

(neglecting R_2^2).

The above formulæ assume that capacity is negligible. This is justified, as the capacity across the reaction coil is very small. Since we are not tuning the reaction coil exactly, but only roughly by tappings, the increase of apparent resistance will be masked by the presence of apparent reactance, so that very little extra damping will arise from increase of apparent resistance.

Results Obtained.

The writer was using a Hartley circuit, the only addition being an extra clip attached to the tapping-lead of the reaction coil, enabling one or more turns to be short-circuited. The writer always uses a counterpoise instead of an earth with this circuit, in order to reduce the damping of the aerial circuit. This is not necessary if a loose-coupled receiver is used. (See Fig. 2.)

It was found that the lower limit of wave-length was reduced to nearly half by simply short-circuiting turns in the reaction coil. The particular reaction coil used was 6 in.

* An alternative explanation is given in the Appendix.

in diameter, with tappings every turn up to the fifteenth, and every two or three turns up to the sixtieth, there being 60 turns in all. It was also found that regeneration was further increased by short-circuiting several turns at once; but there is one caution which must be emphasised here. If too many turns are short-circuited they may act as a wave trap if they are anywhere near resonance with the grid circuit.

There are several combinations which work about equally well on a given wave-length. Thus it is immaterial whether the thirtieth and fortieth turns are short-circuited, or the thirty-second and forty-fifth, to take an example. Hence no difficulty should be found in choosing the right turns to short circuit.

The lowest wave-length without short-circuiting turns on which the set would oscillate, using outdoor aerial and counterpoise, was about 60 metres at the time of experiment. With the turns short-circuited, wave-lengths as low as 35 metres were received, 2LO's harmonics being the standard on which this estimation was gauged. Thus no fewer than 10 harmonics were heard below the fundamental (365 metres), so that assuming none were missed, which is probable, the wave of the lowest was 36·5. If any were missed, it must have been lower still.

The arrangement can be used with advantage on all waves below 200 metres because then the reaction coil need not be coupled nearly so tightly, and any variation in coupling will only produce a slight change in wave-length, so that tuning is much easier.

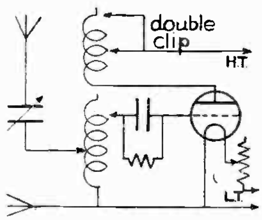


Fig. 2.

The increased oscillation is no sign of instability: on the contrary it is probable that there is a stabilising effect. Also one set of tappings covers a much wider range of wave-lengths than a single tapping on an ordinary coil.

APPENDIX.

This is a curious point: that by increasing the turns and then shorting some of them, the inductance of the coil can remain as before, but that stronger coupling can be obtained. Personally, we believe that the effect is due to the fact that the coils used in wireless are not entirely concentrated; *i.e.*, the coupling between the turns at one end and those at the other is quite small. In consequence the increase of turns gives a greater *mutual* inductance, because there are more turns coupled to the grid-coil. The reverse field set up by the shorted turns, on the other hand, affects most strongly the turns at the far end of the coil and not those nearest the grid-coil. This exposition is a very condensed one, we fear.—Ed. E.W. & W.E.

ERRATA.

One or two errors crept into articles in our November issue, and we beg our readers to make the necessary corrections, which are as follows:—

"An Easy Way to Calculate Circuits."

P. 72, col. 2.

$$L = \frac{167}{\omega} = 88\mu H.$$

The result here should be $84\mu H$, and the same change should be made two lines down.

Same page and column.

The last two equations, which read

$$\frac{1}{Z} = \frac{833j - 20 - 1\,000j}{833j\,(20 + 1\,000)}$$

$$= \frac{-20 - 167j}{833\,000 + 16\,700j}$$

are incorrect owing to a printer's error, and should be:—

$$\frac{1}{Z} = \frac{833j - 20 - 1\,000j}{833j\,(20 + 1\,000j)} = \frac{-20 - 167j}{-833\,000 + 16\,700j}$$

"Intervalve Transformers."

P. 75, equation (35).

The first part of the denominator is given as

$$[1 - L_2C_2\omega^2(1 - k_2)^2]$$

it should actually be

$$[1 - L_2C_2\omega^2(1 - k^2)]^2.$$

P. 79, Table II., last column, ninth line, 4·86 should be $-4·86$.

"Notes on Power Transformer Design."

P. 105, col. 1, six lines from bottom,

$$E.M.F. = 4·44 f A B 10^8 \text{ volts}$$

This should be

$$E M F = 4·44 f A B 10^{-8} \text{ volts}$$

and the same applies to line 7, column 2.

We are asked by Messrs. Beard & Fitch to state that the price of their "Success" transformer is 21s. and not 10s. as appeared in the advertisement on page iv. of the cover.

The Graphical Analysis of Composite Impedances. [R140

By F. M. Colebrook.

In this paper the author considers some of the important arrangements of impedances met with in practical wireless telephony and telegraphy, and shows their characteristics graphically.

THE graphical representation of the solution of any problem involving quantitative relationships has the important practical advantage, due to its direct appeal to the sense of sight, of being very readily understood.

The object of the present paper is to consider some of the most important arrangements of impedances met with in practical wireless telegraphy and telephony and to show their behaviour in pictorial form. It is hoped that in this way even those whose mathematical equipment is insufficient to enable them to follow all the reasoning involved will, nevertheless, be able to obtain a complete grasp of the most significant features of the results.

The sign and direction conventions on which the diagrams are based are virtually those implied in the so-called "symbolic" method of analysis of alternating current

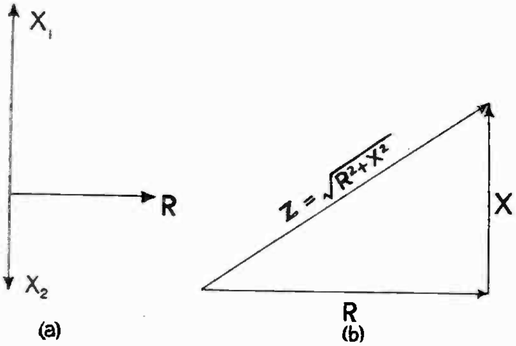


Fig. 1.

problems. Thus, a line in the direction of the bottom edge of the paper from left to right will be used to represent a pure resistance. The scale is, of course, immaterial, provided one scale is adhered to in any one diagram. Taking the scale to be one unit of length for one ohm, then a line R units long will represent a resistance of R ohms. In a similar manner a positive reactance, *i.e.*, the reactance associated with a pure inductance, will be represented by a line

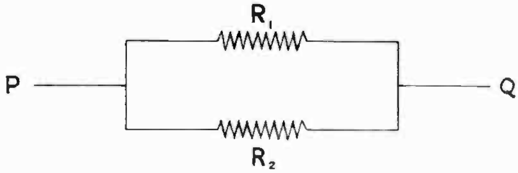


Fig. 2.

of appropriate length drawn upwards and parallel to the edge of the paper, and conversely, a negative reactance, *i.e.*, the reactance associated with a pure capacitance, will be represented by a line of appropriate length drawn downwards in a direction parallel to the edge of the paper.

This system of representation is illustrated in Fig. 1*a*, which shows a pure resistance of R ohms, a pure positive reactance of X_1 ohms, and a pure negative reactance of X_2 ohms. In addition, Fig. 1*b* shows in the same way the line representing an impedance consisting of a positive reactance X in series with (*i.e.*, added to) a pure resistance R. The magnitude of this impedance is clearly given by

$$Z=\sqrt{R^2+X^2}.$$

In symbolic notation the same impedance is represented by

$$Z=R+jX \quad \ldots \quad \ldots \quad (1)$$

the symbol j indicating that in the graphical representation of Z the line representing X must be drawn in a direction making $+90°$ with that representing R.

The rather elementary nature of this introduction must be excused on the ground that sign and direction conventions play a very important part in all that follows.

2.—Two Pure Resistances in Parallel.

This case, illustrated in Fig. 2, may seem too simple to need any pictorial aid for its comprehension. It is included, however,

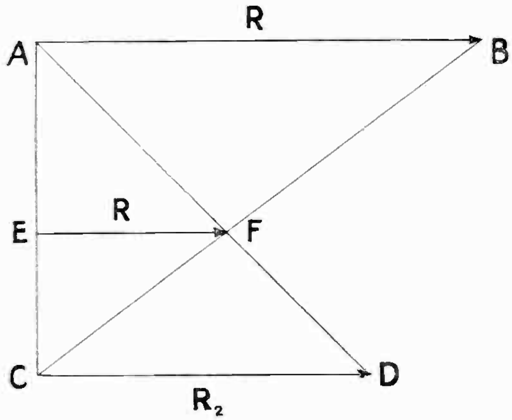


Fig. 3.

because the diagram introduced in this connection will be found to have other and more important practical applications.

It is well known that the impedance between the points P and Q is a pure resistance R given by

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2} \quad \cdots \quad (2)$$

The corresponding diagram is probably less well known. Let AB and CD in Fig. 3 represent R_1 and R_2 respectively, the distance AC being any convenient length. From the elementary properties of similar triangles we have

$$\frac{EF}{CD}=\frac{AE}{AC} \text{ and } \frac{EF}{AB}=\frac{EC}{AC} \quad \cdots \quad (3)$$

By the addition of these two equations

$$EF\left(\frac{1}{CD}+\frac{1}{AB}\right)=\frac{AE+EC}{AC}=\frac{AC}{AC}=1 \quad (4)$$

Therefore

$$\frac{1}{CD}+\frac{1}{AB}=\frac{1}{EF} \quad \cdots \quad (5)$$

i.e.,

$$\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{EF} \quad \cdots \quad (6)$$

By comparing equation (6) with equation (2), we see that

$$EF=R$$

The diagram makes very clear the fact that, whatever the magnitudes of R_1 and R_2, R will always be less than either of them. The graphical representation of this case

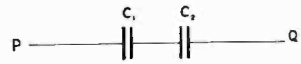


Fig. 4.

may appear to be of theoretical rather than of practical interest. Actually, however, the writer found the diagram very convenient for use in connection with the design of a multi-range stud rheostat for the filament control of different types of valves or of various numbers of valves of the same type, the variation of range being effected by means of shunt resistances connected across one end of the main resistance and the switch arm.

3.—Condensers in Series.

For the case illustrated in Fig. 4 the effective capacity between the points P and Q is given by C where

$$\frac{1}{C_1}+\frac{1}{C_2}=\frac{1}{C}$$

The summation of capacities in series can therefore be represented by a diagram exactly similar to that described above, two vertical lines being drawn to represent the capacities C_1 and C_2. This is illustrated in Fig. 5. It is not really a reactance diagram in the sense suggested in the introduction, but it is nevertheless a very convenient way of representing the behaviour of two condensers in series. As an example of its practical application we may take the case in which a variable condenser of $\cdot 001\,\mu F$ maximum value is converted into a variable condenser of, say, $\cdot 000\,3\mu F$ maximum value by putting a small fixed condenser in series with it. This is illustrated in Fig. 6. Draw AB_{10} to represent $\cdot 001\mu F$.

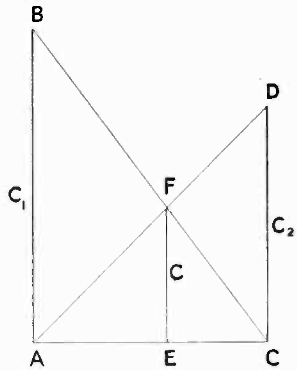


Fig. 5.

to a given scale, and AC, of any convenient length, perpendicular to AB_{10}. Join C to B_{10}. Let F_{10} be the point on CB whose ordinate is ·0003. Then, if AF_{10} cuts the line perpendicular to AC at D, CD is the magnitude of the fixed capacity required. Further, if AB_1, AB_2, AB_3, etc., represent the variable condenser

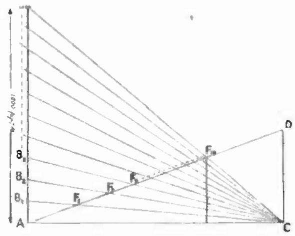


Fig. 6.

scale readings for ·0001, ·0002, ·0003, etc., μF, then the ordinates of the points F_1, F_2, F_3, etc., will give the total capacity of the series combination. The calibration of the variable condenser being known, the calibration of the combination can be read off directly from such a diagram.

4.—The General Case of Impedances in Parallel.

If a number of impedances Z_1, Z_2, Z_3, etc., representing respectively, R_1+jX_1, R_2+jX_2, R_3+jX_3, etc., be connected in parallel, then it can be shown that the resultant impedance is given by Z where

$$\frac{1}{Z}=\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3} \text{ etc., etc.} \quad (7)$$

In fact, impedances in parallel combine according to the same law as resistances in parallel, but it must be remembered that

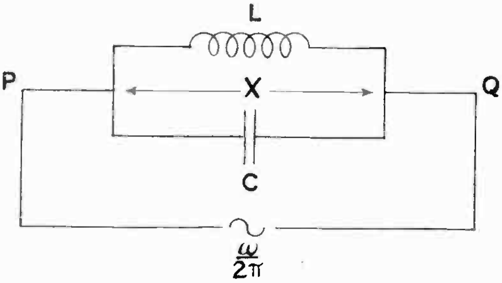


Fig. 7.

in the further development of equation (7) the quantities Z_1, Z_2, Z_3, etc., are similar to and obey the same laws as complex numbers of the type $a+b\sqrt{-1}$. The object of the present paper is, however, to eliminate mathematics as far as possible, or rather to simplify it by means of graphical representation. At present the writer has not found any really simple and convenient graphical representation for the general case. Fortunately, however, the particular cases of the above which are of most importance from the point of view of practical wireless telegraphy and telephony are fairly simple in type, and lend themselves readily to graphical treatment with very useful results.

5.—A Pure Inductance and a Pure Capacity in Parallel.

This important case is illustrated in Fig. 7. At a frequency $\omega/2\pi$ the reactance of the inductance will be $j\omega L$, *i.e.*, it will be represented by a line of length ωL measured upwards in a direction parallel to that of the edge of the paper. Similarly the reactance of the capacity at the same frequency is $-j/\omega C$, *i.e.*, it will be represented by a line of length $1/\omega C$ measured in the opposite direction to that representing the reactance of the inductance. The two lines are represented by AB and CD respectively in Fig. 8. If Z be the impedance of the two in parallel between the points P and Q we have, as indicated in equation (7),

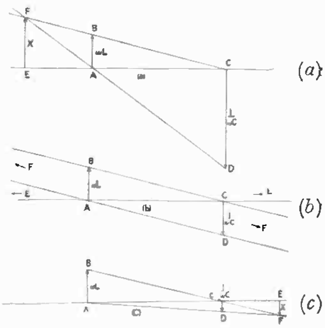


Fig. 8.

$$\frac{1}{Z}=\frac{1}{j\omega L}+\frac{1}{-j/\omega C} \quad .. \quad (8)$$

$$=\frac{1}{j}\left(\frac{1}{\omega L}-\frac{1}{1/\omega C}\right) \quad .. \quad (9)$$

Now complete the diagram of Fig. 8 in exactly the same way as in the case of the resistances in parallel, or the condensers in series, *i.e.*, join AD and BC, and from F, the point of intersection of these two lines, draw EF perpendicular to AD. Then exactly as in the previous cases, it can easily be shown that EF represents the reactance of the two branches in parallel.

The sign and magnitude of this reactance in terms of the relative magnitudes of the component reactances is very easily deduced from the diagram. For the larger values of $1/\omega C-\omega L$, EF will be as shown in Fig. 8*a*, and the combination behaves like a pure inductance of magnitude greater than that of L. As $1/\omega C$ decreases, this being effected by increasing either C or the frequency, the magnitude of EF increases steadily until $1/\omega C=\omega L$, when, as shown in Fig. 8*b*, EF becomes infinite and indeterminate in sign. As $1/\omega C$ decreases still further till it is less than ωL, then, as shown in Fig. 8*c*, EF becomes negative, *i.e.*, the combination behaves like a pure capacity of magnitude smaller than C. It should be noted that so long as both L and C are respectively a pure inductance and a pure capacity, containing no resistance terms, then the reactance of the two in parallel, even when it becomes infinite, will be a pure reactance and will contain no energy-consuming term. These conditions cannot, however, be realised in practice. It is impossible completely to eliminate resistance either from L or C, particularly at radio frequencies, and the resistance terms, though small,

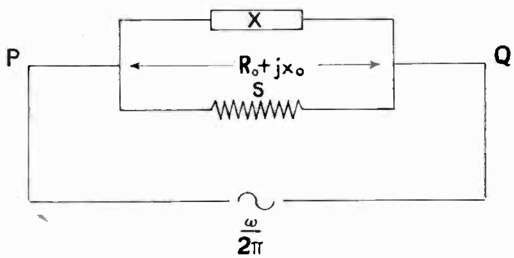


Fig. 9.

will profoundly modify the above behaviour. The diagram is nevertheless of considerable value as illustrating the general behaviour of the two in parallel, and, in conjunction with the more complete diagram which will now be considered, one which take the resistance terms into account, it gives a very complete idea of what happens when an inductance is tuned to a given frequency by means of a parallel variable condenser.

6.—The General Case of a Pure Resistance in Parallel with a Pure Reactance.

The circuit to be considered is illustrated in Fig. 9. If

$$Z=R_0+jX_0$$

be the symbolical expression for the impedance between the points P and Q, then, as indicated in equation (7):—

$$\frac{1}{Z}=\frac{1}{R_0+jX_0}=\frac{1}{S}+\frac{1}{jX}=\frac{1}{S}-\frac{j}{X} \qquad (10)$$

Now consider the diagram of Fig. 10, in which OA=X in magnitude and is drawn up or down according to the sign of X, OB=S, and OD is drawn perpendicular to AB, CD being perpendicular to OB.

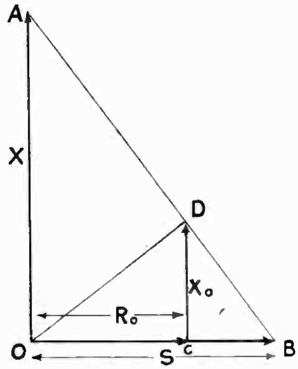


Fig. 10.

From the geometry of similar figures it follows that

$$OC=R_0$$
$$CD=X_0$$

Given, therefore, a known pure reactance X shunted by a known pure resistance S, we have here a very simple diagram for determining in one operation both the effective reactance and the effective resistance of the two in parallel. Further, the line OD clearly represents the effective impedance of the combination. The application of the diagram is not confined to this, however, for, as will now be demonstrated, it not only gives the quantitative solution for any given values of X and S, but will also delineate the result of varying either or both of these factors.

Let us consider first the effect of keeping S constant and varying X between the limits minus and plus infinity, either by varying the inductance and capacitance components or, keeping these constant, by varying the frequency. Wherever the point A may go on the line OA, over the whole of its range from an infinite distance below, to an infinite distance above OB, the angle ODB remains a right angle by construction. The locus of D is therefore a circle on OB as diameter. This is shown in Fig. 11. This interesting result can be expressed in words in the following way: If a pure resistance of magnitude S is shunted by a pure reactance whose magnitude is varied from minus infinity to plus infinity,

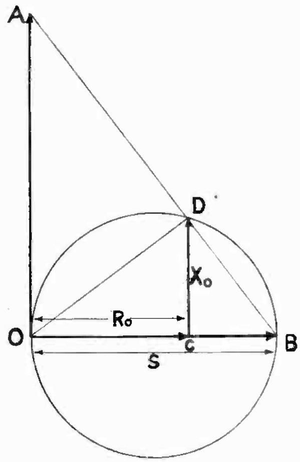


Fig. 11.

then the line representing the impedance of the two in parallel is such that, one end being fixed, the other moves round a circle of diameter equal to the magnitude of S.

Before discussing this result in greater detail we will consider the result of the alternative type of variation, that in which X is kept constant and S is varied from 0 to plus infinity. (It should be noted that S is considered to be always positive. This means that the rather special case of so-called negative resistance is, for the present, excluded from the discussion.) In terms of the diagram of Fig. 10, we have the condition that OA is constant and that OB may have any magnitude from 0 to plus infinity. It is clear that, whatever the position of B in the line of its travel, ODA remains a right angle. The locus of D is therefore a semi-circle on OA as diameter, by construction. The complete diagram, representing the result of the variation of either factor from the initial value X or S, the other factor remaining constant, is therefore as shown in Fig. 12. This last result can be stated in words in the following manner:—

If a pure reactance of magnitude X is shunted by a pure resistance whose magnitude is varied from zero to plus infinity, then the line representing the impedance of the combination is such that, one end being fixed, the other moves round a semicircle of diameter equal to the magnitude of X.

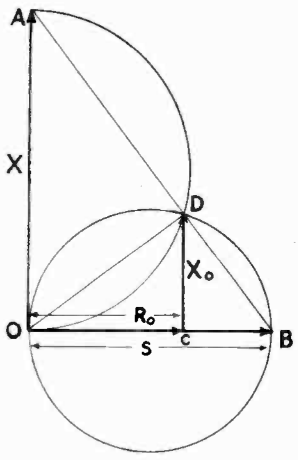


Fig. 12.

The result of simultaneous variations of X and S could, of course, be illustrated on a universal diagram covering all possible values of X and S, this diagram consisting of family of circles of constant S intersecting a double family of semicircles of constant X, one set corresponding to negative and the other to positive values of X. Such a diagram would undoubtedly have useful practical applications.

Before considering the relation of the above circle diagrams to practical problems encountered in wireless telegraphy and telephony, one important characteristic of the constant shunt resistance case should be noted. It is clear that, in general, the

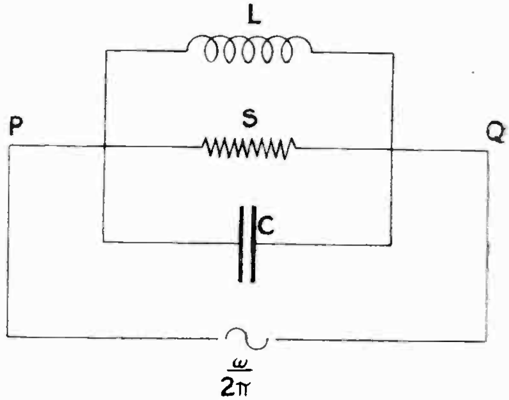


Fig. 13.

effect of the shunt resistance is to make the effective reactance X_0 smaller, in some cases very much smaller, than the true reactance X. Moreover, while there are no limits to the possible values of X, there are very definite limits to the value of X_0, the positive limit being $+S/2$ and the negative limit being $-S/2$. Again, the effective impedance has a definite maximum value S, corresponding to the values $\pm\infty$ for X, the impedance under these conditions being wholly resistive.

7.—Inductance, Capacity, and Resistance in Parallel.

A combination of the results of paragraphs 5 and 6 gives a very simple graphical analysis for the case, frequently encountered in practice, illustrated in the diagram of Fig. 13. The diagram is drawn for a typical case in Fig. 14, and needs no further description in view of what has gone before.

8.—The Effect of the Distributed Resistance of an Inductance.

At a frequency $\omega/2\pi$ the impedance of a coil of inductance L and resistance R is given by

$$Z = R + j\omega L \quad \ldots \quad \ldots \quad (11)$$

By a simple transformation we have

$$\frac{1}{Z} = \frac{R - j\omega L}{R^2 + \omega^2 L^2} \quad \ldots \quad (12)$$

$$= \frac{1}{R + \omega^2 L^2/R} + \frac{1}{\omega j(L + R^2/\omega^2 L)} \quad \ldots \quad (13)$$

The impedance of the coil can therefore be represented as that due to an inductance $L+R^2/\omega^2L$ shunted by a pure resistance $R+\omega^2L^2/R$. For relatively low resistance

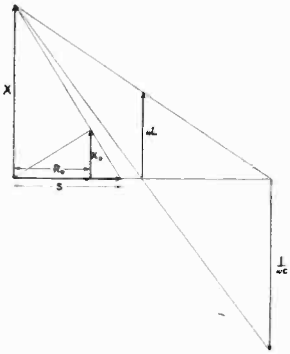


Fig. 14.

coils at radio frequencies R will be negligible compared with ω^2L^2/R, and L will be large compared with R^2/ω^2L. If this coil is used with a parallel tuning condenser we have the closely approximate equivalence represented in the diagram of Fig. 15. For a given value of L and a constant frequency the shunt resistance ω^2L^2/R is a constant. The case is therefore that considered in paragraph 6, *i.e.*, a pure variable reactance shunted by a constant resistance. Referring to the appropriate circle diagram (Fig. 11), it will be seen that the maximum impedance obtainable by the tuning of the coil is the magnitude of the shunt resistance ω^2L^2/R. The effect of the distributed resistance is thus seen to be that, instead of being able to tune the coil to an infinite wholly reactive impedance, it can only be tuned to a finite wholly resistive impedance.

This distinction has considerable practical importance in the case where the coil is being used in the anode circuit of a valve in a tuned anode circuit amplifier. The practical requirement then is that the impedance shall have as high a value as possible, at least 100 000 ohms. Suppose now that we have the numerical values: L, 100 microhenries; ω, 5×10^6 (corresponding approximately to the frequency of the transmission form 2LO); R, 10 ohms. (It must be remembered that the resistance is that corresponding to the high frequency at which the coil is being used. This will in general be very much greater than the D.C. resistance of the coil.) The maximum impedance obtainable by tuning this coil is seen to be $25\times10^{12}\times100^2\times10^{-12}/10$, *i.e.*, 25 000 ohms. Such a coil would clearly be very inefficient in a tuned anode circuit. If some fixed minimum value for the impedance be taken as the standard to be attained, say, 150 000 ohms, then there is clearly a definite upper limit which R must not exceed for any given value of L. This is illustrated in the table below for a frequency corresponding to $\omega=5\times10^6$.

L in microhenries.	Tuning capacity in $\mu\mu$F.	Upper limit for R.
100	403	1·7
200	202	6·7
300	134	15
400	101	27
500	81	42
1 000	40	167

It is clear that, in general, the conditions will be most easily fulfilled by making L as large as is practicable, the upper limit in this direction being the self-capacity of the coil.

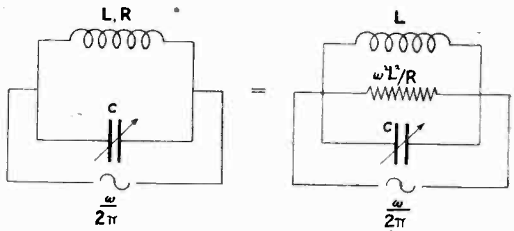


Fig. 15.

The above analysis shows how essential it is that coils for use at high frequencies should be constructed in a way which minimises both the self-capacity and the high frequency resistance. The ideal type is probably a single layer solenoid or helix wound with low resistance wire, preferably stranded, the turns being well spaced (at least two diameters of the wire apart) the mounting being some form of frame (of insulating material) which minimises the proximity of the wire to any solid dielectric. Such coils cannot, of course, be made very compactly, but in this matter compactness is incompatible with high efficiency.

Effective Resistance.

By Marcus G. Scroggie, B.Sc. **[R143**

In this article the author deals with sources of loss, which can often be considered as if produced by a resistance. It may be explained that he abbreviates "Effective Resistance" and "Ohmic Resistance" to E.R. and O.R. respectively.

MANY of the present-day radio experimenters are those who previously worked with ordinary "battery" or "mains" electricity, and were swept into wireless work before they had become acquainted with its rather formidable theory. To them it is often rather puzzling to find the term "resistance," which in their previous work had such a definitely simple meaning, used in a variety of ways totally different to that familiar in Ohm's Law. As "effective resistance" is of such importance, and such a useful idea when understood, a few notes on the matter may not be amiss.

As an example of the confusion which may arise through lack of a clear understanding of what resistance may mean, the case of the condenser is given. Everybody who knows anything about electricity from the D.C. standpoint, knows that a condenser should have a resistance (ohmic) of hundreds of megohms; that is to say, if a steady E.M.F. is applied to it, and the minute current leaking through it measured by an ultra-sensitive galvanometer, the ratio of the two should be of the order of 10^8 or more. On the other hand, books and papers which give what is intended to be a simple explanation of the behaviour of a condenser in an A.C. circuit frequently say that the current passing through a condenser depends upon the alternating voltage, and what may be termed the "resistance" of the condenser, which depends upon the frequency. This is misleading in two respects, and whilst by avoiding the use of the proper word, reactance, it may seem to make the matter clearer to begin with, it only makes it more difficult for the reader when he pursues the subject further. To begin with, the current does not flow *through* the condenser at all, but flows *in and out*, just as air can flow in and out of a rubber balloon when the pressure at the entrance is varied, though no air flows *through* it. If this is realised, the "D.C. man" will have no difficulty in reconciling the current, perhaps quite large, with the almost infinite resistance of the condenser. Secondly, the use of the word resistance instead of reactance is a pure inaccuracy, and the most elementary principles of A.C. can never be grasped so long as it is retained. The only thing reactance has in common with resistance is its unit of measurement, the ohm. The fact that the word reactance is often used when reaction is meant only increases the confusion.

Accordingly, we will rule out this spurious meaning of resistance. But there is yet another, and correct, use of the word in connection with a condenser, which may be distinguished by calling it effective or equivalent resistance as distinct from ohmic. This should always be low in a condenser, and may be a small fraction of an ohm, hence it introduces an entirely new concept of resistance, for, as mentioned before, the ohmic resistance is, or should be, very high indeed. The effective resistance of a condenser is that value of ohmic resistance which, when connected (usually in series, if in parallel it is stated so) with a *perfect capacity* (no leakage or other losses) of the same value, would give rise to the same number of watts loss with a given E.M.F. and frequency. To be strictly accurate, it must be mentioned that a pure sine wave of E.M.F. is assumed. The same definition will hold for an inductance, or any circuit, such as an aerial, a loose-coupled receiving inductance, etc. The whole problem centres around the fact that in real life the three "constants" of circuits—resistance, inductance, and capacity—can never be obtained alone; *e.g.*, every coil besides inductance also possesses resistance and capacity, and this discrepancy between the real and the ideal is more marked the higher the frequency. It is quite possible for a coil of wire to act electrically as a condenser, the inductive effect being of less magnitude. Now, it is very difficult to make calculations such as are essential to radio design particularly if each of our components is a complicated mixture of these three "constants"; it is much simpler to sort them all out and substitute (on paper) a circuit in which the condensers are all capacity, the coils all inductance, and the resistances nothing but resistance. Then we can apply simple formulæ and know what we are doing.

It is when we come to sorting them out that we find it rather complicated, as there are so many variables. To take a simple case first: Suppose a condenser of capacity $0{\cdot}05\mu F$ connected up to 30 volts A.C. at 100 000 cycles (3000 metres wave-length). The reactance,

$$\frac{1}{2\pi fC} \text{ or } \frac{1}{\omega C}$$

as it is usually written, works out

$$\frac{1}{2\pi \times 10^5 \times 0{\cdot}05 \times 10^{-6}} = 32 \text{ ohms.}$$

Therefore the current flowing is $30/32 = 0{\cdot}94$ ampère. At least, that is what it should be if it were a perfect condenser. The current would lead the E.M.F. by 90°, there would be no component of current in phase with the E.M.F., and, consequently, no power supplied to the condenser. The losses would be nil. The vector diagram would be as in Fig. 1.

But condensers are subject to at least three sources of loss. There is the leakage through the medium between the plates, the loss in the resistance of the plates themselves, and the loss in the medium or dielectric due to "dielectric hysteresis." All these losses appear in the form of heat. Now, the amount of heat produced per second in a resistance is proportional to I^2R, this latter quantity is also numerically equal to the watts lost in the resistance, so clearly the E.R. of the condenser is equal to the watts lost in it divided by the current squared. The imperfect condenser behaves the same as a perfect condenser plus a perfect resistance (non-reactive) equal to the E.R. As power is being expended in the condenser, the current must be less than 90° out of phase with the E.M.F., and may be considered to be split up into two components, I_1 90° leading and I_2 exactly in phase (Fig. 2). I_2E is the power lost, so the

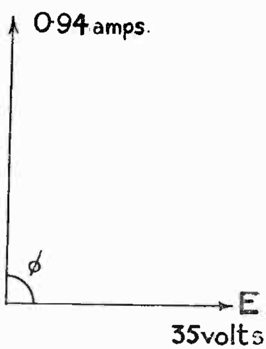


Fig. 1.

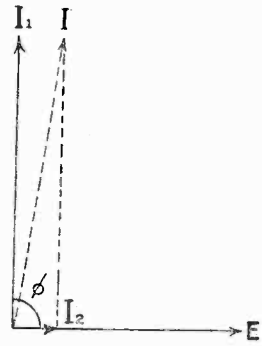


Fig. 2.

$$E.R. = \frac{I_2E}{I^2} = \frac{E \cos \phi}{I}.$$

Cos ϕ is what is called the "power factor" of the condenser, and should be very small. This indicates how the E.R. may be found by measurement: by applying an alternating E.M.F. and measuring the power with a wattmeter, and also the current. But in most cases the power is so very small, and a wattmeter so inaccurate with low power factors, that this method will not do, and the practical methods usually depend on substituting a standard condenser of negligible or known resistance. To show how leakage affects the E.R., suppose the insulation resistance of the $0{\cdot}05\mu F$ condenser previously considered is 50 megohms, so that leaving the other factors out of consideration the circuit is as in Fig. 3. The problem is to find what is the O.R. to be placed in series with the condenser to produce the same loss and phase angle as this leak. The current flowing *through* the condenser, *i.e.*, through the leak, is

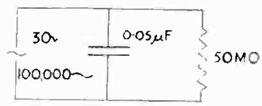


Fig. 3.

$$\frac{30}{50 \times 10^6} = 0{\cdot}6 \times 10^{-6} \text{ amp.}$$

The loss is therefore

$$(0{\cdot}6 \times 10^{-6})^2 \times 50 \times 10^6 = 18 \times 10^{-6} \text{ watts.}$$

The current flowing *in and out* of the condenser is, as before, 0·94 amp (the current taking the leakage path is negligible compared to this, but to be exact would have to be added vectorially) so the E.R. is

$$\frac{\text{watts lost}}{\text{current squared}}=\frac{18\times10^{-6}}{0\cdot94}=20\cdot4\times10^{-6}\,\text{ohm.}$$

This, of course, is a trifling amount. It must be observed, however, that at much lower frequencies the "condenser" current would be much lower, and the E.R. would accordingly be higher, so that leakage is of greater

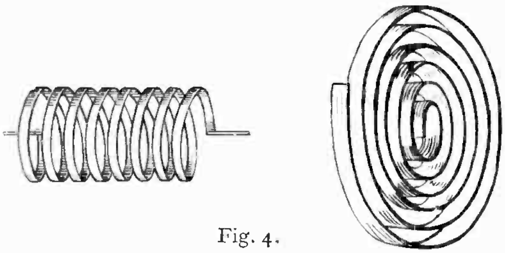


Fig. 4.

importance at low frequencies, till at zero frequency it is the only current. The resistance due to the plates, leads, connections, etc., being in series and carrying the main current is of great importance at very high frequencies, and is zero at zero frequency. The dielectric hysteresis loss, usually the most important, decreases with frequency. The moral of this is that where condensers are used at very high frequencies, such as in short wave transmitters and receivers, the metallic resistance should be kept to a minimum, while in the case of condensers used at low frequency, such as in smoothing systems, the dielectric is most likely to cause inefficiency.

The E.R. of an inductance includes quantities corresponding to the three mentioned in condensers; there is the leakage across the coil, which is usually negligible except at very high frequencies, when high voltages may be set up across the terminals; the series resistance, which is usually important, especially at low frequencies; and the hysteresis loss, which only takes place when a magnetic material, principally iron, is used for a core. In addition, there is the eddy-current loss in the core, if any, in the copper or other winding, and in conducting materials such as screws, frames, etc., in the magnetic field. The coil has self-capacity, and this gives rise to losses as mentioned in connection with condensers. The skin-effect is much greater for coils than for straight wires, and the increase in resistance due to this alone may amount to hundreds of times at radio frequencies. There may also be losses due to other coils inductively coupled. All these quantities increase with frequency, except that there is an apparent decrease in the loss caused by an iron core, due to the surface only of the iron being magnetised. All these effects may be lumped together and called the E.R. It is not practicable to calculate the E.R., but it may be measured by substitution, or by measurement of the power loss. As the loss is usually much greater than in a condenser, the objection to the latter method previously given does not apply to the same extent. An objection that does apply is that it is no easy matter to measure the power at very high frequencies, and some indirect method must be adopted, such as measurement of the heat generated. The substitution method was described in EXPERIMENTAL WIRELESS for March, 1924.

To reduce the E.R. of coils used at frequencies such as that of 100 metres the conductor is of the form of copper strip, wound as in Fig. 4, which shows a solenoid and a helix in section. The writer has seen transmitter coils wound with great trouble so that the strip lies with its edges in and out, instead of with its flat faces in and out, as in Fig. 4. Anything worse could not be imagined, asthe current is only carried by the inner edge of the strip, and the bulk of the metal is practically useless. The coil should be wound on a highly insulating frame containing as little material of any sort as possible, as insulators give rise to dielectric losses and act as conductors to eddy-current losses. Prof. Morecroft gives an instance of a coil of which a terminal was fastened to the end piece with small iron screws. After the coil had been switched on for some time the loss in the screws was so high that they burnt themselves free.

The E.R. of a coil is increased by coupling another coil to it, such as in a coupled transmitter or receiver, and the lower the resistance of the coupled coil the higher the increase in E.R., because currents are caused to flow in the neighbouring circuit, and these cause losses which must be supplied by induction. The increase in E.R. is very great when the coupled circuit is tuned to the working frequency. Examples of this are constantly occurring both in transmission and reception. If in a coupled transmitter there are ammeters in both the closed and aerial circuits, the reading of the former will drop from perhaps 10 amperes to 2 or 3 when the aerial circuit is brought into tune.

In circuits containing both inductance, and capacity it often happens that a reduction in O.R. increases the E.R. This is so in the well-known "tuned anode" amplifier coupling. Here we have L and C in parallel, and when in tune to a particular frequency the E.R. *at that frequency* would be infinitely great if the O.R. were zero. The merit of this coupling is that the D.C. resistance is very low, so no extra anode battery is required, but the resistance to the frequency to be amplified is very high. In dealing with resonant circuits there are always two points of view: series and parallel. In Fig. 5, showing the simple LC circuit, L is both in parallel and in series with C, but at the resonant frequency E.R. is infinity or zero according to the way it is considered.

If an alternator generating the resonant frequency is connected, as in Fig. 6, no current will flow, E.R. being infinity, but an infinitely large current will circulate between L and C, the E.R. that way being zero. As resistance is always present in practice, "infinite" becomes "large" and "zero" becomes "small." The main point is that at resonance the LCR circuit may be substituted by one consisting only of R; large for parallel, small for series.

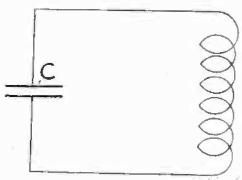


Fig. 5.

It should be noted that while in the case of series resonance, the resistance has no effect on the resonant frequency, the latter being always

$$\frac{1}{2\pi\sqrt{LC}};$$

in parallel resonance the frequency is affected by the resistance, and the formula is more complex—

$$f = \frac{1}{2\pi}\sqrt{\frac{L - R_l^2 C}{L^2 C - R_l^2 C^2 L}}$$

There is one sort of resistance which has not yet been mentioned: radiation resistance. That this seems to give rise to some trouble is shown by the fact that many experimental transmitters make a fetish of large aerial currents and seem forgetful of the fact that if such large currents are obtained by decreasing the radiation resistance, the actual power radiated may be smaller than before. The power radiated is I^2R_r watts, just as the power converted into heat is I^2R_0, where R_r and R_o are radiation ohmic resistance. The two together (E.R.) multiplied by the current squared gives the electrical power permanently disappearing from the circuit. The only two factors materially affecting the radiation resistance are the dimensions of the circuit and the frequency. A circuit with large dimensions, such as an aerial system, has a large radiation resistance, while the latter is also proportional to the square of the frequency. The efficiency of the aerial system is

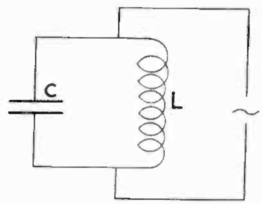


Fig. 6.

$$\frac{R_r}{R_e}$$

where R_e includes R_r and all the sources of loss, which together may be called R_l. If an aerial has a total E.R. of 15 ohms, and there is an aerial current of 10 amps, the energy in the aerial is $10^2 \times 15$ or $1\frac{1}{2}$ kilowatts. If the R_r is 5 ohms, the radiation is $10^2 \times 5$ or $\frac{1}{2}$ kilowatt, and the efficiency is $33\frac{1}{3}$ per cent.

In conclusion, this subject is so related to all the other principles of A.C. work that it is very easy to draw it out to an unreasonable length. Details are not given therefore of all the varied measurements and calculations involved, but it is hoped that this brief outline may be of assistance to some who are experiencing difficulty in passing from D.C. to H.F.A.C.

Erecting a 100-Foot Mast.

By W. J. Turberville-Crewe.

[R320·8

Our contributor finds the erection of a 100-ft. mast an easy matter. But we would not advise readers to approach it too light heartedly if they have had no previous experience. Many such jobs are easy to those who know how, but require thought when tackled for the first time.

WITH the arrival of winter and the consequent reduction in the strength of atmospherics, many of us are overhauling our apparatus with a view to obtaining the last ounce of efficiency; and in that respect we must not forget our long-suffering aerials. Every ten feet that can be added to the effective height of an aerial is equal to pressing into service an additional valve and, in the long run, materially cuts down working expenses.

Many people, however, fight shy of tackling the erection of any mast much above 30 ft., whereas, providing the best method is employed, a 100-footer can almost as easily be placed in position and made to stop there.

A mast four inches square at the base and tapering to four inches by two inches at the truck, constructed from pine and properly guyed, makes a very stately and imposing erection. Moreover, it will stand any weather, even a hurricane, and support the heaviest standard type of aerial up to the extreme P.M.G. limits.

It is the purpose of this article to describe in detail how to make and erect a 100-ft. mast satisfactorily.

Five 20 ft. and one 24 ft. lengths of 4 ins. by 2 ins. pine as free from knots as possible are procured from a timber yard and carefully creosoted. A dozen hexagon-head $\frac{1}{4}$ in. by 5 ins. bolts and nuts with washers should also be purchased, together with twelve steel plates 4 ins. by 12 ins. by $\frac{3}{16}$ in. thick, each being drilled with two $\frac{1}{4}$ in. clearance holes—one $2\frac{1}{2}$ ins. from either end. These will form the clamping plates for bolting the sections firmly in position.

Four 2 ft. 6 ins. lengths of good, hard wood, preferably steel shod, will be required for ground posts to which to anchor the guy wires, and these should also be heavily creosoted or tarred.

A coil of galvanised stranded wire rope to take a "breaking strain" of about 1 cwt. will serve for the guy wire, and with it a supply of galvanised straining screws or turnbuckles for making final adjustments.

Having well creosoted all the lengths of timber, the 24-footer is selected and a platform about a yard square is constructed and fitted to one end (see Figs. 1 and 3). A hole, say 5 ins. square, is cut in the platform at the point where it touches the timber, and through this guide-slot all the other sections will have to be passed in turn.

Next, dig a hole 3 ft 6 ins. in depth to receive the base of the mast, and, taking a radial measurement of 18 ft., mark out the position of the ground posts as illustrated in Fig. 2. These posts should then be driven well into the ground at an angle, great care being taken to see that they are perfectly firm, for if one of them became loose under the strain of the mast, the position would be serious.

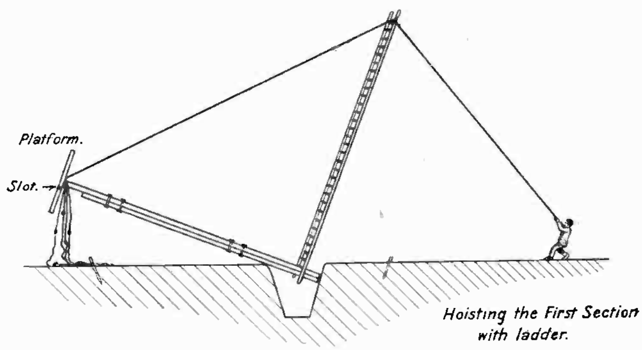


Fig. 1.

With two sets of bolts and plates one of the 20 ft. lengths is then bolted to the first on the same side as that from which the platform projects. The top of the second length should be one foot below the platform (see Fig. 3). The reason for this will be seen later.

The first, or "stub" section, 4 ins. square, is now ready for erection, and the first set of guy wires must be attached. With the aid of a ladder, proceed to hoist this stub into position as illustrated in Fig. 1, and, having securely guyed it, fill up the hole in the ground with concrete. The latter, by the way, *must* be allowed to set before proceeding further.

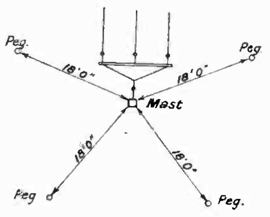


Fig. 2.

If one part of Portland cement and three parts sharp sand (obtainable from any builder) are thoroughly mixed together dry and afterwards sufficient water is added and the mixture stirred with a shovel into a good thick paste (not too sloppy) this will set in a few hours after pouring into the hole.

The aerial pulley is then attached to a further 20 ft. length and a cap nailed on to prevent the wet from running into the grain of the wood. After that the length is pushed through the hole in the platform, the bottom end resting on the ground, and a set of guy wires attached to the top end by an assistant who has climbed to the platform by means of the ladder, which is now lying idle. A pulley is secured underneath the platform, and by its aid the section can be hauled up from the ground and temporarily guyed to steady it.

Next raise another length of timber on end against the stub and bolt the top of it to the bottom of the length just hoisted. Lower the hauling rope to the lower section, and the mast is raised another 20 ft.

An important thing to remember at this point is that the first section that is hauled up becomes the top section of the completed mast—all the intervening lengths being securely bolted to the bottom of the last one and hauled up whilst their lower ends are resting on the ground.

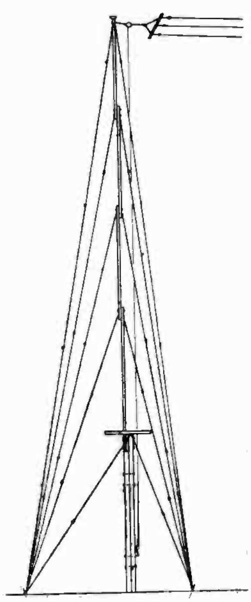
When the four upper sections have been bolted together and hoisted in this manner, the bottom of the last section hauled up will rest upon the top of the shorter timber of the stub section. The reason for leaving the foot overlap is now seen, for it is to this overlap that the bottom of the second section is now bolted.

It will be noted that throughout the operation the hole in the platform acts as a guide slot, steadying the sections as they rise.

The whole secret of the stability of the completed mast lies in the rigging of the guy wires, and it will be found that a set of guys will be needed at every joint from the platform level upwards (see Fig. 3). Staying chocks, made by screwing pieces of wood to the mast, should be used at every point where the guy wires are secured. These chocks should be fitted as shown in Fig. 4.

The guy wires should be fitted with insulators at intervals of 20 ft., particularly is this advisable if the aerial is to be used for transmitting purposes, as otherwise trouble from harmonics will usually manifest itself.

The question of a stable aerial and lead-in that will not sway in the breeze has caused a sleepless night to many an earnest experimenter. Nothing is more annoying than having continuously to swing the condenser in attempted synchronism with the sway of the aerial in order to hold a distant station.



The completed mast.

Fig. 3.

If the aerial is tensioned up to the last ounce of pull on a warm, dry day, and contraction ensues with a fall in temperature, or rope halyards shrink under the influence of damp weather, something has to go—and it is usually the aerial!

A very simple expedient will overcome these exasperating difficulties, however. Instead of securing the halyards to a cleat on the mast, why not rig up a counterweight running in a guide? Everyone is familiar with the weights used on lifts to balance them, yet I have rarely seen the principle applied to the aerial. If the weight is selected with a little care it will keep the aerial steady under all conditions, and any unexpected, abnormal tension will be automatically compensated by the rising of the weight.

An idea of the completed mast is shown in Fig. 3.

It is advisable to secure the assistance of at least five friends—one to stand at each ground post and feed out the guys as the mast rises, and another to bolt sections together and attach guys as they come up through the platform. The owner can then remain at the foot of the mast and do the necessary hauling and control operations.

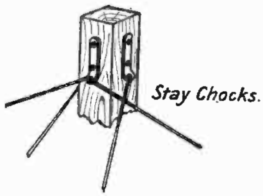


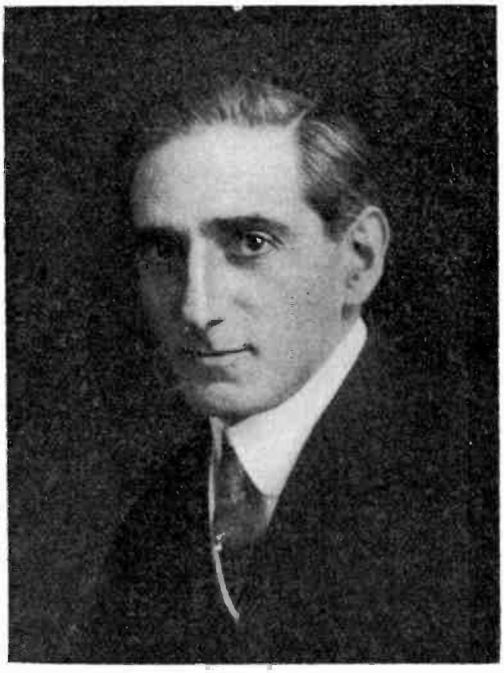
Fig. 4.

The principles of construction and erection will hold good for a mast of any reasonable height provided the at the guy wires, thick-ness of the mast-sections and the radial measurements to the ground posts are all increased in direct proportion.

The Change at Marconi House.

[R097

MR. KELLAWAY.



MR. GODFREY ISAACS.

Mr. Godfrey Isaacs, whose name has long been a household word among our readers in connection with his onerous duties as Managing Director of the great Marconi undertaking, has been forced by ill-health to resign.

Mr. Kellaway, who will be remembered as a recent P.M.G., and still more recently as a Director at Marconi House, has taken Mr. Isaacs' place.

The Perfect Set.

Part III: L.F. Amplification.

[R342·7

Unfortunately, this subject is too large to be covered in the available space. Below we deal with the valve: a later part will be devoted to the intervalve coupling.

It may seem illogical at first glance that we should call this part of our series "L.F. Amplification" instead of "The L.F. Amplifier." But the principles underlying amplification are essentially the same in single- and multi-valve amplifiers. In describing a single stage, while specifying the differences between various stages, it is possible to cover the whole ground.

Right at the beginning, however, one must distinguish clearly between amplifying morse and telephony. It is hardly necessary to labour the point, but one may as well state formally that in the first case we are only interested in amplifying one particular note, so that "note tuning" or audio-frequency selectivity is an advantage and high amplification the desideratum; in the case of telephony we desire beyond everything distortionless working, *i.e.*, even amplification of all audible frequencies (or in some cases a known deviation from this) and high amplification may have to be sacrificed.

We will consider first the question of telephony, for it is in this branch that there is the most immediate need.

Now a stage of amplification essentially includes two separate devices: the valve (with its supply for filament, etc.) and the intervalve coupling. It is the fashion at present to concentrate attention on the coupling, which is an excellent thing, but must not tempt one to neglect the study of the valve. For this reason we shall take the valve first.

It is hardly necessary, even in a fairly elementary article, to go into the question of how a valve amplifies. We believe that all our readers already realise that if the output is to be a faithful reproduction of the input, the grid volts must never go on to either the upper or lower bend of the valve curve; *e.g.*, if the characteristic of the valve under the conditions of working is as shown in Fig. 1, the input must not make the grid go beyond +2 or − 2 volts.

But the second condition for faithful amplification is even now not so fully realised. *Grid current must be prevented.* When the grid is so negative that there is no grid current, the valve behaves towards the input like a very small condenser. It offers a reactance of the order of several megohms to currents of audible frequency. If, during the positive swing of the input voltage, the grid becomes too positive, the valve acts like a condenser and resistance in parallel, and may offer only a hundred thousand ohms or so. The effect is much like that of putting a "short" on the domestic lighting supply—down come the volts with a rush. In this case that means a loss in amplification. But this resistance of "a hundred thousand ohms or so" is not

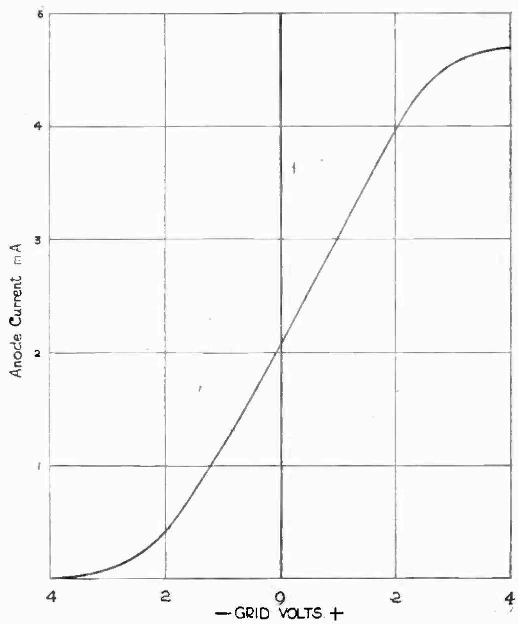


Fig. 1.

constant, but varies during each cycle of input. Hence the amplification is uneven, and distortion is introduced.

There is just one, and only one, way of avoiding this trouble, and that is *grid bias*. To us, a valve without bias is like an egg without salt, or—to use the mid-Victorian maiden's simile—a kiss without a moustache: the result has not the taste of the real thing.

In considering this question, we open up the whole question of the correct three voltages—anode, grid, and filament—for any valve. The usual method of settling these, as far as we can make out, is to use rather less than the maker's rated filament heat (to get long life), and then to apply whatever anode volts are available, and put on any grid voltage fancied. In actual practice, one can make very definite specifications for all three, if one has proper information, to wit, full valve characteristics and a knowledge of the input voltage (of which more anon).

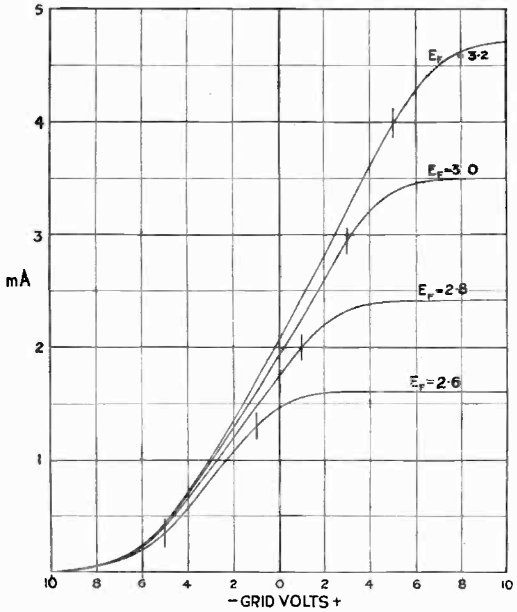


Fig. 2.

Filament Heat.

In every case, the first consideration is the minimum filament heat. An increase does no harm to amplification, but shortens the valve's life. Fig. 2 shows curves for a French valve of the 60mA type at various filament voltages, with 100 volts on the anode in each case. There is a rapid increase in saturation current, but, more important, a much greater permissible input. In each case, the grid must not go below about — 5 volts. But increase of filament heat enables us to extend the range of — 5 to — 1 (4 volts "swing") in one case to a range of — 5 to +5 (10 volts "swing") at the largest filament heat shown. In practice, as hinted above, we shall see that the grid stays negative, but, as is shown below, that does not affect the total "swing" obtainable.

Our rule for filament heat, then, is simple (in theory): *The minimum filament heat is that which allows the required input swing on the "straight" of the valve curve.*

In practice, what is the input? This is the crux of the whole question, and is not yet widely known. The real difficulty is to get a good definition. Suppose we give the input to the last valve for "good loud-speaker strength," what will our readers understand by it? In further detail, our idea of this is that the announcer speaks very loudly; the soloist is a little below his actual strength in the studio; the orchestra considerably less than its original strength (the difference arises, of course, in the control room, where the input to the transmitter is cut down for loud performances). Most of the programme can be *heard* all over a four-storey house if the room door is open: it can be *understood* one floor up or down. The input to our last valve has an amplitude (measured) of about 7 or 8 volts, *i.e.*, a swing of 15 volts. This figure is the same as that given by Capt. Eckersley as "probable for good loud-speaker work in a fair-sized room," and tallies with that in last month's E.W. & W.E., as measured by G. W. Sutton (E.W. & W.E., Nov., 1924, p. 92). From it one can find the probable input for other stages.

The other question is as to the output of the valve (or rather its maximum safe input) at different filament heats. Unfortunately it is comparatively rare that this information is given. Our own test reports do so, and we show elsewhere in this issue how to convert the condensed curves we show into the ordinary form. It is just as well to repeat here that the effect of increasing anode volts is as if the curve were shifted toward the left. There is not an increase of saturation current (there may be a small increase in some cases, but not a *working* increase).

Going back to our curves of Fig. 2, we see that this valve, even at 3·2 volts, will only give 10 volts swing, and will, therefore, not give "good loud-speaker strength" without distortion. But if it is used as the last valve but one, resistance coupled, we can estimate its input swing as, say, 2 volts; for it happens to give a magnification of 10, so that with resistance coupling it would give an amplification over the whole stage of, say, 7 to 8, so that 2 volts on it would give 15 on the last stage.

This swing of 2 volts can quite easily be handled by this valve, even at only 2·6 volts. But since the curve at that filament heat is not a particularly nicely shaped one, it will probably be better to use 2·8 volts.

Grid Voltage.

Next, the grid bias. Our condition is that there shall be no grid current. It is frequently assumed that this will be avoided if the grid never becomes positive compared to the negative end of the filament. But this is not quite correct. Different valves have different "thresholds," as it were: within the common range of receiving valves are some where grid current begins at — 2 volts on the grid, and others where there is none till the grid reaches +2 volts. In the absence of a curve or other definite information, it is fairly safe to call — 1 volt the limit.

If now the *most positive* value of grid volts is to be — 1, the steady voltage must obviously be half the swing below — 1, *i.e.*, for the last valve it must be — 8½ at least; for the last but one, with a swing of 2 volts, it must be 1 volt below — 1, which is — 2.

This is quite simple: the main point to grasp is that the least desirable grid bias is fixed, not in a laudable attempt to keep down anode current with a given anode voltage, but is given by the input before the anode voltage is decided.

Anode Voltage.

This again is quite easy. Knowing the grid bias and the input swing, we know the limits between which the grid volts will vary. All that is necessary is to apply such anode volts that between these limits the characteristic is straight.

Thus, suppose we are using for last stage the power valve whose curves are shown in Fig. 3. We see that the requirements are fulfilled by an anode voltage of 160. We could use a higher anode voltage if desired, with a larger grid voltage, such as 200 on anode and — 15 on grid, but this has no advantage so long as we are beyond the minimum values found as indicated.

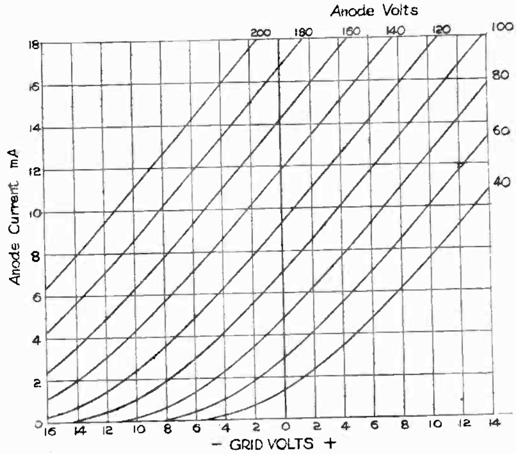


Fig. 3.

Summarising, our rules for valve adjustments are:—

First.—See that the filament volts are enough to handle the input on the straight part of the curve;

Second.—Set the grid bias to at least one volt more than half the swing;

Last.—Use sufficient anode volts to bring the centre of the straight part to the grid bias already found.

It will be remembered that we divided the subject of L.F. work into morse and telephony, and then divided a stage into the valve and the coupling. We have now (we hope) given some idea of how the valve should be treated. We have next to examine the coupling, and then consider what modifications we shall make when our object is not distortionless telephony work, but high efficiency for morse. But space is short, and we must defer these parts of our subject till next month.

Radio 5KO. An Amateur Station.

By T. W. Higgs, B.Sc.(Eng.). [R612

DESPITE that the old call sign 5KO is heard no more on the air, many people will read about the station with interest.

The receiving side, of course, has been in existence for years, in various forms, alternately at Bristol and Wolverhampton, and at both places simultaneously. Transmission, however, was not commenced until January, 1923, when the call sign 5KO was allotted and the station appeared on 440 metres, C.W. and telephony.

A few weeks of this proved quite enough to arouse the hatred of every broadcast enthusiast for miles around Bristol, so a descent was made to 200 metres, in the vain hope that this would settle the quarrel. There followed the usual wild search for vanished aerial current, the erection of counterpoises, and all the struggles involved in a first attempt at short-wave transmission, until, at the end of March, 1923, we were proudly putting half an ampère into the aerial and had worked with F8AB—the Ultima Thule in those far-off days.

In spite of QRN and the periodic collapse of the aerial, the summer passed pleasantly enough, the efficiency of the set being gradually increased; and in May, our faithful friend, Mr. Steffensen, reported 5KO's telegraphy in Denmark, and shortly afterwards succeeded in hearing weak speech from the station. At about this time the circuit, after much dabbling in "reversed feed-backs," Colpitts, etc., finally settled into the Hartley, and the aerial current reached the delightful figure of 0·9 ampère with 10 watts input. Theorists have claimed that 1·2 amps can be reached, but although the writer has actually seen this obtained, he is doubtful whether the average amateur station can honestly claim to come anywhere near it.

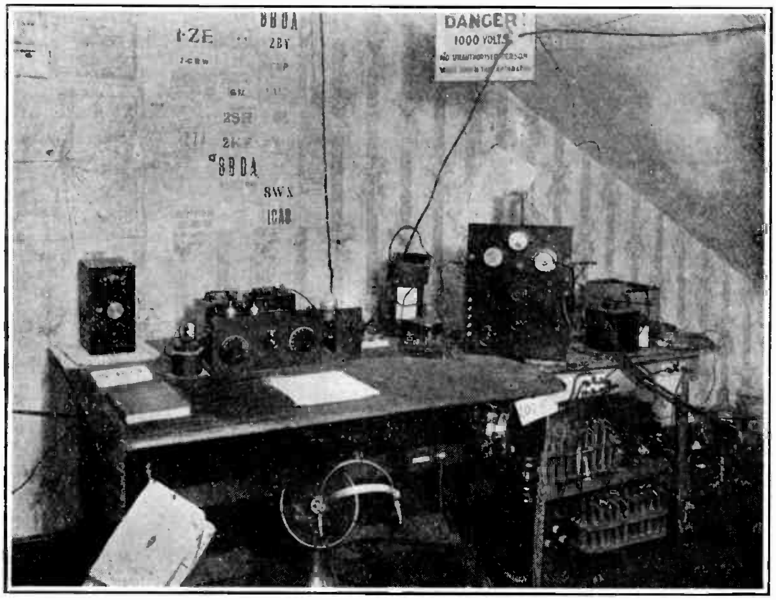


Fig. 1.—A general view of 5KO's station.

Towards the end of the summer the Transatlantic tests began to loom large on the horizon, and after a careful review of finances, for this was not a millionaire station, an application was made for a 200-watt licence. The remainder of the year was spent in writing letters inquiring when the said licence might be expected to materialise. It finally arrived in the nick of time, and since the amateur radio enthusiast is nothing if not optimistic, all the apparatus was in readiness.

In the meantime the receiver had been somewhat improved, and persuaded to tune down to 100 metres and under, and we had the surprise of our lives when the first two stations we logged on these waves turned out to be F8AB and U1MO engaged in friendly conversation—the first we had heard of the actual accomplishment of amateur two-way work across the Atlantic.

At 1 a.m. on the morning of December 22, with two 50-watters in the sockets, an attempt was made at the first code group; the key was pressed and the aerial ammeter crawled over to 3 amps. Note to beginners: Never try to key in the aerial circuit when there are three ampères in it. . . .

A new key was next placed in a less "juicy" part of the transmitter, and a fresh start made. The first five 50-watt valves proved soft, and it will readily be imagined that they did not turn more blue than did the air around the "den" after the operator had made his comments on the situation. As a consequence we had to fall back on two trusty Mullard 30's, and the rest of the tests, and all our subsequent two-way work, were carried out with these two long-suffering valves, the input to the two in parallel being around 50 watts.

The first report received was from 3APV of Washington, who logged the code DZWWT correctly on December 27. From this time until the end of April frequent two-way work was carried on—sixteen American and four Canadian stations being worked—while the signals were reported in the 1st, 2nd, 3rd, 4th, 8th and 9th U.S. districts and in the first three Canadian districts, the farthest being BX and 9AKE. After April the approach of a final examination caused a slackening off in early morning activities, though Argentine CB8 was logged on the morning of May 25. At the end of June, examinations being over, Finnish 2NM was worked, and in early July the station was closed down owing to the owner's removal to Newcastle-on-Tyne.

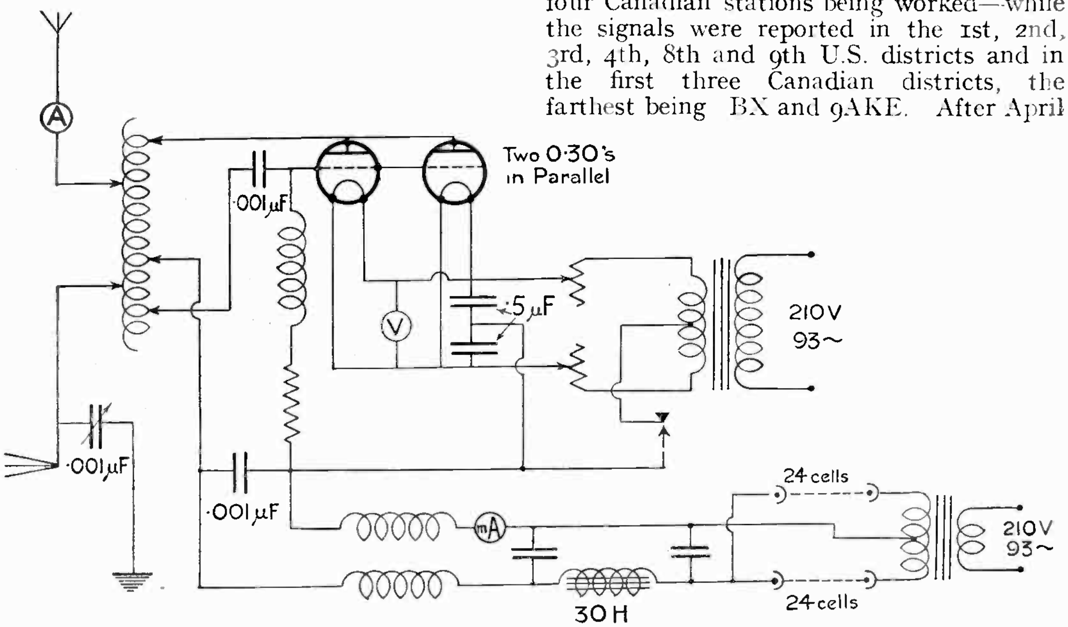


Fig. 2.—A Circuit diagram of 5KO's apparatus.

During practically the whole of this work, the circuit used was the Hartley, with series supply: the H.T. was 1 000 volts of rectified A.C., and the only type of rectifier used was the electrolytic, which gave every satisfaction. They were made up in five-inch test-tubes filled with a solution of borax, 24 cells in series with each outer of the transformer in the usual centre-tap circuit. The filaments were supplied from an 8-volt winding on the transformer, the periodicity of the supply was 93 cycles.

A general view of the apparatus is given in Fig. 1, and a circuit diagram in Fig. 2. The aerial was a 4-wire cage 50 feet long and of an average height of 50 feet with T lead-in also caged; one end supported by a 30-foot steel tubular mast on the roof of the house, the far end on a 60-foot tree. An 8-wire counterpoise ran more or less beneath the aerial, and the earth connection was made to the zinc roof of the building, all buried earths having proven unsatisfactory owing to the length of the lead, since the "den" was in the top storey.

Two receivers were in general use—a loose-coupled tuner, with detector and one stage L.F., and a Reinartz with one L.F. The station was heard in U.S.A., Canada, W.N.P., Algeria, Finland and 13 other European countries.

For the future 5KO will be located in Newcastle-on-Tyne, at present in lodgings; but probably by the time this article appears a more settled QRA will have been found and a lady operator added to the *personnel*. Address for the present is 4, Victoria Square, Jesmond, Newcastle. Reception is still carried on, of course, but the 240-volt D.C. mains do not provide much "kick" for the transmitter, and it is hoped that the next move will be to a house equipped with A.C. mains. But the question we are asking ourselves is: "Is it worth while re-erecting the station in order to communicate *only* with stations in Great Britain and Northern Ireland?" The answer certainly seems to be in the negative.

Fault Tracing.

Diagnosing Defects without Instruments.

By L. R. Gleason. **[R620·068**

WIRELESS sets, no matter how carefully constructed, are liable at times to develop faults. This in no way reflects on the skill of the designer or workman, for the fault is usually due to fair wear and tear. Sometimes the hand of the user, not always well-trained in the delicate adjustments of control, is the main cause of the trouble. In all cases it is well to be able to remedy speedily minor defects which have the annoying property of turning up exactly at the wrong moment.

To have a sound knowledge of a receiving set is always of value to the operator, but the fullest knowledge can only be obtained by the actual construction of the set. When this is not possible it is at least useful to have a swift means of diagnosing the cause of the trouble.

It has been said that a little knowledge is dangerous. Probably this is quite true, but it is by no means so dangerous as the unskilled investigator armed with a screw-driver and in a hurry to remedy a fault.

Apart from a dull spot on a crystal, a burnt-out valve or a valve fitted with plugs that do not make good contact with the sockets, the majority of faults are due to broken or imperfect connections, and if the latter there are none more irritating than an intermittent disconnection.

We do not pretend in this article to give a method of measuring the capacity of condensers or the resistance of transformers or grid-leaks. The principal object is to provide a simple means by which a circuit can be tested when a defect develops and, in the case of a home-made set, the connections tested and checked without stripping the set down.

It cannot be emphasised too strongly that, in seeking for a fault, the only swift and sure method is to use a definite system. Without this all efforts are haphazard. The systematic method is employed by all large telephone and telegraph concerns and by the maintenance engineers of intercommunication telephone companies.

The principal feature of the system is that no instruments are necessary and that the set itself provides the requisite means for making an adequate test. Every receiving set is fitted with at least one headphone, and this, allied to the ear of the user, furnishes a means of testing that can hardly be surpassed by even a very sensitive galvanometer.

Systematic Testing.

Fig. 1 is a diagram of the internal connections of the familiar G.P.O. telephone. It will be seen that there is normally a D.C. voltage of about 22 across the lines connecting with the Exchange. So long as the receiver is on the hook, no D.C. current passes through the instrument. For our purpose a fault now arises and to locate it we possess only a headphone. Simply with this, the fault can be traced, and the same system applies to wireless sets; transmitting or receiving; large or small.

We will assume that on attempting to call the Exchange no reply is received. Replace the receiver on the hook and proceed as follows. Connect the headphones across the terminals B and C (Fig. 1). A loud click will show that the line to the exchange is intact. If none is heard the line is broken, or the lightning arrester has been in action. A dead short circuit in the condenser between F and H is also a possible but unlikely fault. Leave one of the headphone cords connected to C and with the tag of the free one make the following contacts, A, D, E, K, L, T, R, G, F. In each case a click should be heard. If not, the fault lies between the last point giving a click and the silent point.

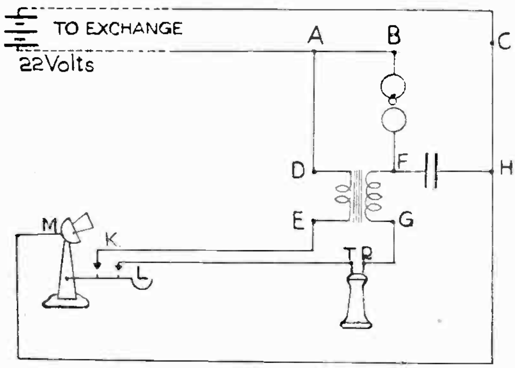


Fig. 1.

For example, a click at F shows that the bell coils are unbroken; similarly a click at G indicates that the secondary of the induction coil is intact. A silent point at R indicates that there is a break in that particular lead of the receiver (G R). Now disconnect the lead of the headphone from C and connect to B. A loud click on touching F indicates a short-circuited condenser, while a click at point M proves that the circuit between the microphone and the line wire is complete.

There are many other tests that will suggest themselves to the reader, but as telephone testing alone is not the purpose of this article, it is sufficient to indicate the working of the method.

Application to Wireless.

To come now to the application to wireless sets. Fig. 2 is a diagram of a crystal set which we will assume has suddenly become silent. In this case a small battery is a convenience and one of the ordinary pocket flash-lamp type is quite suitable. Disconnect the telephones and first make sure that *they* are all right by connecting them across a battery. A loud click should result and no uncertain crackling sounds be heard as the cord is run through tightly gripped fingers. The cord, by the way, is very frequently the culprit. If no battery is available, a small pile of silver and copper coins placed alternately and moistened with vinegar will provide enough current to test the phones.

After making certain that the *outside* connection of the aerial to the lead-in is sound, connect the headphones in series with the battery and after removing the crystal, apply one lead to A. A click on touching E shows that both coils of the variometer are in order: silence at E would prove a break in one or other of the coils.

Failure to obtain a click on touching the top of the crystal holder at B proves the fault to lie between it and A.

Next disconnect the telephone lead from A and connect to E and prove E P. A loud click on touching H indicates a short circuit in or across the condenser.

It will be seen that all the above tests can be made without removing a single screw.

The case of a valve set (Fig. 3) is just as simple and is facilitated by batteries being available. First remove the valve; then disconnect the headphones and prove them as described. Then connect them in series with the L.T. battery, which should be disconnected from the set. The H.T. battery should also be unplugged. A click between A and E shows that the ATI is in order, but if it is of the type varied by a switch

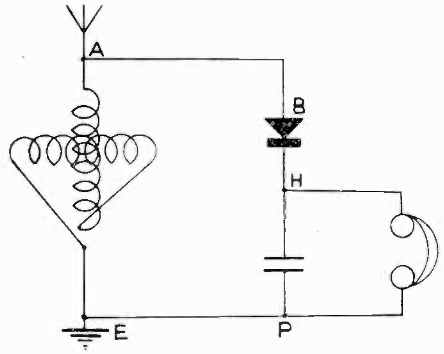


Fig. 2.

and a number of tappings to studs, each of these should be tested. This can be done rapidly and will often show that although the ATI as a whole is intact, a silent stud proves a break in that particular tapping.

The reactance is tested by touching the terminal P with one lead and the plate socket in the valve-holder with the other. No crackling sounds should be heard while the reactance is rotated or varied. A very loud click between A and G (the grid socket in the valve-holder) points to a shorted grid-leak or condenser, which should be removed and tested separately. Similarly a loud click between M and K indicates a short circuit in the telephone condenser. Particular care should be taken in testing between points B and S. The valve should be replaced before making this test and the filament resistance manipulated to ascertain if there is any uncertain contact between the switch-arm and the resistance-spiral.

As in the case of the crystal set, all these tests—with the exception of removing the grid-leak condenser—can be made with speed and ease without opening up the set.

The same system can be applied to a

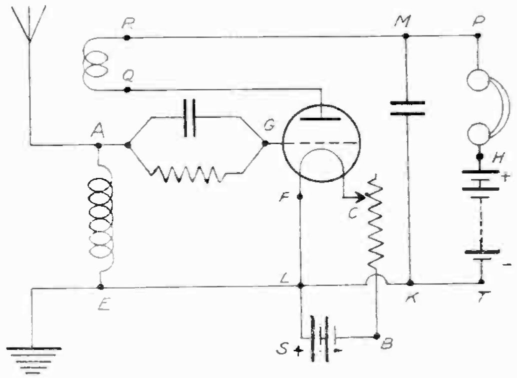


Fig. 3.

multi-valve set provided that the person testing will adhere to a definite routine and observe the golden rule of beginning at the beginning and suspecting every part of the circuit until it has been proved clear of doubtful or intermittent continuity. Tapping the apparatus with a pencil or the knuckles while listening during the various tests will often disclose, by the rustling sounds caused, an intermittent contact that otherwise would remain an elusive nuisance.

Volume I. of E.W. and W.E.

Our publishers ask us to state that arrangements have now been made with regard to Volume I. of EXPERIMENTAL WIRELESS AND THE WIRELESS ENGINEER.

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All these prices are post free.

Cumulative Grid and Anode Current Rectification. [R134

By H. J. Barton Chapple, Wh.Sch., B.Sc. (Hons. Lond.), A.C.G.I., D.I.C.

The writer gives the results of some quantitative tests, showing the degree of rectification obtained with various values of grid resistance, grid and anode voltages.

THE object of these experiments, carried out in the High Frequency Laboratory, Bradford Technical College, was to obtain quantitative data for reference when employing the thermionic valve as a rectifier.

The principles involved in cumulative grid, or—as it is sometimes called—grid-current, rectification, and also anode current rectification are fairly well known, but a brief reference to the mode of operation will not be out of place here.

Referring to Fig. 1—which indicates a simple single valve receiver arranged for cumulative grid rectification—and omitting for the moment the grid-leak resistance R, if the filament is incandescent, the grid will assume a slightly negative potential—just sufficient to repel further electrons from accumulating on the right hand side of C, which, of course, acts as an insulator. This potential is generally about —1·5 volts.

When the received signal produces oscillations in the L_1C_1 circuit, the grid is made alternatively positive and negative with respect to the filament, as C is a conductor to the alternating potentials. Electrons will be attracted to the grid during the positive half-cycle and, since they remain on the right hand side of C, will cause the grid to assume a higher negative potential than previously.

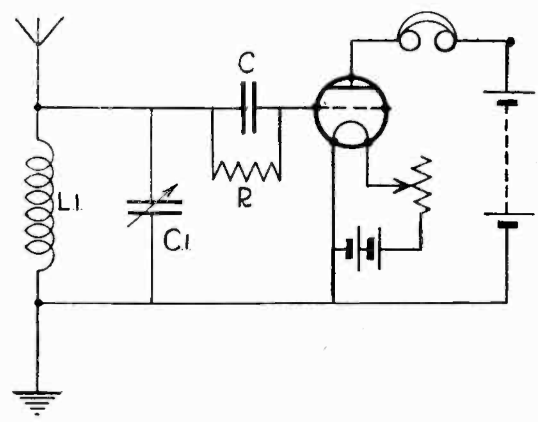


Fig. 1.

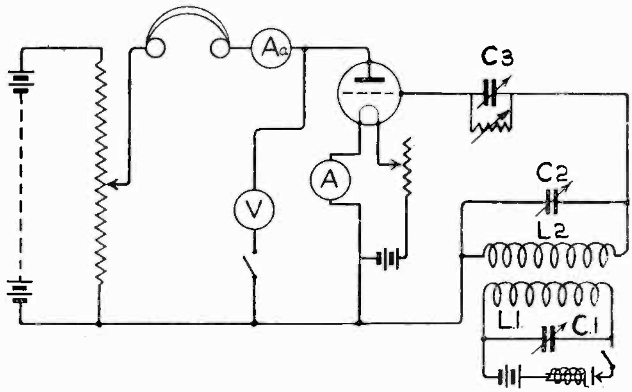


Fig. 2.

The negative half-cycle makes the grid momentarily still more negative, but no electrons are attracted. The following positive half-cycle raises the grid potential above its initial normal value, and more electrons are attracted; and so on, until at the end of a wave-train the grid will be at a relatively large negative potential. The anode current has decreased in consequence, and further wave-trains would produce little or no effect on this resulting condition.

The object of the grid-leak resistance R is thus to restore the thermionic valve to its initial condition by allowing the electrons accumulated on the right hand side of C to escape across C and travel to the filament *via* L_1. The resulting change in anode current gives the familiar telephone signals. In order to secure the maximum decrease in anode current for a given alteration in grid-potential the thermionic valve should be worked on the straight line portion of its particular static characteristic curve for the given anode potential.

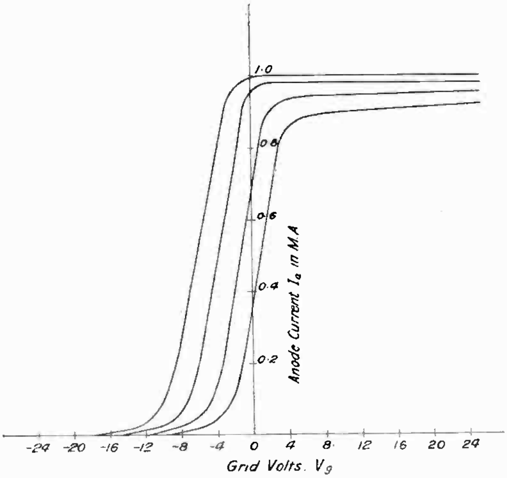


Fig. 3.

In the case of anode current rectification advantage is now taken of the bends in the static characteristic, and signals are heard in an almost identical manner to ordinary crystal rectification. For a given change of grid potential, the average resulting alteration in anode current will be an increase if working on the bottom bends, but a decrease if operating on the saturation bends.

For the purposes of this experiment, apparatus was first connected as indicated in Fig. 2. L_1C_1 is an oscillatory circuit buzzer exciter very loosely coupled to L_2C_2, which is connected to the grid of the thermionic valve through the variable grid-leak resistance R and variable air condenser C_3.

Varying potentials could be applied to the anode by the potentiometer across the H.T. battery, while to measure the anode current a sensitive unipivot micro-ammeter (A_a) was employed, shunted by a resistance box to give suitable scale deflections. A new Mullard Ora thermionic valve (F153) was used, with the filament current kept constant at 0·6 amp. Four static characteristics of this thermionic valve are shown in Fig. 3, with anode current I_a plotted against grid volts V_g for anode potentials V_a between 40 and 100 volts.

A Watmel variable grid-leak resistance was utilised for R, and, adjusting this to 1 megohm with the aid of a bridge megger, it was shunted across C_3. With C_3 set at a low value, A_a was read with the buzzer off and working, corresponding to the aerial circuit (equivalent to L_1C_1, which had been tuned to the frequency of L_2C_2) unexcited and excited by incoming signals. This was repeated for various values of C_1 up to 0·001 5 microfarad, the anode potential being kept constant at 40 volts throughout. Corresponding sets of readings were taken with V_a at 60, 80 and 100 volts, and R at 2, 3, 4 and 5MO. The change of anode current (decrease in every case) was then plotted against values of C_3, and the whole 18 curves are shown in Fig. 4.

A good deal of interesting information may be secured from an analysis of these curves, as they indicate the magnitude of signal strength to be expected with the familiar 0·0003 grid condenser, and the advantages accruing by increasing this value and also using other grid-leak resistances than the usual 2MO, with subsequent adjustments V_a. This may be best studied by turning to Fig. 5, which is plotted from

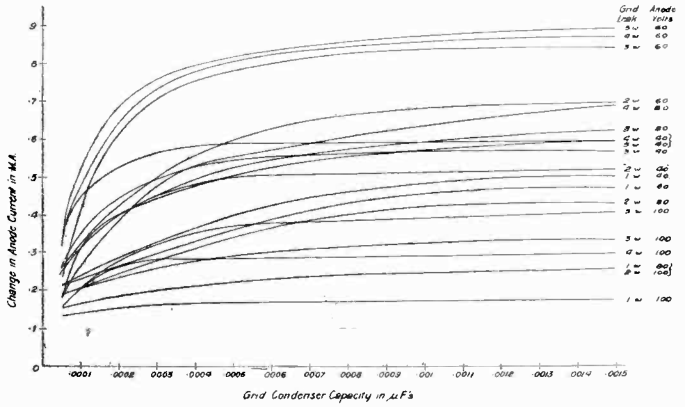


Fig. 4.

Fig. 4, with change of I_a against R for C_3 at 0·000 3 and 0·000 $6\mu F$, curves indicated by thick lines being with the latter condenser setting and by thin lines with the former.

The results drawn for V_a=60 volts are distinctly the best, and doubling C_3 gives 25 per cent. added current change with R = 2MO and 16 per cent. with R=3MO. The advantages of 3MO and 0·000 6μF are particularly noticeable in every case, but it is seen that increasing V_a beyond 60 volts results in a reduction of signal strength. Again, increasing R to 4 or 5MO, while giving a slightly greater telephone sound with V_a at 40 and 60 volts, reduces it with V_a at 80 and 100 volts.

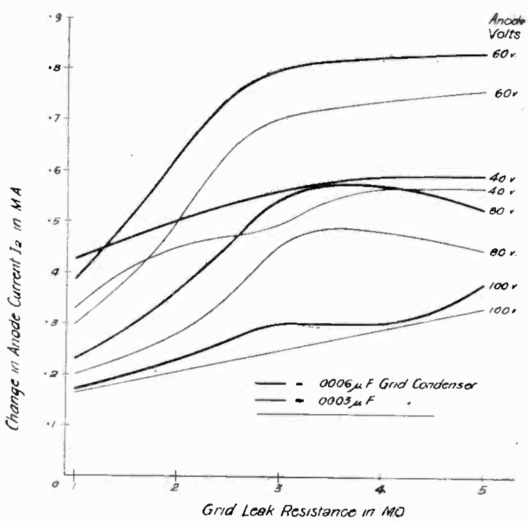


Fig. 5.

A further set of curves are shown in Fig. 6, which is derived from Fig. 5, with change in I_a plotted against V_a, C_3 being at 0·000 3 and 0·000 6μF as before for various values of R, while thick curves stand for the latter condenser setting and thin ones for the former. These conclusively indicate how critical is the choice of V_a in the cases of 3, 4 and 5MO, and emphasise the necessity for a careful examination of the static characteristics of a thermionic valve to ensure efficient working.

Referring to Fig. 3 it is clear that the 60-volt curve is bisected by the —1·5 grid volt ordinate, which is the normal steady working point, and thus would have been chosen in the usual circumstances, although with R at 1MO, 40 volts is slightly better than 60 volts.

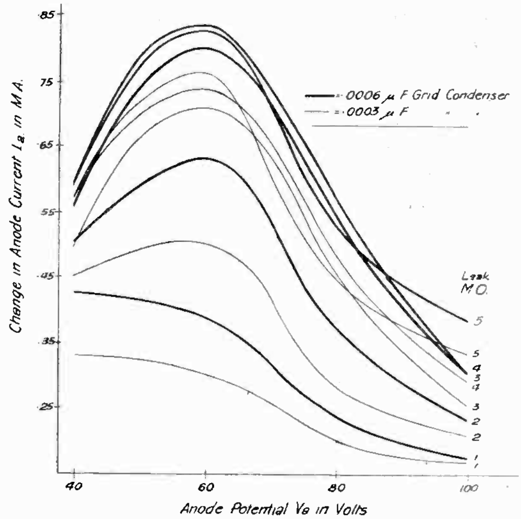


Fig. 6.

While the necessary value of V_a will depend upon the magnitude of the filament current and the type of thermionic valve employed, the results indicate that improved signal strength will be the outcome of an adjustment of R to 3MO and C_3 to 0·000 6μF. To ensure maximum efficiency both these quantities should be variable in any good receiving set, as it then permits the operator to make careful adjustments to suit particular requirements.

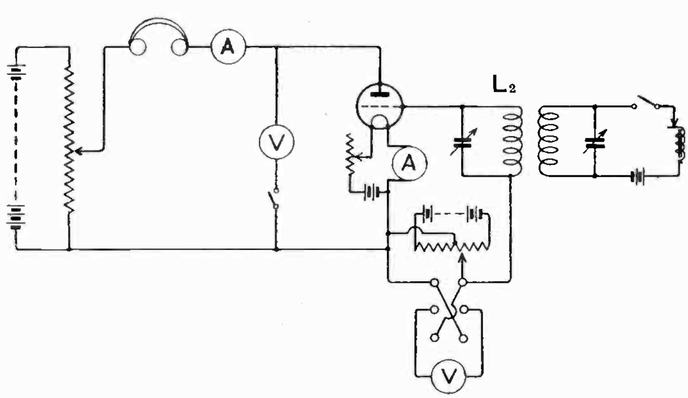


Fig. 7.

The author has found during the course of his experience that too often little attention is paid to this portion of a receiving set, although it is just as important as the tuning arrangements; and the substitution of "variables" for "constants," while necessitating extra care and adding to the multiplicity of the controlling factors, invariably gives ample repayment for the time spent in making the adjustments. In the case under review 0·000 6μF. shunted by 3MO give excellent results when used in conjunction with 60 volts on the anode.

Turning attention now to the less familiar mode of rectification, viz., anode current, the circuits of Fig. 2 were modified to those shown in Fig. 7.

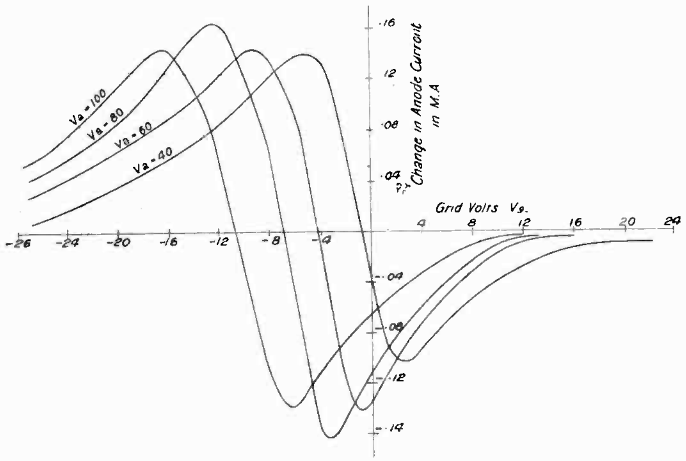


Fig. 8.

By the aid of a potentiometer across a 50-volt battery, various positive and negative potentials could be applied to the grid *via* L_2, the negative leg of the filament being permanently attached to the centre point of the potentiometer, while the free end of L_2 was connected to the movable contact as indicated.

With V_a set at 40 volts, the grid potential was adjusted to -24 volts and readings of anode current taken with the buzzer off and working. This was repeated for several values of V_g up to $+24$ volts, and the whole process then repeated for V_a at 60, 80 and 100 volts. The curves shown in Fig. 8 are the result of plotting V_g against the change of anode current brought about by the incoming oscillations.

With negative potentials on the grid, an increase in anode current is observed when operating on the bottom bend of the characteristic, which, of course, is what would have been expected. The resulting changes exhibit almost equal maxima for the four chosen anode potentials, and the value of V_g is seen to be fairly critical. Similar results accrue at the top characteristic bend with a rapid falling off of signal strength between bends; *i.e.*, on the straight line portion of the static characteristic.

Perhaps the most important feature to notice is that the change in anode current when employing this type of rectification is considerably smaller than with the former and more popular method, about one-fifth of the signal strength being secured under the best working conditions. Thus little doubt exists as to the more preferable mode of operation, especially as the latter method necessitates the employment of additional batteries requiring periodic charging.

The author wishes to thank Messrs. Rhodes and Sutcliffe, electrical students, for assistance in determining some of the experimental data.

A Receiver for Wave-lengths of 3 to 5 metres.

By E. H. Robinson (2VW). **[R343**

WORK on short wave-lengths of only a few metres is now attracting the attention of wireless experimenters to an increasing extent every day. In the American and French technical Press particularly articles dealing with these ultra-short wave-lengths have been appearing for some time past, but the majority of these articles only tend to show that this branch of the science is at present in a very elementary stage.

A number of ingenious transmitting circuits to operate on 5 metres or so have been devised and published, but the receiving side does not seem to have received its share of attention. This is a lamentable state of affairs, as it is of no use to us to be able to transmit on a wave-length on which we cannot receive.

In the writer's rather limited experience of short waves the question of sensitive and stable reception is a considerably more difficult one than that of transmission. On 100 metres the possibility of material H.F. amplification is open to question; on 4 metres it is right out of the question. The present state of the art therefore offers only three alternatives, namely, the plain regenerative detector valve, the supersonic heterodyne or the Armstrong super-regenerative detector. All three involve as a starting-point a good one-valve regenerative receiver, and a brief description of a one-valve receiver forms the subject of the present article.

Figs. 1 and 2 between them should give the reader a pretty clear idea of the writer's receiver, which was constructed for work on about 3-5 metres. Fig. 1 gives details, while Fig. 2 is a perspective sketch of the whole assembly. Absolute simplicity is desirable, so it was decided to use a Hartley circuit, with one simple solid oscillatory circuit.

A stout ring (A) of copper bar (both Figs.) has a gap in it, the free ends being soldered to two parallel copper plates (B and C). A forms an inductance of one turn, while B and C form the plates of the tuning condenser. The ring A is stiff and springy, and tends to hold the plates B and C apart, while an opposing screw action (illustrated at J in Fig. 1) enables the plates to be pushed together to a greater or less extent by rotating the insulated arm H. This constitutes the means of tuning the circuit.

By means of flexible leads as short as possible, plates B and C are connected to grid and anode respectively. The beauty of the Hartley circuit, which few people seem to appreciate, is that it has little or no mean H.F. potential to surrounding bodies, and has a nodal point somewhere in the middle of its inductance. The former fact tends to reduce stray dielectric losses and the latter fact has been utilised by suspending the whole circuit at its nodal point N.

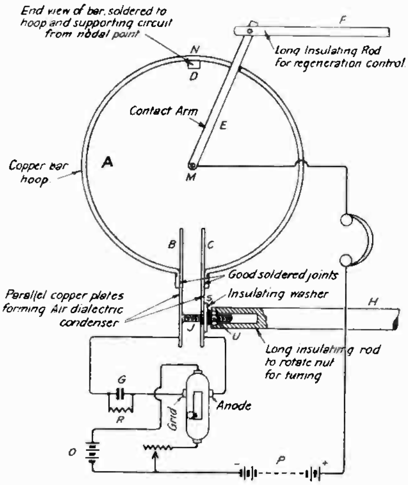


Fig. 1.

A is soldered at N to a brass arm (D) projecting from the vertical wooden back. The H.T. for the valve may be supplied through a pair of telephones *via* the nodal point of the tuned circuit. Under these conditions, the valve oscillates most freely. If, however, the connection is made to a point on the ring somewhat removed from the nodal point, the tendency to oscillate is greatly reduced; this gives us a very simple and convenient means of reaction control. A radial arm (E) of springy brass is pivoted about the centre (M) of the circle, and makes rubbing contact with the edge of the ring A in the neighbourhood of N. It is through this contact that the H.T. is supplied *via* the telephones. If the path of contact is kept smooth and clean, the reaction control is smooth and silent, but it is important that the area of contact should be small as well as definite. Lubrication with vaseline or oil frequently improves a rubbing contact—a rather surprising fact.

One great advantage of this method of controlling reaction, apart from its simplicity, is that it has but little effect on the tuning—a very important point. The reaction arm and its centre support should not be massive, and the amount of metal in them should be as small as possible to be consistent with robustness, so that eddy-current losses are reduced to a minimum.

To return to the tuning arrangement, Fig. 1 will serve to make the idea clear. J is a straight piece of brass rod soldered in to plate B and having a good, fairly fine thread. It passes through a hole in plate C which allows ample clearance. A nut (U) engages with the thread of J, and may be rotated by means of the anti-capacity handle (H) of wood, ebonite or glass. An insulating washer (S) keeps U out of contact with plate C, thus avoiding a short circuit, while a metallic washer may be inserted between S and U to improve the mechanical action.

Great care must be taken with this part of the apparatus both mechanically and electrically. On the mechanical action much of the fineness of tuning depends. The washer S, as the one solid dielectric in the tuned circuit, requires particular attention. If ebonite is used, it should be of the very best quality and should be at least $\frac{1}{8}$ inch. If a better substance than ebonite is available it should be used.

Various arrangements no doubt occur to readers by which the dielectric flux through washer S could be reduced, but even in the case illustrated it would not appear to be very serious provided that a good dielectric is used. Of course, some support for the free end of H and the reaction rod (insulated at H) should be provided but it has not been considered necessary to encumber the diagrams with these details.

As far as the writer is aware, this would seem to be the nearest approach to a real low-loss tuner that has yet been devised.

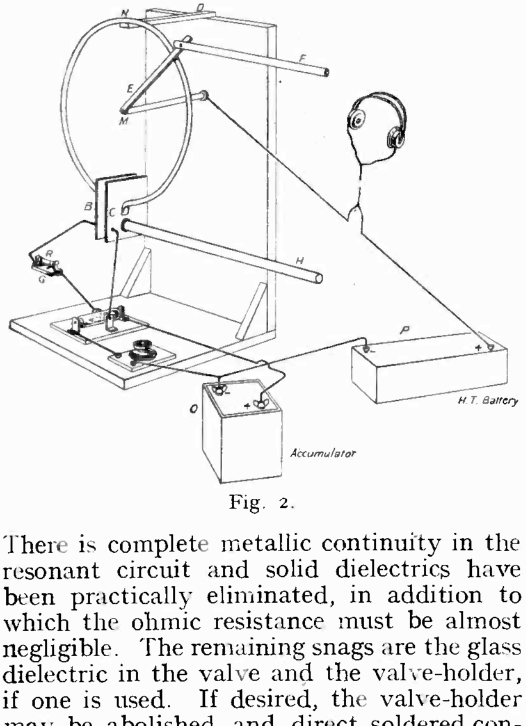


Fig. 2.

There is complete metallic continuity in the resonant circuit and solid dielectrics have been practically eliminated, in addition to which the ohmic resistance must be almost negligible. The remaining snags are the glass dielectric in the valve and the valve-holder, if one is used. If desired, the valve-holder may be abolished and direct soldered connections made. At the time of writing, however, the author has not tried this refinement, a V24 valve in an ordinary sort of holder having been used. Four-pin valves in the usual four-pin socket usually work, but not with such certainty, since the losses in the holder sometimes prevent the set from oscillating.

Exactly what is gained on these short wave-lengths by trying to cut down energy losses in tuners remains yet to be decided. There does not appear to be much margin on 3 metres between positive losses and the "negative resistance" due to regeneration, so that one must be careful if one wants a set to oscillate at all; but once a set is just on the point of oscillating, or just actually doing so, the open question remains: "Is it worth reducing the losses any further?" The writer of this article certainly does not know for certain yet. One point worth bearing in mind is that at the enormous frequencies under consideration the radiation resistance of the single turn may quite likely be greater than all the other losses of the circuit put together; and it is no good trying to reduce the radiation resistance of a receiver, because this would necessarily entail destroying its properties as a pick-up.

So far no dimensions have been given. It is no use designing a circuit of this type and then trying to calculate its wave-length by first calculating the inductance and capacity. The capacity between the plates may be worked out easily enough by measuring the dimensions of the plates and the distance between them; but it is not so with the inductance. In most good text-books you will find a formula for the inductance of a single turn of round wire, but this gives hopelessly wild results, because the formula assumes a current uniformly distributed through the cross-section of the wire.

Now, if you pass an H.F. current through a straight piece of wire, it confines itself almost entirely to the surface of the wire. If you bend the wire into a circle, things are worse still, as the current tends to confine itself to the innermost edge, so that a kind of new moon-shaped distribution of current results. Therefore, any simple theoretical formula is of no use in the case under discussion. The only thing, then, is to find one's own dimensions by experiment. The following dimensions gave a receiver which, according to some rough Lecher wire experiments, covered a range of about 3·5 to 5 metres:—

Inductance (A): Copper strip 8 in. mean diameter, $\frac{1}{4}$ in. wide by $\frac{1}{8}$ in. thick.

Condenser plates (B and C) each 4 in. by 3 in. by $\frac{1}{16}$ in. thick. Greater length horizontal.

Minimum distance between plates, $\frac{1}{8}$ in.

Maximum distance between plates 1 in.

There are few other miscellaneous details to mention. An ordinary kind of grid condenser is used, and the capacity should not be greater than .0001μF. The grid lead R may be taken across the grid condenser or to the positive filament terminal. If the leak is taken straight across the condenser, its resistance should be higher than usual—say, 5 megohms, as it has full H.T. across it. The arm D should give rigid support to the loop to avoid vibration ; this is one of the reasons for using such thick material for the loop.

The disposition of the L.T. leads, the phone leads, as well as those of the L.T. battery (O), and the H.T. battery (P) is important. The two latter may be arranged compactly together behind the set out of the way of the H.F. circuit, while it is advisable to take the L.T. and phone leads straight back from the apparatus in a direction parallel to the axis of the loop A. This reduces coupling between these leads and the H.F. circuit. Loose contacts between conducting bodies anywhere in or near the receiver should be avoided, as their effects are exaggerated at these frequencies.

The question of coupling a 4-metre receiver to an aerial is not within the scope of this article. Suffice it to mention that "tight" coupling between the receiver and a straight wire is obtained when the wire is in the same plane as the receiver coil and within a foot of it. One readily gets stray coupling effects to wires, pipes, etc., that may be present near the scene of operations.

It is interesting to note that when one is listening on 3-5 metres, one gets a lot of QRM from the ignition of motor vehicles passing in the neighbourhood.

There appears to be no ostensible reason why the above method of constructing a receiver should not be adapted for wavelengths up to 20 metres or more, for there would be no great difficulty in replacing the one-turn coil by three or five convolutions, with the reaction arm acting over one of them.

Some Recent Books. [R020

We deal below with some new books of most varied intention, from the simple to the "high-brow."

"The Story of Broadcasting."

THIS, by the Director of Programmes to the B.B.C., *alias* "Uncle Arthur" (alas, too seldom heard nowadays), *alias* A. R. Burrows, F.J.I., is very much more than a story of the B.B.C. It begins, in fact, with a chapter which aims to give a non-technical idea of the essential similarity of all types of ether wave, while Chapter II. is devoted to the "Milestones" of wireless. Broadcasting in morse is covered, both as to S.O.S. calls and Press and propaganda, and some very interesting information is given as to German war wireless, with which Mr. Burrows was in official touch at this end.

The author reminds us that Fessenden succeeded in experimental telephony as far back as 1902, but goes on to explain how the coming of the valve made it practicable. The initial concerts from Chelmsford in 1920 introduce broadcasting in the modern sense of the word.

From this onwards, the history does become one of the B.B.C., and very interesting it is, for it is not only history, but a detailed description of the inside workings of this great organisation, with some most interesting details as to staff personalities, illustrated by an excellent series of portraits.

Published by Cassells, at 3s. 6d.

"Broadcast over Britain."

VERY different from the various other excellent books by B.B.C. personalities, this work reflects very strongly the personality of its author, Mr. J. C. W. Reith, the Managing Director of the Company.

In most cases these other books have been designed to give the curious a peep behind the scenes, as it were—and most admirably they have done it. Mr. Reith's book, on the other hand, is really a treatise on the ethics and policy of broadcasting, the B.B.C. being useful as an example.

To a certain extent the book is a statement of the aims and ideals of the B.B.C., with one or two delicate hints as to reasons why some of them have not yet been fulfilled.

In our opinion, Mr. Reith is almost *too* delicate in dealing with some of the sources of opposition—he mentions none of them by name. As he says, the company has always left open a door for negotiation in these cases, so perhaps he "lets them down lightly" to prevent the closing of that door. But we fear that the success of the B.B.C.'s own symphony concerts and plays will prevent any reconciliation with the choleric gentlemen who are the head and fount of the concert and theatrical opposition.

As we have already mentioned, *Broadcast over Britain* reflects its author's strong and strange personality. It is serious, idealistic —even at times a little mystical. It is not nearly so "entertaining" as some of the other broadcasting books. But for those who have a real and deep interest in this wonderful thing we recommend it as food for thought.

It is published by Hodder & Stoughton, at 6s. net.

"Alternating Current Rectification."

By L. B. W. Jolley, M.A., M.I.E.E., A.M.I.C.E., A.Amer.I.E.E., of the research staff of the G.E.C., this is essentially a handbook of power rectification.

For this reason, little of it applies directly to wireless work: for the conditions are very different. In power work, efficiency is of paramount importance, while in most wireless uses of rectifiers suitability, cheapness and other factors are often more necessary.

His general mathematical analysis is, of course, applicable to all rectification, but after this there follows Part II. on mechanical rectifiers of which little is useful for our particular purposes, except for battery charging.

Part III., again, on Gaseous Conduction, begins with five chapters on Mercury Arc Rectifiers, which, however great their importance for high power commercial rectification, are of little interest to the wireless reader. The one chapter on rectifying by thermionic valves of the usual type is excellent as far as it goes, and is followed by a chapter covering Neon tubes, the Tungar, etc. The new "S" tube is not mentioned, except in a short paragraph on p. 271 which may refer to it.

This is followed by a chapter on "freaks" and methods not yet developed.

In discussing the electrolytic rectifier we came upon one of the few hints of immediate use to the wireless man: the author gives some information as to the tantalum rectifier, and also mentions that tungsten in either nitric, hydrochloric, or sulphuric acid makes a good rectifier, with lead as the cathode. He quotes as a result from using the filament of a 60-watt lamp, the successful rectification of ·5 amp: strength of electrolyte 1 200 S.G. A 5 per cent. solution of potassium bichromate also gave good results.

Part V. is devoted to wireless rectifiers (*i.e.*, detectors). Here, unfortunately, the author is not thoroughly abreast of his subject. He has fallen into a familiar trap when dealing with valve grid current rectification, and when dealing with crystals shows one whose characteristic does not pass through the zero point, which is a novelty to us, though conceivably possible. This section might well have been omitted.

The book is well produced and indexed, and copious bibliographies are provided for each chapter. While, as we indicate, it contains little of immediate use to the wireless enthusiast, it is valuable for those (like ourselves) who consider the acquisition of knowledge of allied subjects to be one of the best guides to success in our own sphere.

xvii.+351 pp., copiously illustrated.

Published by Chapman & Hall, at 25s. net.

"Wireless Valve Transmitters."

There is no doubt that a book on this subject is called for, and the author, Mr. W. James, has undoubtedly devoted considerable time to its production. Nevertheless, we must confess that the result hardly satisfies us.

To begin with, the first three chapters, amounting to 58 pp., are devoted entirely to the study of the fundamentals of circuit law—Resistance, Inductance, Capacity, etc. This is excellent in itself. But surely the prospective reader—presumably the owner of a transmitting licence—must know it already! It seems out of place in a specialist work of this type.

There are other points where not quite sufficient care has been taken. For example, when considering 3- and 6-phase rectifiers for H.T. supply, the author states that each valve passes current for only $\frac{1}{3}$ or $\frac{1}{6}$ of a cycle, which does not seem correct, and the resulting wave form is quite incorrectly shown. Again, the typical loose-coupled transmitting circuit (sometimes called the "reversed feed-back") is classed as a variety of Hartley, whereas the loose coupling makes it essentially different; while in describing the Meissner circuit, no particular mention is made of its most serious disadvantage, that its wave-length depends entirely on the aerial, and is therefore often unsteady.

On p. 177, the Author is, quite rightly, calling attention to the importance of low loss in condensers; but he states that ordinary variable condensers have a "fairly high effective resistance," and recommends the use of mica condensers as having "fairly low losses." Both statements appear to us of doubtful truth.

The output from a set supplied by pure A.C. is described as "completely modulated." How then would the author describe what we usually call complete modulation; that in which the anode volts rise from say 0 to 2A (the A.C. supply, of course, varies between +A and —A)?

There are other little obscurities of a similar nature, which might give trouble to the comparative beginner.

viii.+271 pp., well illustrated.

Published by The Wireless Press, at 9s.

"Captain Eckersley Explains."

THE Chief Engineer's book is, primarily and beyond everything else, an explanation in reply to some of the criticisms addressed to the B.B.C. Those of us who have technical knowledge realise the wonderful work done by the Company's engineers; but the uninformed often do not realise in the slightest the difficulties of the task, and to them Capt. Eckersley addresses himself.

The author states at one point that the book is in no way to be taken as official, but of course this can hardly be taken literally, for (whatever his own wishes) it will be certainly taken as at any rate semi-official. Essentially, it shows how to avoid some of the most common troubles: it is divided into four chapters. Of these the first deals with the technical policy of the B.B.C.—such questions as 5XX, and so forth. Next, "Signal strength," deals with modulation on the transmitting side, and such matters as aerial design, fading, etc. We are at one with the Author on the all-important "factor of safety" in receiving.

On "Interference" also we are in general agreement with the author. But as regards the amateur's position we do not see eye to eye with him, as explained in the November issue of E. W. & W. E.

Lastly, he writes of "Quality," and gives some idea of the principles of the microphone and amplifier, with some interesting notes on echo.

86 pp., illustrated.

Published by The Wireless Press, at 2s. net.

"Uncle Jack Frost's Wireless Yarns."

AS a reprint of technical talks broadcast by Capt. C. C. J. Frost, M.I.R.E., of the Headquarters' engineering staff, we expect this book to be essentially simple; and since it is for those hitherto entirely unversed in wireless work, it must above all be accurate. Unfortunately it fails in the latter respect.

A statement on the subject of the Heaviside layer—that "iron" particles are the cause, may be simply a misprint for "ionic" (though it occurs twice). But what about the case of a man with a 300-yard aerial? He naturally got 2LO only faintly: but Capt. Frost says, "It was really astonishing that he received anything at all, *but he must have been receiving one of the harmonics*" (the italics are ours). What about a telephone diaphragm which will not vibrate more than approximately 1 000 to 1 500 times per second (p. 49)? And here have we been designing amplifiers to reach 10 000 cycles!

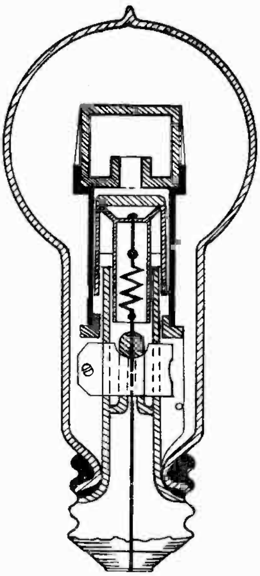
Again, on p. 86, the author has stated that by putting a second wire on an aerial both inductance and capacity are increased, an obvious fallacy. And there are others. We must say that we think it hard on the beginner to have his progress retarded by such misleading statements, even if they are due simply to haste.

106 pp. illustrated.

Published by The Wireless Press, at 2s. net.

"S-Tube" Rectifiers.

WE have received for test two S-tube rectifiers as produced by the American Radio and Research Corporation (Amrad), and handled in this country by Messrs. Sanders Bros. & Co., Ltd., 54, Gresham Street, E.C.2. To those experimenters who study American journals these tubes will be familiar by name, but hitherto they have, unfortunately, not been obtainable in this country. The S-tube has the advantage of being very robust and having no filament to bother about, a gaseous ionic discharge being used instead of a pure electron discharge. There are two electrodes in the bulb, which contains helium gas under a reduced pressure of a millimetre or so of mercury. The rectifying action involves the "short path" principle, details of which are to be found in a recent issue of E.W. & W.E. The electrodes are made of carbon, the larger being the hollow carbon cylinder which is the chief visible feature within the bulb, and the smaller electrode being concealed from view by the carbon cylinder. As the business part of the discharge takes place within this carbon cylinder, there is practically nothing to be seen when the tube is in operation; sometimes in a darkened room a faint yellow glow may be observed. Presumably the reason why helium has been chosen as the discharge medium is that it has a low ionising potential (200 volts or less, according to conditions), and also that the mean free path of the helium molecule at low pressures is about twice as long as with any other gas.



The S-Tube in section.

The particular S-tubes submitted to us for test are rated to pass a maximum current of 100 milliampères at 1 000 volts. We have had these tubes installed under working conditions at our experimental transmitting station for several weeks. During this period they have been in constant use for rectifying about 1 000 volts A.C. at 50 cycles and have proved most satisfactory. Their efficiency is greater than that of the electrolytic rectifier and compares very favourably with that of the thermionic valve rectifier. There appears to be a minimum voltage of about 200 below which no conduction takes place, but once this voltage is exceeded by 100 volts or so the effective impedance seems to drop to a very low value. Certainly on voltages above 500 the tubes will pass almost any current that a normal transmitting valve is likely to take. The advantage of being able to fit up any full-cycle rectifying circuit without having to bother about separately insulated filament supplies can only be fully appreciated by those who have had to work with the ordinary thermionic rectifier. A couple of S-tubes work extraordinarily well with the condenser doubling circuit shown for electrolytic rectifiers in EXPERIMENTAL WIRELESS, Vol. I., No. 3, p. 158. The tubes may be worked with perfect safety at the makers' maximum rating; they warm up after running for some time, but never become violently hot, indicating that there is not an unreasonably large amount of power wasted in the rectifiers themselves. They are intended to run warm normally. The tubes we have tested will rectify quite well above the rated maximum of 1 000 volts, but we can say nothing at present as to the advisability of over-running them. A test with one of the tubes on a separate D.C. supply showed that when 1 500 volts potential was applied to the tube in the inverse direction only 4 or 5 milliampères were passed, while the tube acted almost as a dead short-circuit to the source when this was connected in the conducting direction. The rating of a hundred watts per S-tube is a liberal allowance for most amateur work, and the tubes function quite well on much lower powers. Where greater power is required a number of tubes may be run in series or parallel as in the case of electrolytic rectifiers

It is important, the manufacturers tell us, not to switch a cold S-tube on to full power at once. Where a potential of above 750 volts D.C. is to be delivered it is necessary, in order to bring the tube up to the required condition, to insert a resistance of 8 to 10 ohms in the primary circuit of the transformer when starting and to keep this resistance in circuit for one minute. After one minute this resistance may be short-circuited and the tube is ready to deliver its rated voltage. Since the tube cools slowly, after once it has been heated, it is not necessary to use the resistance to restart within a period of one hour. When starting at greater intervals the resistance should be used. The reason for this precaution is that the insulation resistance of the tube depends upon the purity of the helium gas which the tube contains. The tube, when in operation, has the characteristic of cleaning up the impurities of the gas. On cooling these impurities are released, making it necessary to reduce the voltage when starting.

As regards the life of an S-tube, we have no definite data, but (apart from mechanical breakage) this would appear to be indefinitely long. The makers give 3000 hours as a conservative estimate.

It is well to note that S-tubes are made to fit screw holders such as are standard in America for electric light fittings.

This form of rectifier is probably the nearest approach to the ideal for the experimenter that has been yet commercially realised.

Long-Distance Work.

By Hugh N. Ryan (5BV) **[R009·2**

In view of the extraordinary advance in this section of the science that has taken place since last winter, we feel that the re-introduction of this series will be appreciated.

NOW that the season of long distance work is with us again, I am resuming the monthly reports on this branch of our work, which were published last winter under the title of "The Month's DX."

I might start right away by writing an account of all that has happened since the last report appeared, but I think our readers will get the facts in better perspective if I write them in the three divisions into which they naturally fall: *i.e.*, work done during the summer; work done at the beginning of the "DX" season (September and early October); and work done in October and November—the last-named forming the first of the ordinary monthly reports.

The article will, then, be rather in diary form, each of the three parts having been actually written at a time current with the events chronicled.

Work done during the Summer, 1924.

In order to bring last season's readers up-to-date I will commence by reviewing the work which has been done during the summer. This has been quite considerable, and we might have cause to congratulate ourselves on a very good summer performance, but for the deplorable fact that we lost touch with America and Canada for several months, and this in spite of the "summer" weather which, from a wireless point of view, if from no other, has been unusually favourable. This failure to maintain touch across the Atlantic is a sad end to our boast of last winter that we would "work 'em right through the summer." However, next summer I think we really will do it, provided that the Americans don't go to sleep and forget to listen for us, as I suspect that most of them did this time.

Some interesting data on the way in which signal strength varies over the "Pond" is provided by a well-known Canadian amateur who spent a considerable part of the summer in a ship anchored in mid-Atlantic. He tells me that right through the summer my own signals were very strong out there, and so were those of Canadian 1AR.

It is curious, therefore, that 1AR and I were quite unable to hear each other, in spite of repeated attempts. Other signals reported to be strong in mid-Atlantic were those of 2KF, 5LF, 5KO, 5MO, 5MA, 2NM, to mention a few of the strongest among a large number, which also includes several well-known Continental stations, such as Danish 7EC, and Belgian W2.

The station which was reported as one of the most consistently strong was 5KO, which reminds me that we have now lost that famous Bristol station, its owner having left Bristol. He is now in Newcastle and may sometimes be heard from 5MO and 2CC.

At the time of writing the last notes, we were just beginning to hear amateur signals from Finland, and naturally concluded that another country was just "starting up." It was, therefore, with considerable surprise that we learnt there were some 150 Finnish stations in operation, and that they have had a fully organised Relay League for some years! The only question which arises is why we never heard them before. Even now we don't hear many of them. They are numbered by districts, in the same way as the Americans, and every call-sign begins with the number of the district and the letter N. The strongest signals seem to come from 1NA, 2NM and 3 NB and several British stations have worked with these.

A considerable number of Swedish stations have appeared during the summer, their calls all beginning with "SMZ." The best known in England are SMZP, SMZS, SMZV and SMZY, all of whom produce quite strong signals.

The Italian amateur, Adriano Ducati, whose call sign ACD was very familiar to most of us last winter, has been carrying out some experimental work for the Italian Navy, on board a ship with the call sign IHT. The most distant point which he visited was the

Brazilian coast, and even from there his signals were very strong in England. While he was there he received strong signals from British 2KF, which is a very fine achievement. 2KF thus holds the enviable record of being the first British amateur heard in South America. Speaking of records, our last year's readers may remember two unconfirmed records which I mentioned—the reception of 2JF by American 8CWR on October 12, 1923, and my own working with American 8AJW on December 2. These have now both been confirmed, thus establishing 2JF as the first British amateur to be heard in U.S.A. and 5BV as the first British amateur to effect two-way communication with U.S.A. and the only European amateur to do so on 200 metres. The communication between 5BV and 8AJW was very short and spasmodic, and it is claimed merely as a record, since as an actual performance it does not, of course, compare with the reliable communication achieved by 2KF, a few days later, on a shorter wavelength.

" The beginning of the 1924-25 DX Season."

We now come to the time when working with Americans and Canadians is just starting again. The whole position has been altered recently by the revision of the conditions under which the Americans are licensed. Last year the ordinary American amateur was licensed for 150-200 metres only, and special experimental stations for 110 to 150. This has now been changed, and only a very few are still allowed on 100-150 metres, while all of them are now allowed to work on 4 to 5 metres, 20 to 22 metres, 40 to 45 metres and 75 to 80 metres. Interest on this side centres at present on the 75-80 metres band, on which large numbers of Americans can be heard every night, often faster than they can be written down. There is no doubt that this band is a real " discovery," and the Americans are making the best of it. The only trouble is that, since we are not allowed the same band, all Transatlantic work this winter will have to be on two wave-lengths, our stations being on about 115 metres* and the Americans on 75-80, while the Canadians appear to be everywhere between 50 and 200 metres. This two wave-length working will be a great advantage once it gets going, as stations on both sides will be free from local QRM, which was so troublesome last year, but at present the difficulty is that nearly all the American stations transmitting on 75-80 metres listen only on this wave. A few of them are slowly realising that they must listen higher up, and as a result of this several of our stations, notably 2OD, 2KF and 5LF have already worked them, but it is still very difficult to " hook up." It will be very useful if every British amateur who sends cards to the Yanks puts a note on each card, reminding the American to listen on about 115 metres* when he sends a CQ call on 75-80. Several London stations are doing this and it is slowly bearing fruit.

An attempt is being made to run a relay through from England to Australia via America. It should be easy enough if it were properly organised, as all the links are working, but it is quite an impromptu affair. It may succeed, with any luck, and we hope it will. The chief obstacle to any impromptu relay is that, in spite of their boasted relaying efficiency, American stations nearly always seem to forget to QSR messages sent to them from this side.

October-November.

We have to record at this time what is probably the most important event in the history of amateur radio, and certainly the most important in British amateur history. We have at last " got through " to the Antipodes.

It is curious that, though we had for a long time had visions of working " right across the world," and some of us (including myself) had prophesied that it would come off this winter, we had, somehow, always thought of Australia as our goal. We had never given a very serious thought to the more exact Antipodes, New Zealand, and no attempt, as far as I know, had been made to work with that country, though several attempts were made at either direct or relay communication with Australia. The reason, I suppose, was that Australia, as the bigger country, seemed a more natural goal (or a bigger target, perhaps!) though most of us had heard of " the world's best receiving station "—New Zealand 4AA.

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*Since writing the above, a number of the best-known British amateurs have adopted 90-100 metres as their transmitting wave, though 115 is still in use also.

When the great result was achieved, it happened in a very casual sort of way, without any preliminary attempts. On the morning of October 18th G2SZ wanted to connect with a first district American station, and could not succeed in "raising" him. He asked G2OD to try to attract the American's attention, and 2OD did so, only to find, when he came back to call 2SZ, that the latter was working Z4AA, who had called him in the interval! 2SZ had heard the New Zealander's first call to this country, and Z4AA had heard 2SZ's first reply.

2SZ tells me that his feelings on first "hooking" a New Zealander were exactly the same as my own, a year ago, when I first worked a Canadian: he just couldn't believe it! However, the cable service was, as usual, called upon to convince him, and he received a confirmatory cable message next day.

This achievement was indeed an occasion for rejoicing in amateur circles, but for its immediate sequel I shall never forgive myself. I first heard the news by radiophone from 2KF the following night. We both decided to stay on all night and see what we could do, but soon after 5 a.m. I got "fed up"—having heard nothing all night but a few Yanks—and, deciding that 2SZ's effort was only an unrepeatable freak, went to bed.

A few minutes later 2KF heard Z4AA—and worked him! Such is life. Since then the following stations have succeeded in communicating with New Zealand: British 2OD, 2NM, 2WJ, 5NN, 2JF, 5LF, 6TM and French 8BF. British 2SH and 5BV have been heard in New Zealand, but have not, so far, worked both ways, neither of them having had time to come "on the air" often.

The New Zealand "Big Three" are: 4AA, 4AG, and 4AK, though 2AC has been heard several times. It is a curious fact that all these three stations (4AA, 4AG, 4AK) are within a few miles of each other, and of our direct Antipodes (which is in the sea off the East Coast of the South Island). They are, we understand, all quite low power stations compared with some of the North Islanders, of whom 2AC is the chief; and yet 2AC is seldom heard and the other North Islanders never.

It is to be presumed that our waves, going out in all directions, come to a focus somewhere at or near the Antipodes, making low power communication with that point much easier.

For the benefit of those who have not yet heard them, I may say that 4AA uses pure C.W., 4AG uses C.W. with a fairly distinct A.C. "mush" in it, and 4AK practically raw A.C.

So far we have only worked them in the mornings (their evenings), but we should be able to do it "when it's night time in New Zealand" just as well as "when it's night time over here." For this purpose everyone is specially requested to listen for them (on about 80 metres) between 6 p.m. and 7 p.m. Greenwich Mean Time, when they are transmitting for us.

Several Australian stations have been reported over here, and several of our men have been reported in Australia.*

Working with Americans and Canadians is still not very easy, though a certain amount of work in this direction is done on most nights.

Several of the Americans have worked New Zealand, and at the moment of writing I have just heard Canadian 1AR ("Globe-trotter Joe") calling New Zealand 4AG, whom he is receiving well.

That is, I think, all the news; but before concluding may I remind you that if this monthly article is to be as interesting as it should be, I must have reports of their activities every month from every station engaged in DX work? Please let me have them by the 10th of each month at the latest, and *don't forget.*

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* THE LATEST "DX" RECORD.

It is with pleasure that we are able to announce that successful two-way communication has been effected for the first time between the British Isles and Australia.

The station at this end was worked by Mr. E. J. Simmonds (2OO), of Meadowlea, Gerrard's Cross, Bucks., who exchanged signals with Mr. M. Howden (3BQ), of Boxhill, Melbourne, Victoria, on Thursday, the 13th of November. Mr. Simmonds worked on a wave-length of 95 metres with an input of 105 watts.

3BQ worked on 75 metres, and, apart from that, no particulars of his power, etc., are available at present.

Continuous exchange of messages was kept up from 6.50 a.m. to 7.15 a.m. Prior to 7.15, the Australian signals were perfectly clear, but afterwards faded quickly and soon became inaudible.

It would seem that we have reached the goal in DX work, and look forward to the time when these long distances will be bridged by the phone.

A Short Radio Course of Esperanto, the International Language. [R800

PERHAPS a few introductory remarks on the subject of an international language for radio will be of interest to our readers.

To the vast majority of the world's inhabitants who have never travelled abroad or corresponded with other countries or rubbed shoulders with foreigners, the need of such a language has not seemed vital until the advent of radio telephony. Now it is possible, while seated in one's most comfortable armchair at home, to hear voices from many lands and in many tongues. A novelty on the first occasion, to be sure, although incomprehensible and meaningless, but afterwards a mere waste of good "juice"!

As with the "broadcaster" so with the experimenter. The dots and dashes, as well as telephony, are easily picked up from abroad, but unless *all* foreign transmitters in whatever countries they dwell can work in English, or, conversely, unless the British amateur is conversant with all the languages spoken or "tapped" out, little really effective work can be done.

Esperanto comes as a "boon and a blessing" to such — it needs only co-operation in each country, and very soon an experimenter here will be able to carry out tests with his foreign friends to an extent never before hoped for or even thought possible.

Although this Course contains the whole of the grammar of Esperanto it has of necessity been written in a most compact form.

Experimenters desirous of making a really serious study of the language should obtain one of the many excellent textbooks published, and should, if possible, join a local Esperanto society or class. There is nothing like personal tuition—particularly for *conversational* practice—and the reader who wishes to use the language in front of a microphone or joined to a pair of earphones should obtain as much speaking and listening practice as possible. Failing that, enrolment in a Correspondence Course or even the study of a textbook will suffice to enable a keen student to obtain a good grip of the language very quickly.

The feature that immediately strikes the learner is the use of accented letters. Those who are accustomed to send and receive Morse will wonder how these can be telegraphed without the invention of special Morse signs. All that is necessary is to replace the circumflex accent by the letter "h," thus: write "ch" for ĉ, "sh" for ŝ, etc.

Esperanto can therefore be telegraphed just as easily as any national language without accents.

In order to assist students of this fascinating language, arrangements have been made to correct and criticise any exercises sent in; each piece of work to be accompanied by 3d. in stamps to cover postage to our contributor and return. Please address such communications to: ESPERADIO, c/o EXPERIMENTAL WIRELESS AND WIRELESS ENGINEER, 19, Surrey Street, Strand, W.C.2.

THE GRAMMAR OF ESPERANTO.

THE ALPHABET.

Aa Bb Cc Ĉĉ Dd Ee Ff Gg Ĝĝ
Hh Ĥĥ Ii Jj Ĵĵ Kk Ll Mm Nn
Oo Pp Rr Ss Ŝŝ Tt Uu Ŭŭ Vv Zz

Note.—No Q, W, X, or Y.

PRONUNCIATION.

The VOWELS sound as in Italian :—

A	E	I	O	U
par	*pear*	*pier*	*pore*	*poor*
are	*there*	*three*	*or*	*two*

Most CONSONANTS sound as in English, **C** is like **ts** in beat; thus, **caro** like *tsaro*; **acido** like *ah-tsee-doh*. **Ĉ** like **ch** on **church. G** like **g** in **galena. Ĝ** like **g** in **gem. J** like **y** in **yes,** e.g. **jaro** like *yaro*, **bojo** like *boyo*. **Ĵ** like **z** in **azure. S** like **s** in **so. Ŝ** like **sh** in **show. Ĥ** (used in very few words) like **ch** in **loch** (guttural).

DIPHTHONGS (Vowel Glides):

AJ, OJ, as in **my boy. EJ,** as in **obey. UJ** as in **hallelujah** or in **ruin. Ŭ** is the Esperanto **W; AŬ** as ow in **how.**

The ACCENT is always on the last syllable but one. Phonetic spelling. No silent letters.

The **GRAMMAR** is based upon **SIXTEEN FUNDAMENTAL RULES.**

I.—THE ARTICLE.

A or **An** (the indefinite article) is not expressed. *Anteno*, an aerial.

The (definite article) in Esperanto is **La,** which never changes. *La krado*, the grid. *La kradoj*, the grids.

II.—THE NOUN.

All Nouns (names of things, places or persons) end in **O.** *Borno*, a terminal; *stacio* (pronounced stahtseeo) a station; *Londono*, London; *Johano*, John. To form the plural add **J** (pronounced as **Y**). *Fadenoj kaj telefonoj*, Wires and telephones.

There are only two cases: **Nominative** and **Accusative** (objective)—the latter is formed from the Nominative by adding **N.** *Johano konstruas aparaton*. John is building a set. *La patro sendas mesaĝojn*. The father sends messages.

The question may be asked, Why the accusative ending in Esperanto? It is international and occurs even in English although irregularly, e.g., *me, thee, him, us, them, whom*. It removes ambiguities and makes the language flexible. Its abolition would introduce difficulties, especially to those nations whose word order is different from that of English.

*Tomaso frapis Roberto***n**.	Thomas hit Robert.
*Roberto***n** *frapis Tomaso*.	Ditto ditto (Note that the **n** distinguishes the object wherever the word is.)
*Roberto frapis Tomaso***n**.	Robert hit Thomas.
*Tomaso***n** *frapis Roberto*.	Ditto ditto (As above.)

The DAYS of the WEEK are:

Sunday, *dimanĉo*.	Thursday, *ĵaŭdo*.
Monday, *lundo*.	Friday, *vendredo*.
Tuesday, *mardo*.	Saturday, *sabato*.
Wednesday, *merkredo*.	

The MONTHS of the YEAR are:

January, *Januaro*.	July, *Julio*.
February, *Februaro*.	August, *Aŭgusto*.
March, *Marto*.	September, *Septembro*.
April, *Aprilo*.	October, *Oktobro*.
May, *Majo*.	November, *Novembro*.
June, *Junio*.	December, *Decembro*.

Christmas Day, *Kristnaska Tago*; Easter, *Pasko*; Whitsun, *Pentekosto*.

III.—THE ADJECTIVE.

All Adjectives (words which qualify or describe nouns) end in **A.** They agree with their noun in number or case. *La lerta amatoro desegnis nova***n** *cirkuiton*. The clever amateur designed a new circuit. *Granda***j** *stacioj sendas longa***jn** *ondojn*.

The **Comparative** is formed by using **Pli-ol**= more-than. *Dika fadeno estas* **pli** *utila* **ol** *maldika*. Thick wire is more useful than thin wire.

The **Superlative** is formed by using **Plej (-el)**= most (-of). *Galeno estas la* **plej** *populara* **el** (*la*) *kristaloj*. Galena is the most popular of (the) crystals. *Donu al mi la* **plej** *grandan transformatoron*. Give (to) me the largest transformer.

IV.—THE NUMERALS.

The **Cardinal Numbers** are:

1 **unu**	5 **kvin**	9 **naŭ**	13 **dek tri**
2 **du**	6 **ses**	10 **dek**	20 **dudek**
3 **tri**	7 **sep**	11 **dek unu**	25 **dudek kvin**
4 **kvar**	8 **ok**	12 **dek du**	50 **kvindek**

100 **cent,** 138 **cent tridek ok,** 1,000 **mil,** 1,924 **mil naŭcent dudek kvar.** 1,000,000 **miliono.**

Nouns are formed from them by adding **-o:** *unuo*, a unit; *milo*, a thousand; *dek-duo*, a dozen.

The **Ordinal Numbers** (adjectives) are formed by adding **-a** (the adjectival ending) to the foregoing numbers; *unua*, first; *dua*, second; *tria*, third; *kvardek-kvara*, forty-fourth; etc.

The **Ordinal Adverbs** are formed by adding **-e** (the adverb termination) to the cardinal numbers. *Unue*, firstly; *due*, secondly; *trie*, thirdly; *sepdek-oke*, seventy-eighthly; etc.

For **Multiples** (in English -fold, as in hundredfold), add **-oblo, -obla** or **-oble** respectively for a noun, adjective or adverb.

duobla, double.	*triobla*, treble, threefold.
duoble, doubly.	*trioble*, trebly.

duobla fadeno, a double (twofold) wire, thread.

For **Fractions** add **-ono, -ona,** or **-one;** *duono*, a half; *duona*, half (adjective); *duone*, by halves.

For **Distributives** use the prefix **po,** at the rate of: *po kvar pencoj por ĉiu*, at fourpence (for) each.

For **Collectives** add **-op:** *duope*, by twos; *unuope*, one at a time, singly; *dekope*, by tens, in tens.

V.—THE PRONOUN.

The **Personal Pronouns** are:—

mi, I	**ni,** we
ĉi, thou / **vi,** you	**vi,** you
	ili, they
li, he	**oni,** one
ŝi, she	**si,** himself, herself, etc.
ĝi, it	(Used only in reflexive.)

The **Possessive Pronouns**, being adjectives, are formed by adding **-a**:

mia, my, mine	**nia,** our, ours
cia, thy, thine / **via,** your, yours	**via,** your, yours
	ilia, their, theirs
lia, his	**sia,** his own, her own, their own, etc. (reflexive only).
ŝia, her, hers	
ĝia, its	

The above words being in effect adjectives, take the endings **-j** and **-n** when necessary.

*Li invitas sia***jn** *amiko***jn,** He invites his (own) friends.

*Mi rompis mia***n** *valvo***n,** I broke my valve.

*Lia***j** *amiko***j** *estas mia***j,** His friends are mine.

*Oni aplaŭdis via***n** *kanto***n,** Your song was applauded (one applauded your song).

VI.—THE VERB.

The **Verb** (denoting action or state) does not change for person or number.

For the **Present** time (or tense) add to the verbal root **-AS.**

For the **Past** time (or tense) add to the verbal root **-IS.**

For the **Future** time (or tense) add to the verbal root **-OS.**

mi estas, I am — *mi estis*, I was
li iras, he goes — *li iris*, he went
vi laboras, you work — *vi laboris*, you worked
mi estos, I shall be
li iros, he will go
vi laboros, you will work

The **Conditional** mood takes the ending **-US.** *Se vi lernus, mi ankaŭ lernus*, If you were to learn, I would also learn.

The **Imperative** (command) mood takes the ending **-U.** *Lernu Esperanton*, Learn Esperanto.

The **Infinitive** (indefinite) mood, takes the ending **-I.** *Paroli*, to speak. *Promeni*, to walk. *Viziti*, to visit.

Every verbal ending is applicable to every verb in the language, without exception.

The **Active Participles** (with adjectival, substantival, or adverbial sense respectively) :—

Present end in **-ANTA, -ANTO, -ANTE.**
Past end in **-INTA, -INTO, -INTE.**
Future end in **-ONTA, -ONTO, -ONTE.**

La frato estas studanta Morson, The brother is studying Morse. *Studanta viro*, A studying man. *Studanto*, a student. *Studante, oni lernas*, By studying one learns. *La policano estas parolinta*, The policeman has spoken. *Parolinto*, a speaker (after he has spoken). *Parolinte, li sidiĝis*, Having spoken, he sat down.

La sendilo estas funkcionta, The transmitter is about to work (function).

La kantonto, The singer (the person about to sing).

The **Passive Participles** (with an adjectival, substantival, or adverbial sense) :—

Present end in **-ATA, -ATO, -ATE.**
Past end in **-ITA, -ITO, -ITE.**
Future end in **-OTA, -OTO, -OTE.**

La kondensatoro estas konstruata, The condenser is being constructed. *La batato*, The person being beaten. *Batate, li elkriis*, Being beaten, he cried out. *Amplifite, la signaloj estis tre fortaj*, Having been amplified, the signals were very strong. *Kuplitaj bobenoj*, Coupled coils.

All the forms of the **Passive Voice** are made by the aid of the verb **Esti,** to be (which is the only auxiliary verb in Esperanto), and a **passive participle** of the required verb.

La ricevilo estas agordata, agordita, agordota, The receiver is being tuned, has been tuned, is about to be tuned.

The preposition with the Passive is **de**—by.

La filamento estas varmigata de la akumulatoro, The filament is (being) heated by the accumulator. *Reakcio estos provizata de bobeno kuplita al la antena induktanco*, Reaction will be provided by a coil coupled to the aerial inductance.

The Esperanto verb is entirely regular. There are no irregular verbs to learn in Esperanto.

VII.—THE ADVERB.

Adverbs (words which modify verbs or adjectives) end in **E.**

Ne kantu rapide, Do not sing quickly.

The **Degrees of Comparison** are the same as with the adjectives, i.e., **pli** and **plej.**

Mia perikono detektas pli bone, ol via, My perikon detects better than yours. *Kiu funkcias la plej efike, diodo, triodo, aŭ tetraodo?* Which works most efficiently, a two-, three-, or four-electrode valve?

VIII.—THE PREPOSITION.

(A) All **Prepositions** require the **Nominative** Case after them.

Mi donis ĝin al **li** (*not lin*), I gave it to him. *Li aĉetis la eboniton por* **mi** (*not min*). He bought the ebonite for me.

The chief prepositions with their meanings are :—

al, to	**gis,** until	**pro,** on behalf of
ĉe, at	**kun,** with	**pri,** concerning
de, of, from	**por,** for	**tra,** through
el, out of	**per,** by means of	**trans,** across

(B) Each Esperanto preposition has a definite and constant meaning. If the meaning of an English preposition is not clear, it may be translated either by the preposition **je,** which has no definite meaning in itself, or by **-N** without a preposition provided that the meaning is clear.

Ili ridis **je** *li*, or *Ili ridis li***n,** They laughed at him.
Oni obeis **al** *li*, or *Oni obeis li***n,** One obeyed him.

IX.—PRONUNCIATION.

Every word is read as it is written, and there are no silent letters, e.g., *Kune* is pronounced *kooneh*, not *kewn*.

X.—ACCENT.

The **accent** or stress falls **always** on the **last syllable but one.**

***Fa**zo, Re**la**jo, Reo**sta**to, Izola**to**ro, Altfrek**ven**ca, Potencio**me**tro.*

XI.—COMPOUND WORDS.

Compound words are formed by joining the various root-words together, the qualifying word coming first and the chief word coming last :—

Fulmŝirmilo, lightning arrester; *varmfadena ampermetro*, hot-wire ammeter; *laŭtparolilo*, loud-speaker.

Word-building on these lines is very frequent in Esperanto, and does away with the necessity of learning a vast number of words.

Agordi, to tune; *agordilo*, a tuner (an instrument for tuning); *oscili*, to oscillate; *oscilema*, inclined to oscilate; *ekoscili*, to break into oscillation; *teni*, to hold; *valvtenilo*, a valve-holder; *akumulatoro*, an accumulator; *akumulatorujo*, an accumulator case.

XII.—ORDER OF WORDS.

The order in which words are put in Esperanto is generally the same as in English, with the two following important deviations :—

(A) In **Interrogative Clauses** (asking questions), the order of the words is not inverted, as in English, but the word **ĉu** is used at the beginning of the sentence. It may be considered as a *warning* word to indicate that a question is coming. **Ĉu** is not required when an interrogative pronoun (*kiu, kia, etc.*) is used.

Mi parolas, I speak, I do speak. *Ĉu mi parolas?* Do I speak? Am I speaking? *Mi parolis,* I spoke, I did speak. *Ĉu mi parolis,* Did I speak? *Kiu blokas nun?* Who is jamming now?

(B) In **Negative Clauses** (denials), the word **ne** (not) is placed before the word it modifies. *Mi ne sendis lin,* I did not send him. *Ne mi sendis lin,* It was not I who sent him. *Mi sendis ne lin, sed ŝin,* I sent not him but her. *Malgraŭ la simpla cirkuito, ĝi ne estas ne-radianta aparato,* In spite of the simple circuit, it is not a non-radiating set.

XIII.—THE ACCUSATIVE OF DIRECTION AND MEASURE.

The **-n** of the Accusative Case is also used :—

(A) To show **direction towards.**

After **al** or **ĝis** the **-n** is unnecessary, as these words in themselves indicate direction.

*Li iras Londono***n**, or *Li iras al Londono,* He goes to London. *La birdoj flugas en la ĝardeno***n**, The birds fly into the garden. *La birdoj flugas en la ĝardeno,* The birds fly (about) in the garden.

(B) To show **duration of time.** *Ili interkomunikis tri horoj***n**, They communicated with each other for three hours.

(C) To show **weight, measure,** or **distance.** *Li iris du mejloj***n**, He went two miles. *La pano pezas du funtoj***n**, The bread weighs two pounds.

XIV.—PREPOSITION (see Rule VIII. B).

XV.—THE FOREIGN WORDS.

A large number of words, mostly of Latin or Greek origin, exist, which are common to most languages. These words, after being made to conform to the rules of phonetic spelling, may be used in Esperanto. They take the usual terminations. *Tele***fo***no, Tele***gra***fo, Aero***pla***no, Markoni-***gra***mo, Galvano***me***tro,* **Vol***to, Fa***ra***do,* **O***mo, Tea***t***ro, Na***tu***ro,* etc.

All international scientific and technical terms are similarly adopted. Some radio terms have alternative Esperanto equivalents, such as *transformatoro* or *transformilo,* for transformer; *kondensatoro* or *kondensilo,* for condenser; *detektoro* or *detektilo,* for detector; *koherooro* or *koherilo,* for coherer. In each case it may be taken that the latter form expresses the **general** meaning of the term, while the former has the special **technical** meaning; e.g., *kondensilo* is derived from **-ilo,** an instrument, and *kondens-*, to condense, and means "an instrument for condensing," electrical or otherwise; whereas *kondensatoro* is specially applied to electrical condenser.

XVI.—ELISION IN POETRY.

For euphony in poetry the final **O** of the noun (in the nominative case only) may be dropped and replaced by an apostrophe.

Al la mond' eterne militanta, To the world eternally fighting.

The **A** in **la** may be dropped when it follows a preposition ending in a vowel.

De l'soldato, of the soldier. *De l'maristo,* of the sailor.

WORD BUILDING IN ESPERANTO.

From all Esperanto roots, there may be formed by the application of certain fixed rules, a number of derived words, to express all shades of thought. Thanks to this, the amount of material required for a vocabulary of all words likely to occur in everyday life, is enormously reduced.

THE REMARKABLE FLEXIBILITY OF ESPERANTO.

Suppose you learn 500 root-words in Latin, French, Spanish, German or Russian.

You cannot with certainty apply any principle of word building.

So that, if you learn 500 words you have but them, and for the derivations you must learn about 2,000 NEW root-words.

BUT

Suppose you learn 500 root-words in ESPERANTO. Then :—

(1) By applying the grammatical endings **-O, -A, -E, -I,** you have **2,000** words at your command.

(2) Applying an average of 10 of the 30 prefixes to each of the 2,000 you now have **20,000** words at your command.

(3) Adding words formed with two or more words, made by adding one root to another root, we easily bring the number of words at your command up to **25,000.**

Thus, LEARN 500 WORDS AND YOU HAVE 25,000!

HOW WORDS ARE BUILT UP.

To create new words, as mentioned above, we make use of :—

1. **Grammatical terminations**: for example, from the root *parol'* (which expresses the idea of speaking), we can form :—

parol'i, to speak; *parol'o,* speech; *parol'a,* oral, spoken; *parol'anto,* speaker; *mi parol'as,* I speak, etc.

2. **Compound words,** for example :—

en'ir'i to enter (*en* in, *ir'i* to go); *el'ir'i,* to go out (*el* out, from, *ir'i* to go); *rul'kurteno,* window-blind (*rul* to roll, *kurteno* curtain).

3. **Prefixes and Suffixes,** of which some thirty are in common use :—

-aĉ—denotes contempt: *domo,* a house; *domaĉo,* a hovel; *hundo,* a dog; *hundaĉo,* a cur.

-ad—denotes action, or (where the root already signifies action) continued action (like English -ation, -ing): *radio,* radio; *radiado,* radiation; *diri,* to say; *diradi,* to keep on saying.

-aĵ—denotes something made from, or having the quality of what is mentioned: *malnova,* old; *malnovaĵo,* an antique; *metalo,* metal; *metalaĵo,* a metallic article.

-an—denotes an inhabitant, member, adherent (like English -an, -man): *kolegio,* college; *kolegiano,* collegian; *asocio,* association; *asociano,* member of association; *Londono,* London; *Londonano,* Londoner; *Kristo,* Christ; *Kristano,* Christian.

-ar—denotes a collection of what is mentioned: *fadeno,* wire; *fadenaro,* collection of wires, wiring; *vorto,* a word; *vortaro,* dictionary; *libro,* a book; *libraro,* a library.

bo-—denotes a relation by marriage: *filino*, daughter; *bofilino*, daughter-in-law.

ĉj—these letters added to the first few letters of a masculine name make of it an affectionate diminutive: *Vilhelmo*, William; *Vilĉjo*, *Viĉjo*, Willie, Will, Bill; for feminine names add **nj** instead of **ĉj**: *Mario*, Mary; *Manjo*, Molly.

dis-—denotes separation (as in English): *tordi*, to twist; *distordi*, to distort; *doni*, to give; *disdoni*, to distribute.

-ebl—denotes possibility (English -able, -ible): *fleksi*, to bend; *fleksebla*, flexible; *porti*, to carry; *portebla*, portable.

-ec—denotes a quality (English -ness): *bela*, beautiful; *beleco*, beauty; *bona*, good; *boneco*, goodness.

-edz—denotes a married person: *doktoro*, doctor; *doktoredzino*, doctor's wife; *lavistino*, washer-woman; *lavistinedzo*, washerwoman's husband.

-eg—denotes enlargement or intensity of degree: *anteno*, aerial; *antenego*, an enormous aerial; *pluvo*, rain; *pluvego*, downpour, deluge; *granda*, great, large; *grandega*, immense.

-ej—denotes the place where an action occurs: *kuiri*, to cook; *kuirejo*, kitchen; *fabriki*, to manufacture; *fabrikejo*, factory; *generi*, to generate; *generejo*, generating station.

ek-—denotes the beginning or short duration of an action; *brili*, to shine; *ekbrili*, to flash; *ridi*, to laugh; *ekridi*, to burst out laughing.

-em—denotes propensity or disposition: *kredi*, to believe; *kredema*, credulous.

-er—denotes a unit, particle, atom, speck, etc., one of the parts which form a whole; *sablo*, sand; *sablero*, a grain of sand; *mono*, money: *monero*, a coin.

-estr—denotes a chief or leader (English, -master): *ŝipo*, ship; *ŝipestro*, captain; *telegrafo*, telegraph; *telegrafestro*, chief telegraphist.

-et—denotes decrease or diminution of degree: *valvo*, valve; *valveto*, tiny ("peanut") valve; *rivero*, river; *rivereto*, rivulet; *ridi*, to laugh; *rideti*, to smile.

ge-—denotes persons of both sexes: *patro*, father; *gepatroj*, parents; *sinjoro*, gentleman, Mr.; *gesinjoroj*, ladies and gentlemen.

-id—denotes a child or descendant: *kato*, a cat; *katido*, a kitten; *Izraelo*, Israel; *Izraelido*, Israelite.

-ig—denotes to make, render, cause to be: *morti*, to die; *mortigi*, to kill; *simpla*, simple; *simpligi*, to simplify.

-iĝ—denotes the action of becoming, turning to: *pala*, pale; *paliĝi*, to turn pale; *fluida*, fluid; *fluidiĝi*, to melt; *saturo*, saturation; *saturiĝi*, to become saturated.

-il—denotes the instrument by means of which an action takes place: *pafi*, to shoot; *pafilo*, rifle; *fajli*, to file; *fajlilo*, file; *sparko*, spark; *sparkilo*, spark gap.

-in—denotes the feminine gender: *koko*, a cock; *kokino*, hen; *heroo*, hero; *heroino*, heroine.

-ind—denotes worthiness, merit: *honori*, to honour; *honorinda*, honourable; *kredi*, to believe; *kredinda*, credible.

-ing—denotes that in which an object is set or put, a holder (for one object only): *kandelo*, candle; *kandelingo*, candlestick; *cigaro*, cigar; *cigaringo*, cigar-holder.

-ism—denotes a doctrine, practice, cult, ism (in this sense): *katoliko*, catholic; *katolikismo*, catholicism; *alkoholo*, alcohol; *alkoholismo*, alcoholism.

-ist—denotes a person following a given occupation, a person habitually connected with: *eksperimento*, an experiment; *eksperimentisto*, an experimenter; *elektro*, electricity; *elektristo*, electrician; *anonci*, to announce; *anoncisto*, announcer.

mal-—denotes the direct opposite of any idea: *bona*, good; *malbona*, bad; *estimi*, to esteem; *malestimi*, to despise; *alta*, high; *malalta*, low.

re-—denotes, as in English, again or back: *iri*, to go; *reiri*, to return, to go back; *doni*, to give; *redoni*, to return, to give back; *agordi*, to tune; *reagordi*, to re-tune; *radiado*, radiation; *reradiado*, re-radiation.

-uj—denotes that which contains a number or quantity of: *mono*, money; *monujo*, purse; *Turko*, a Turk; *Turkujo*, Turkey; *rezistanco*, resistance; *rezistancujo*, resistance-box.

-ul—denotes a person who is characterised by a given quality: *bela*, beautiful; *belulino*, a beauty; *sperta*, expert (adj.); *spertulo*, an expert.

-um—this syllable is amongst the suffixes as **je** is amongst prepositions—indefinite in meaning; and its use is confined to a few words, to be found in the dictionaries: *plena*, full; *plenumi*, to fulfil; *proksima*, near; *proksimuma*, approximate.

In addition to the above, a number of other affixes, chiefly of a technical nature appertaining to chemistry, botany, zoology, etc., are in more or less common use, though not yet officialised.

Such, for example, are **mono-, di-, tri, tetra-, hiper-, hipo-, -at, -it, -id, -oz, -ik** (of chemistry); **-al, -ine, -ac** (of botany); **-oid, -oin** (of botany and zoology); and the following more general affixes: **mis-** (English mis-, erroneous); **-end,** which is to be, . . . ed (*laboro farenda*, work to be done; *problemo solvenda*, problem to be solved); **-iv,** which can . . . (*bruliva*, combustible); **-oz,** containing, full of (in the material sense only), *ŝtona vojo*, a stone road, *ŝtonoza vojo*, stony road.

HINTS ON CORRELATIVE WORDS.

The table of correlative words (opposite) is worth careful study. They are made up of **5** beginnings, and **9** endings, each with a definite meaning. The following hints may help the memory:—

Beginnings:—

I—some (or other), **I**ndefinite.

KI—*wh*ich, *wh*at (corresponds to the **K**westion words in English beginning with *wh*).

TI—That.

ĈI—is like ea*ch* said backwards.

NENI—is simply *NE* (no, none) with "n" added for euphony.

Endings:—

-A—is the adjectival ending.

-AL—think of "reAL reason."

-AM—think of a.m. (time in the morning).

-E—is the last letter in the English and Esperanto words.

-EL—think of "ELegant manner."

-ES—think of " onE'S," possESsive case.
-O—the noun ending.
-OM—think of 'Ow Much, 'Ow Many.
-U—short for Unu (one), or individUal.

In a negative or interrogative sentence English substitutes *any* for *some* in the **I-** column; thus: *Ne estas iu tie*, There is not *anyone* there.

The **T-** column words may be changed from *that* to *this* by prefixing or adding the word "**ĉi.**" thus: *ĉi tio, tio-ĉi*, this thing, *ĉi tie, tie-ĉi*, in this place, here.

The words ending in a vowel may take the accusative ending: *Mi havas nenion*, I have nothing. Words ending in **-A** or **-U** may take the plural: *tiuj*, those.

The **K-** column words may be followed by *ajn* (English *ever*), thus: *Kial ajn*, why ever.

EASY EXERCISES.

Translate any or all of the following exercises. For conditions see introductory remarks.

I.

agordi, to tune.
alta, high, tall.
aŭ, or.
bobeno, coil.
brili, to shine.
ĉefa, chief, principal
devi, to be obliged to, to " must."
flui, to flow.
forta, strong.
ĝis, until, as far as, up to.
inventi, to invent.
kaj, and.
krado, grid.
necesa, necessary.
patro, father.
per, by means of.
povi, to be able to.
ricevilo, receiver (receiving set).
se, if.
speco, sort, species.
suno, sun.
tago, day.
tra, through.
uzi, to use.

Note.—*Words which have already been explained, or which have sufficient resemblance to the English equivalents to be easily recognisable, have been omitted from vocabulary.*

TABLE OF CORRELATIVES.

	INDEFINITE	DEMONSTRATIVE	INTERROGATIVE OR RELATIVE	UNIVERSAL	NEGATIVE
QUALITY.	**ia** some kind of	**tia** that kind of such a....	**kia** what kind of what a....!	**ĉia** every kind of	**nenia** no kind of
MOTIVE.	**ial** for some reason	**tial** for that reason therefore, so	**kial** for what reason why	**ĉial** for every reason	**nenial** for no reason
TIME.	**iam** at some time, ever	**tiam** at that time then	**kiam** at what time when	**ĉiam** at every time always	**neniam** at no time never
PLACE.	**ie** somewhere	**tie** in that place, there	**kie** in what place where	**ĉie** everywhere	**nenie** nowhere
MANNER.	**iel** in some manner somehow	**tiel** in that manner thus, so, as	**kiel** in what manner how as	**ĉiel** in every manner	**neniel** in no manner nohow
POSSESSION.	**ies** someone's	**ties** that one's	**kies** whose	**ĉies** each one's every one's	**nenies** no one's
THING	**io** something	**tio** that thing that	**kio** what thing what	**ĉio** everything all	**nenio** nothing
QUANTITY.	**iom** some quantity somewhat	**tiom** so much / as many	**kiom** what quantity how much, many	**ĉiom** the whole quantity	**neniom** no quantity none
INDIVIDUALITY.	**iu** some one	**tiu** that one (person or thing)	**kiu** which one who	**ĉiu** every one each one each	**neniu** no one nobody

Patro kaj patrino. La suno brilas en la tago. La anteno devus esti tre alta[1]. Kristala ricevilo estas tre simpla. Oni povas agordi per bobeno aŭ variometro. Se oni uzas variometron, kondensatoro ne estas necesa. Ju pli alta la anteno, des pli fortaj[2] la signaloj. Ekzistas[3] tri specoj de valvo, du-elektroda (aŭ diodo), tri-elektroda (aŭ triodo), kaj kvar-elektroda (aŭ tetradodo). Fleming inventis la diodon kaj de Forest la triodon[4]. Triodo konsistas el tri ĉefaj partoj: filamento, krado kaj plato (aŭ anodo). Elektronoj fluas el la filamento tra la krado gis la plato.

(1) Not *altan*, because verb *esti* takes nominative after it.

(2) Note plural, as this word qualifies the word *signaloj*.

(3) Translate by "There exist," word "there" understood.

(4) Accusative, as *inventis* is understood.

II.

apliki, to apply.
artefarita, artificial.
daŭre, lastingly, steadily.
inter, between, among.
inverse, inversely.
komuna, common, mutual.
kontraŭpezo, counterpoise.
kupleco, coupling.
kurento, current.
laŭ, according to.
mezuri, to measure.
oscila, oscillatory.
premo, pressure.
produkti, to produce.
proporcia, proportional.
rekte, directly.
tero, earth.

Volto estas la elektra premo kiu, daŭre aplikata al rezistanco de unu omo, produktas kurenton de unu ampero. Ampermetro estas instrumento por mezuri kurenton laŭ amperoj en cirkuito. Kontraŭpezo estas artefarita "tero." Kupleco estas mezuro de la komuna induktanco inter du oscilaj cirkuitoj. Kurento estas rekte proporcia je premo kaj inverse proporcia je rezistanco de cirkuito.

III.

beast, *besto*.
brother, *frato*.
care, to take, *zorgi*.
clean, *pura*.
conductor, *kondukilo*.
connection, *konektaĵo*.
copper, *kupro*.
ebonite, *ebonito*.
excellent, *bonega*.
experiment, *eksperimento*.
husband, *edzo*.
important, *grava*.
insulator, *izolatoro*.
internal, *interna*.
iron, *fero* (noun).
laboratory, *laborejo*.
lion, *leono*.
science, *scienco*.
solder, to, *soldi*.
than, *ol*.
while, *dum*.
wire, *fadeno*.

Sister and brother. Lions are beasts. Radio is an important science. Ebonite is an excellent insulator. Copper wire is a better electrical conductor than iron wire. Take care that every internal connection is clean and well soldered. The wife listens to the concert while the husband experiments in his laboratory.

More about Valve Testing. [R330-09

WE have received several inquiries as to our method of representing the behaviour of a valve by its "lumped" characteristic, and how curves of the usual type can be obtained from it. As it chances, we have only two new valves to report on this month, so we will devote a little space to an explanation.

The lumped characteristic is based on the fact that over the greater portion of the working range the anode current of a valve depends on the anode and grid voltage in a special way. We all know that the current depends on both voltages, but the point is that the voltages enter the equations together under the form $(E_a + \mu E_g)$, or, in words: (anode volts + μ times grid volts) acts as one unit; μ, of course, is the amplification factor. It is this combined voltage that Eccles has called the "lumped voltage."

It follows that a given anode current can be got by various combinations of anode and grid voltage. If, for example, the valve has a μ of 10, and gives 3mA of current at 100 anode volts and 0 grid volts, we can get the same 3mA by 80 volts anode and +2 grid, or 110 volts anode and −1 grid.

Now we can look for a moment at Fig. 1. This shows the lumped curve of a valve, of which the μ is 10·5. We see that at 100 volts it gives 2·1mA, while at 121 it gives 2·85mA. But since μ is 10·5, the effect of adding 21 volts on the anode is just the same as putting +2 on the grid.

In fact, if we find the current for 16, 37, 58, 79, 100, 121, 142, 163, and 184 lumped volts, the values must be the same as for a constant 100 volts on the anode, but with −4, −3, −2, −1, 0, +1, +2, +3, and +4 volts on the grid. In this way we can draw the curve A, Fig. 2. Next, if we take 30 volts off the anode, we can keep the same current by adding $30/10\frac{1}{2}$ volts or +2·85 volts on the grid; so we can draw the curve for 80 volts anode by transferring every point of curve A 2·85 volts to the right, thus giving curve B. By repeating this procedure we get the complete set of curves shown in Fig. 2, which are of the well-known type.

The results obtained in this way are not, of course, quite so satisfactory as those obtained by direct plotting; for they depend on the valve having a constant μ over its working range, which is not always the case. Again, it is obvious that in a set of curves obtained as we have done in Fig. 2, the saturation current is constant, whereas in many cases the saturation current increases a little with the anode volts. In fact, for unduly low values, the saturation current may be very sensitive to change in anode volts. A further point is that where the grid volts become strongly positive, the large grid current not only decreases the saturation anode current, but causes a general drop in the steepness of the curve. In fact, the actual curves for the value of Fig. 2 might easily be as shown in dotted

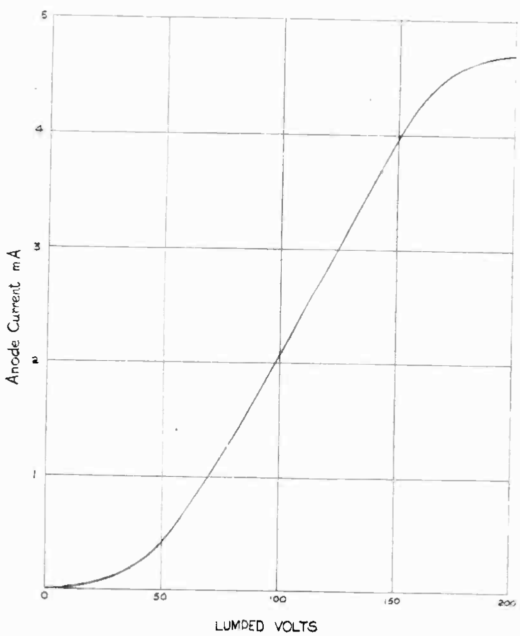


Fig. 1.

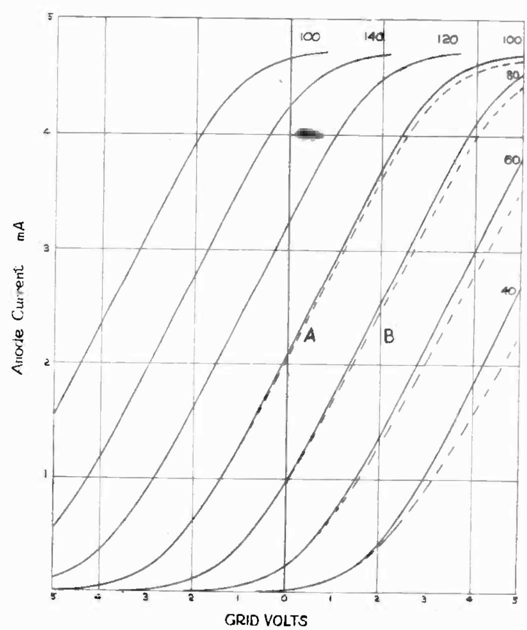


Fig. 2.

lines. But these are all conditions outside the working values of the valve *as an amplifier*; and it is still quite true to say that for working conditions curves got in this way are quite reasonably accurate.

For some purposes, notably for resistance coupling and for transmission, another form of curve has great advantages. This is a curve connecting anode volts and anode current, for a fixed grid voltage. This type of curve is a great favourite with Capt. H. J. Round, which would seem to indicate that it must have very solid advantages. It is readily seen that our "lumped" curve is in fact just such a curve, drawn for zero grid volts. Now if we want a curve of anode current against anode volts for -2 grid volts, we have to remember that 100 volts, say, with 0 grid, gives the same as 121 volts with -2 grid volts. So if we move every point of the curve 21 volts to the right we shall get a new curve for -2 grid volts; and we can repeat this procedure to get the effect of Fig. 3.

Thus we see that it is quite a simple procedure, from the lumped curve and the value of μ, to draw out for oneself a complete set of curves of either type. The reason why we throw this work upon our readers, instead of doing it ourselves, is simply to save space. It would make a very confused diagram if we drew on one sheet complete sets of curves for various filament heats, and we attach so much importance to this latter point that we prefer to utilise the available space for giving lumped curves for several values of filament voltage.

In future reports we hope to find room also for a small grid current curve, which gives useful information as to a valve's detecting properties.

The Radion G.P.

This is one of a series of valves made by Radions, Ltd., of Bollington, near Macclesfield; the series including both bright and dull emitters. The G.P., or general purpose valve, is rated to take ·48 amp at 3·6 to 4 volts on the filament, with 30 to 80 anode volts. As will be seen from our curves and table,

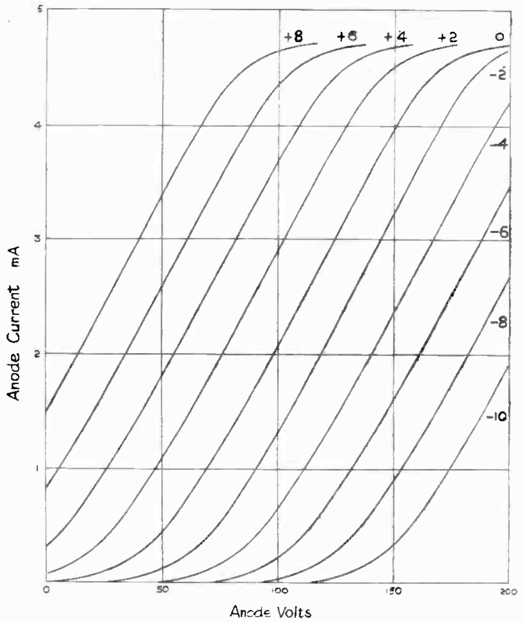


Fig. 3.

we tested it at 3·6, 3·9, 4·2, and 4·5 volts, with the results shown.

It will be seen that the output is on the low side as present-day valves go, being about equal to that of the "R" valve. Judging by the figures for filament efficiency, the filament is conservatively rated, and can be safely run up to its full rated voltage and perhaps above. The filament current is quite accurately rated.

Our table shows a fairly high μ, varying between 7·5 and 10; it is unusual to find the μ increasing with filament heat as in this instance. The anode impedance is normal for this type of valve, but below the average in view of the high amplification, with the result that the power amplification is distinctly good; a value of 5 is above the average for a general purpose valve.

In view of the fact that the valve is essentially a moderate-priced production (10s.) its finish is good, and it would appear to be excellent value. It is interesting to note that the firm undertakes the repair of valves as well as the manufacture.

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 $\left(=\frac{I_s}{\text{Watts.}}\right)$
3·6	·46	1·7	33 000	7·25	1·6	1
3·9	·48	3·1	27 000	9·0	3·0	1·6
4·2	·50	4·8	22 000	9·7	4·3	2·3
4·5	·52	7·2	19 000	10·0	5·2	3·1

The D.E.7.

In our last issue we stated in error that we were reporting the D.E.7 among other M-O valves; it was, of course, the F.E.3 that was reported. However, we have now tested out the D.E.7, which is the same valve except for the substitution of a D.E.R. type filament for the bright one of the F.E.3.

We are not actually printing the curves for this valve, for they are practically the same as for the F.E.3. The output as a "low H.T." valve is a little less, but otherwise the performance is similar.

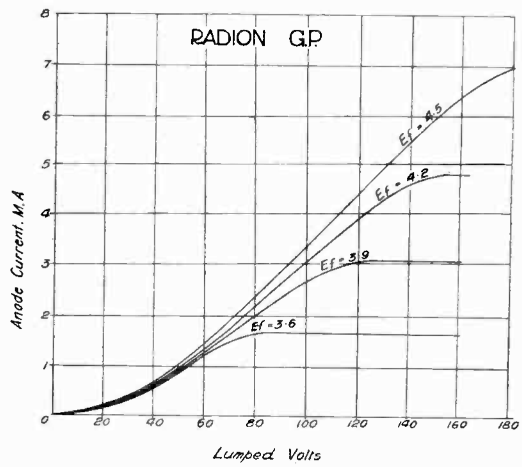


Fig. 4.

For those who are taking advantage of the excellent properties of the 4-electrode valve as dual amplifier to build a compact portable set, this dull emitter is undoubtedly most useful.

Price, 37s. 6d.

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.

"Effective" Transmission.

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

SIR,—In his recent articles on "Effective Transmission," Mr. Ryan makes some suggestions which can hardly be passed without comment. In the first place, how does this extraordinary conception of "broadly-tuned" C.W. transmitters and "spreading" come about? Surely C.W. is C.W., however it is generated? And by definition C.W. consists of oscillations generated continuously without decrement. There is only one kind of C.W.—namely, a sine wave with no low-frequency modulation at all. Even the presence of harmonics does not affect the present argument, for the fundamental resolves into a pure sine wave, and it, as well as each harmonic, will have the properties of a pure C.W. transmission. In any case, any exact multiple harmonics which may be produced are so far from the fundamental wave-length as not to affect a receiver tuned to this wave-length.

Any decrement in a valve transmitter must be a function of the H.T. supply or one of the well-known causes enumerated below. How can the use of high-loss H.F. circuits introduce modulation in a valve oscillator? Yet Mr. Ryan says that a poorly-designed inductance wound with fairly thin wire causes "spreading" if used with a high-power set. When Mr. Ryan made this discovery, did he make quite sure that the percentage ripple in his H.T. supply was the same when the high-loss inductance was used as when the low-loss inductance was used, and that the extra power wasted in the high-loss inductance did not increase the load of the H.T. supply sufficiently to increase the percentage of ripple in the rectified A.C. supply? Again, the direct-coupled Colpitts oscillator is accused of being "the most broadly-tuned transmitter in existence." How? And why? I experiment a good deal myself, and listen to the transmissions of many other stations, but cannot confirm such statements.

The following causes may make a transmitter take up, or appear to take up, more than its allotted band at receiving station:—

Modulation due to ripple in H.T. supply of transmitter.

Key clicks, which are only momentary.

Loose contacts in or near transmitter earth system.

Swaying of aerial.

Spacing wave if used.

Variation of frequency, or "quacking" while the key is down.

Chirps at beginning or end of key-stroke.

Modulation due to filament being heated by A.C.

Unselective receiver.

Abnormal strength or proximity of transmitting station to receiver.

In my own experience many amateurs who ought to know better entirely ignore the last two possibilities in condemning a nearby transmitting station. As far as long-distance work in this country goes, the honours seem just about equally divided between transmitters using pure C.W. and notes with a good deal of A.C. ripple in them.

Mr. Ryan seems to have performed a miracle with raw A.C. when he claims to have prevented raw A.C. transmission from "spreading beyond the inevitable band between $(N+n)$ and $(N-n)$ where N is the radio frequency and n the A.C. frequency." I should like to point out that the analysis giving only two side-bands only applies to the case where a pure C.W. carrier is modulated less than 100 per cent. Raw A.C. means that the valve is oscillating only during every other half-cycle, and the modulation is much more than 100 per cent. This makes things very complicated, and I believe that an infinite series of side-bands is formed; in any case, there is no question of being able to confine a raw A.C. transmission to as narrow a band as $2n$ by the use of tuned circuits on a wave-length as low as 200 metres.

Now for a second, and even graver issue. Mr. Ryan cites experiments purporting to show that an increase of aerial current may result in a decrease of signal strength at a distance. We are on admittedly dangerous ground here, and Mr. Ryan himself admits that he is at a loss to explain some of these apparent inconsistencies. If by the mere increase of power in the aerial system, without altering anything else, his range has really decreased, then the only conclusion is that some entirely new physical effect has been discovered which is not catered for by present-day science. I think, however, that Mr. Ryan is making mysteries worse instead of trying to clear them up. There are so many things which may alter when different transmitters are tested on different nights, and even at different times on the same night, that reliable range comparisons can only be arrived at by experiments repeated night after night with the same stations, keeping one's aerial and earth and counterpoise arrangements absolutely unchanged, as well as the wave-length. I am familiar with circumstances which make one think that the higher one's power, the less the range; but in my case, at any rate, I think there is always a simple reason if only it can be recognised.

Take Mr. Ryan's own case, when he says that he gave up the direct-coupled Colpitts circuit for a loose-coupled circuit, with a reduction of aerial current from 3 amps. to 2·5 amps. and an increase in range; in the Colpitts circuit there was a series condenser below the A.T.I., whereas with the loose-coupled circuit there was probably none. Now, any such change in the loading of the aerial is bound to shift the nodal point and the potential distribution along the aerial. Two things result from this: First, if the aerial ammeter is kept in the same position, it is bound to give different readings in the two cases; secondly, the radiating properties of the aerial may be considerably altered. I mention this as an example of how careful one must be to consider all the possibilities of the case before forming premature conclusions.

I think also that a little misconception may exist over the harmonic evil. Granted it is undesirable to radiate harmonics, but there is not much harm in generating them in the first place. It is well to remember that no ordinary valve can generate a pure sine wave on one frequency only unless it is working at an efficiency less than 50 per cent. The wave form of oscillations generated at high efficiency must necessarily be distorted, a condition which results in the production of an infinite series of harmonics which become progressively feebler as the order increases. But even at high efficiencies the total sum of the energies on all these is not anything like equivalent to the powerful fundamental, and a carefully-tuned loose-coupled aerial circuit should not respond to them to any serious degree. It is much best to work at high efficiency in the valve, and then to sort out the fundamental from the harmonics in this way. If the harmonics are not passed on to the aerial, they remain as wattless components in the closed circuit, and represent no expenditure of energy. The only harmonics of the aerial which exist are the odd ones, but these are not the harmonics which a C.W. transmitter puts out. The harmonics we get with a valve transmitter are those due to the valve characteristic and the distortion of the oscillatory currents through the valve. All harmonics, odd and even, are produced. Hence another of Mr. Ryan's alleged discrepancies between theory and practice disappears.

In conclusion, I should like to suggest that the many amateurs who despise theory as not in agreement with practice, should inquire more closely into their actual knowledge of theory and the precision with which they observe practical facts.

London. E. H. Robinson (2VW)

Intermediate H.F.

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

Sir,—In the article " A High Power Super-Het," your contributor uses the phrase, " Intermediate H.F." I have heard of all sorts of frequencies, but this is a new one. I suggest High L.F. would be more applicable. But excuse the sarcasm. Your contributor has misunderstood the application of the word " intermediate " in this connection. It came into use for the " Super-Het " because the frequency at which amplification takes place is between H.F. and L.F., hence I.F., or approximately the band from 65 to 25 kilocycles.

Another small point. (I am great at criticism, if at nothing else.) Mr. Hugh P. Ryan states, in parentheses: " By the way, who invented condensers with metal end-plates ? " The drift of the paragraph in which this occurs is somewhat obscure, and this question does not escape the general haze. However, it would appear that he does not wish for an answer in order to bestow honour where it is due, and I would therefore join issue with him. Surely such an authority as Mr. Ryan is aware of the considerable increase in efficiency accruing by the abolition of solid dielectric in the fields of coils and condensers carrying H.F. current. (The equivalent series resistance at 1 000 cycles of a badly designed ebonite end-plate condenser may be of the order of 500 ohms, whereas the figure for a " Low-loss " condenser with moving plates grounded to metal ends may be as low as 20 ohms.) But perhaps Mr. Ryan means that a variable condenser should have end-plates of air. An excellent idea.

15, Auriol Road, W. J. Potter.
London, W.14.

[As a matter of fact, we believe that either ebonite or metal end-plates will give good results *if the design is good*. This is the important point.—Ed., E.W. & W.E.]

H.F. and L.F.

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

Sir,—I am very interested indeed in the discussion now going on in the E.W. & W.E. regarding the respective merits of H.F. and L.F. amplification on the short waves.

So far, no one has mentioned a possible and very practicable method of obtaining additional selectivity by means of L.F. amplification. This may be brought about in two ways: (1) By using a specially designed high ratio L.F. transformer having a decided amplification peak near 1 000 cycles. (2) By using what I believe is known as the Kooman's low frequency amplifier, which was originated in Holland, and described shortly in one of the early numbers of E.W. & W.E. In this an oscillating circuit tuned to 1 000 cycles is connected in parallel with the secondary of the intervalve transformer, and by means of a suitable reaction coil connected in the plate circuit of the valve, the L.F. valve is practically made to oscillate at 1 000 cycles.

Both these methods give a very decided amplification peak near 1 000 cycles, and if the note of the received signal is adjusted to come right on this peak, it will be amplified very strongly, while most interference, which will not be tuned to this frequency, will not be amplified nearly so much.

Several Americans have tried method (1), and report very satisfactory results. I am shortly going to experiment on method (2), and would be glad to hear from anyone who has used such a device.

With regard to the question of whether to use

H.F. or L.F. amplification for short wave work, if one is working on schedule with a transmitting station whose wave-length is known, by all means use H.F. Both theoretically and practically it is possible to get greater sensitivity by this method, and, in this case, as much time as required can be spent in adjusting the receiver to the point of maximum sensitivity. But, on the other hand, if it is desired to search efficiently and rapidly over a wide band of wave-lengths—say, from 70 to 150 meters—it is better to use L.F. It is very much easier, and probably more efficient to cover the entire band of wave-lengths with a well-designed detector and single note magnifier, which only introduces two controls, and can therefore be rapidly adjusted to maximum sensitivity. It is interesting to note the fact that at least two out of the four English amateurs who have so far worked 2-way with New Zealand were using L.F. amplification only in their receivers.

Of course, by H.F. I do not mean the super-heterodyne, which is undoubtedly the best receiver for short waves, for those who can afford it.

Cambridge. E. J. MARTIN.

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

SIR,—There seems to be a tendency on the part of those who advocate H.F. amplification to regard the non-H.F. enthusiasts as persons who are not clever enough to get H.F. to work on short waves. Granted that it is a difficult matter to construct an effective short wave H.F. amplifier, it is rather ridiculous to tack on a quite unnecessary collection of apparatus to one's receiver simply to demonstrate that the owner can get it to work. That it is quite unnecessary is shown by the final test of excellence—results. It does not matter at all how excellent theoretically H.F. amplification may be, or how utterly wrong L.F.; if the latter produces the results, all other arguments go for nothing.

It is hardly necessary to mention the results obtained with non-H.F. receivers, particularly in two-way working, where the greater ease in tuning scores heavily. The first two-way transatlantic working was with "O-v-1" receivers at each side. The record log of transatlantic signals (by Mr. S. K. Lewer) is obtained on O-v-1 or O-v-o. Argentine (CB8) was first reported from all parts of the country on the same type of receiver. And the last amateur feat—New Zealand—received well with two or even single valve receivers, and no H.F.

The fact is, that the most important requirement in design is no longer sensitivity, but ease in handling. Any decent single valve receiver, with an optional L.F. for bringing up weak stuff, will get practically everything going, so long as it is designed to give freedom from capacity effects, smooth reaction, fine adjustment over a large band of waves, calibrated scale, and an arrangement for very close wave-length adjustment giving precise control of the heterodyne note received, etc.

These and other features are those required to search over a wide band of very short waves, and at the same time maintain the same standard of receptiveness. Personally, I find it possible to arrange reaction control so that one can search over, say, 95-140 metres with one knob, the receiver being in its "just oscillating" condition all the time, leaving the other hand free to take down the traffic. If signals are a little weak, press the L.F. button; if QRM troubles, bring off oscillation and switch on the heterodyne wavemeter.

Most of the textbooks say that if signals are inaudible, the addition of L.F. will not bring them up. This is incorrect, as anyone will find out if he takes the trouble to try it, assuming the receiver is a good one. It must be admitted that the strength is not so great when brought out from "nothing" in this way as if H.F. had been added, but in practical work the H.F. valve takes at least several seconds to tune in to the best advantage, and by that time it may be too late.

It is quite possible that some may ask "What about the super-het.?" It is unfortunate that in most descriptions of this excellent type of receiver it is represented as being a true H.F. amplifier in the sense that the peculiar advantage of H.F. amplification—strengthening of signals before rectification—is obtained. It seldom seems to be made clear that it is simply a method of L.F. amplification which is more selective and less noisy than the usual types.* The undeniable merit of this form of receiver merely confirms the view that H.F. is unnecessary, as here we have an elaborated L.F. amplifier which preserves the essential ease in handling, and at the same time gives very great amplification without undue noise or interference. Still, the humble single valve has such a magnificent DX record to its credit that those unable to afford the "Rolls-Royce" of receivers need not greatly envy those who can.

37, Cluny Gardens, Edinburgh. MARCUS G. SCROGGIE. (5JX)

[*Our correspondent does not seem to us to be quite correct here.—ED., E.W. & W.E.]

Short-Wave Signals.

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

SIR,—Having been successful in receiving all the short-wave signals transmitted from the Eiffel Tower during July, a short summary of the conclusions arrived at may be of interest to readers.

The signals were sent on four different wave-lengths, 115, 75, 50 and 25 metres, and the emissions were of two types:—

(1) F where the aerial functioned at its natural wave-length.
(2) H where the aerial functioned at a harmonic.

The conclusions were:—

(1) Day strength always less than night strength.
(2) Ratio of strength of F to strength of H inversely proportional to wave-length. It being unity at about 50 metres.
(3) Strength greater when there is more QRN.
(4) Impurity of wave and a spacing wave present on 50 and 25 metres.

When fading is present:—

(5) It is less on shorter wave-lengths. It is absent below 50 metres.
(6) Ratio of fading of F to fading of H inversely proportional to wave-length.
(7) It is greater when there is more QRN.

VYVYAN A. G. BROWN (6JZ).

Sparks from the Aerial.

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

SIR,—Having been very much interested in the comments of several observers regarding sparks from antennæ, I am impelled to offer some data of my own.

Located as we are on a large plain and far from the sea coast, thunderstorms of great energy are very common. Our antenna at W.C.A.J. is connected to earth through a S.P.D.T. switch of 100 ampères capacity. By leaving this switch open sufficiently to leave a small gap between the blade and the lower terminal, sparks from $\frac{1}{8}$ to $\frac{1}{2}$ inch have repeatedly been observed with with thunderstorms at a distance of three to ten miles, also in hail and snowstorms, and often in winter when dry snow is being blown about by a high wind. When thunderstorms are overhead, experience has taught us to keep away from the lightning switch, as the antenna has twice been struck by lightning, splitting the insulators and fusing the wires, the second time fusing the switch blade into the clip.

In connection with some experiments on the electrical charges on falling rain, I have recently had opportunity to measure the potentials induced by atmospheric charges on an insulated metal deck which is being used as a collector. The deck is of galvanised iron, 10 by 14 feet, and mounted on the flat roof of a building thirty feet high adjoining the Physical Laboratory. A highly insulated wire connects the deck to one terminal of a sensitive galvanometer, the other galvanometer terminal going to earth. On a clear summer day the deck has a potential of —·01 to —·05 volts, the higher values usually being recorded about noon. In hot, sultry or cloudy weather, potentials of nearly +1 volt have been recorded, the sign of the charge having a tendency to vacillate with the approach of a storm. Lightning discharges from distant clouds induce in the deck potentials of 50 to 1 000 volts, the sign being more frequently negative than positive for a distant storm, and changing to principally positive as the cloud approaches. With heavy lightning directly overhead, potentials of +6 000 volts have been recorded, and on a number of occasions the instrument was thrown entirely off the scale, indicating even greater potentials.

We hope to publish later a more extended report of the present investigation, but the figures cited will give some idea of the magnitude of the potentials involved.

Department of Physics, J. C. JENSEN.
Nebraska Wesleyan University.

New Zealand.

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

SIR,—With reference to recent announcements *re* reception of New Zealand amateurs, the following information of G5NN's work may be of interest to you.

Z4AA, Z4AG, Z4AK were first heard at 5NN on Monday morning, October 20th, at 6.42 a.m. Constant reception, often with phones on the table, has been carried out on each succeeding morning to date. On Sunday, October 26th, Z4AA reported to G5NN very strong. Two-way working was not established owing to sunrise. On Thursday, October 30th, Z4AQ called G5NN, and reported signals very QSA with slight QSS. Signals readable all the period that they were audible.

Transmitter at G5NN consists of Meissner circuit. Full wave rectification with M.T.1 valves. Oscillator two T·250 valves in parallel. Input 200 watts, radiation 1·85A on 97 metres. Aerial 56 ft. high, 6 wire cage. Counterpoise 6 wire, 12 ft. above ground. Receiver, Burndept Ultra III., using detector (D.E.Q.) and one L.F. (D.E.5) only. Reception when working New Zealand always carried out without aerial to avoid atmospherics.

S. Norwood. J. H. D. RIDLEY.

A Correction.

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

SIR,—I have just noticed an error in my article on " Some Measurements on a Broadcast Receiver," p. 88 of the present number, and I should be glad if I may be allowed to correct it.

The object of the large shunting condenser in the anode circuit of the valve voltmeters is to reduce the impedance of the circuit external to the valve to a negligible quantity at all frequencies, thus rendering the calibration independent of frequency. This is very necessary as the instrument is most conveniently calibrated on 50*f*. A.C. and may be used, perhaps, on $3 \times 10^6 f$.

G. W. SUTTON.

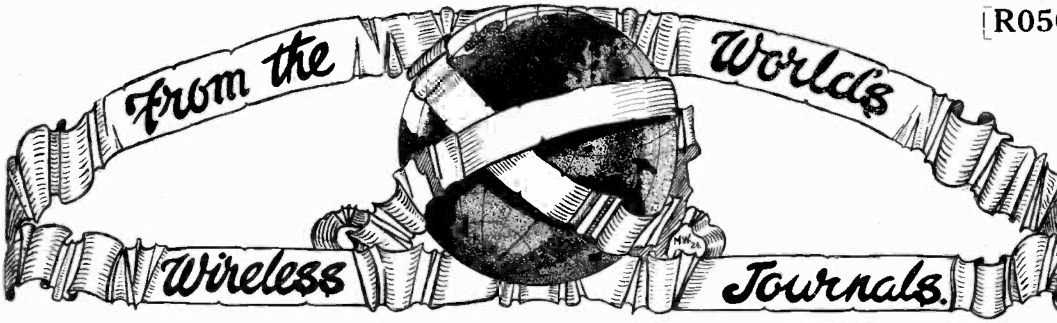
Tribute to Amateurs.

The following grateful tribute to the value of the work of American wireless amateurs was broadcast from the Naval Research Laboratory at Bellerne, D.C. on Navy Day by authority of Mr. Curtis Wilbur, Secretary of the U.S. Navy. It refers to the assistance given by amateurs in maintaining wireless communication during the flight of the Shenandoah.

> " To Amateur Radio Operators of the United States.
>
> " The co-operation of the amateur radio operators with the Naval Research Laboratory has resulted in increasing the communication efficiency of our Navy. The new long distance communication records made by the Shenandoah are a direct result of your co-operation.
>
> " Interest, such as you have shown in the Navy in time of peace is the country's best guarantee of our Navy's readiness when called upon for our country's defence.
>
> " It seems appropriate, therefore, that on Navy Day, which coincides with the completion of the wonderful transcontinental flight of the Shenandoah, I congratulate and thank you for your contributions towards a better and more efficient Navy.
>
> " CURTIS D. WILBUR."

We do not, unfortunately, hear of any activities on the part of the R.S.G.B., which might have led to a similar official appreciation in this country.

[R050



R000.—GENERAL.

R008.—Digests of United States Patents Relating to Radio Telegraphy and Telephony Issued. June to August, 1924.—J. B. Brady (*Proc. I.R.E.*, Oct., 1924.)

An interesting regular feature of the Proceedings of the Institute of Radio Engineers giving an idea of what has been recently patented in the U.S.A.

R009·2.—My Radio Experience in the Far North.—Donald H. Mix (*Q.S.T.*, Nov., 1924.)

The operator of the "Bowdoin" expedition gives an account of short-wave communication conditions throughout the various phases of the expedition. Though semi-topical, the account contains practical data which form a distinct addition to our knowledge of short-wave radio work.

R114.—Discovery of a Place Where No Static Could be Heard in August.—R. H. Marriott (*Proc. I.R.E.*, Oct., 1924.)

A point was found off the Alaska coast where no atmospherics were heard during a period of six days in August, 1921. Such spots have been found to be dead spots with respect to certain transmitting stations, while they are favourable for the reception of other stations. The observed effects are ascribed by the observers to the mountainous nature of the Alaska coast.

R582.—The Transmission of Pictures by Wire and Wireless.—(*W. World*, Oct. 29.)

A short *résumé* of a paper on the subject recently read before the Royal Photographic Society by Mr. Thorne Baker, F.R.P.S.

R100.—GENERAL PRINCIPLES AND THEORY.

R113.—Unsolved Problems of Wireless.—R. H. Barfield, M.Sc. (*W. World*, Nov. 12.)

A paper read before the Radio Society of Great Britain dealing with the irregularities experienced in the propagation of wireless waves: namely, the bending of waves round the curvature of the earth's surface, night ranges, fading and variations in directional bearings at night.

R113.—More About Effective Transmission.—H. N. Ryan (*Exp. W.*, Nov., 1924.)

A topically-written article on some observations on the relation between the range of a transmitting station on short wave-lengths, and the power and circuital arrangements used.

R134·4.—An Analysis of Two Triode Circuits.—J. H. Morecroft and A. G. Jensen (*Proc. I.R.E.*, Oct., 1924).

An analytical examination of two typical triode circuits used for obtaining regeneration by mutual induction, with the idea of testing the results by experiments. Measurements made on circuits operating at 1 000 cycles confirm the theoretically derived relations to a remarkable degree of precision.

R141.—An Easy Way to Calculate Circuits.—P. K. Turner (*Exp. W.*, Nov., 1924).

An explanation in simple language of how the impedance, reactance, etc. of circuits containing resistance, inductance and capacity may be calculated with the use of "*j*"; the methods being reduced to simple arithmetic and no knowledge of higher mathematics being necessary.

R200.—MEASUREMENTS AND STANDARDISATION.

R113·2.—Etude sur les Irrégularités de Propagation des Ondes Courtes.—M. Lardy (*Onde Elec.*, Oct., 1924).

Second part of a description of some experiments made on the variation of signal strength over various parts of the day and night. More signal strength curves are given and some data has also been obtained on "dead spots" and the effect of topographical conditions.

R131.—Experimental Determination of the Fundamental Dynamic Characteristics of a Triode.—Eijiro Takagishi (*Proc. I.R.E.*, Oct., 1924).

By picking out the fundamental component only from the distorted current in a triode while functioning, the writer has found, first, new forms of dynamic characteristics for a triode, and secondly that the grid current may reach a large value and that a certain constant depending on the emission merits attention. Some experiments have been carried out relative to the voltage amplification factor, for which a new expression has been found.

R220.—THE MEASUREMENT OF SMALL CAPACITIES. —(*W. World*, Nov. 12.)

A bridge method of measuring small capacities against a variable standard capacity.

R220-240.—A NEON LAMP METHOD OF COMPARING CAPACITIES AND HIGH RESISTANCES.—W. Clarkson, M.Sc., and J. Taylor, B.Sc. (*Exp. W.*, Nov., 1924).

Various uses of the flashing method of comparing capacities and resistances are described. Experimentally-determined graphs are reproduced showing that a linear relation exists between the flashing period and the supply resistance to the lamp or the capacity across it.

R250.—ETALONNAGE D'UN AMPERMÉTRE EN HAUTE FRÉQUENCE.—M. Clayeux (*Onde Elec.*, Oct., 1924).

Brief description of a method of calibrating a H.F. ammeter against a D.C. ammeter by placing each in turn in series with the filament of a thermionic valve, the filament being heated with D.C. when the D.C. instrument is used, and with H.F. when the H.F. instrument is used. The currents in both cases are adjusted to the same thermal value as indicated by the emission of the filament, which is indicated by a plate milliammeter.

R261.—SOME MEASUREMENTS ON A BROADCAST RECEIVER.—G. W. Sutton, B.Sc. (*Exp. W.*, Nov., 1924).

Description of some experiments in which a Moullin voltmeter was employed to measure received voltage, amplification, etc., on a broadcast receiver.

R270.—A METHOD OF MEASURING RADIO FIELD INTENSITIES AND ATMOSPHERIC DISTURBANCES.—L. W. Austin and E. B. Judson (*Proc. I.R.E.*, Oct., 1924).

A method of measuring signal strength by the use of a telephone comparator. For determinations on a C.W. signal the heterodyne note is adjusted to the same pitch as that of a standard tuning-fork generator, the output of the latter being adjusted by means of a potential divider to give the same intensity in a pair of telephones as the heterodyne note of the signal. For measuring atmospheric disturbances the standard generator currents passed into the telephones are broken into morse signals by keying and the intensity varied until the signals are just readable through the atmospherics.

R300.—APPARATUS AND EQUIPMENT.

R134·2.—NOTE SUR LA DETECTION PAR LES LAMPES À TROIS ELECTRODES.—Messrs. Davaud and Petit (*Onde Elec.*, Oct., 1924).

A simple and concise description of the action of grid-leak and condenser rectification.

R139.—HELIUM TUBES.—F. S. McCullough (*Q.S.T.*, Nov., 1924).

Short note on thermionic power valves containing pure helium. It is stated that the presence of helium reduces the impedance of the valve and assists cooling. Such valves are said to be in successful operation at several American broadcasting stations.

R320.—ANTENNAS FOR SHORT WAVES.—H. F. Mason (*Q.S.T.*, Nov., 1924).

Short article pointing out that short waves permit the experimenter to realise his ideals in design, as the magnitude of aerials for short wavelengths need not be large.

R342·6.—INTÉRESSANTE UTILIZATION D'UN ETAGE D'AMPLIFICATION À RESONANCE.—P. Girardin (*R. Elec.*, Oct. 10, 1924).

Description of the use of a three-electrode valve as a means of coupling between a receiving set and an aerial. The circuit described would appear to amount to very much the same thing as one stage of tuned anode H.F. amplification.

R342·701.—THE PERFORMANCE AND PROPERTIES OF TELEPHONIC FREQUENCY INTERVALVE TRANSFORMERS.—D. W. Dye, B.Sc. (*Exp. W.*, Nov., 1924).

Concluding part of an important article on the electrical properties of intervalve transformers, including inductance, impedance, resistance, capacity, ratio of windings, etc.

R343.—THE ONE-CONTROL SUPERHETERODYNE.—J. L. McLaughlin (*Q.S.T.*, Nov., 1924).

Detailed description of a supersonic heterodyne receiver in which the local oscillator and the tuner are simultaneously varied by one knob. In order to make this feasible the proportions of inductance to capacity in the two circuits have been ingeniously chosen so that the numerical frequency-difference between the local oscillator and tuner is constant over the whole range of adjustment.

R343.—THE ONE-VALVE SET.—P. K. Turner (*Exp. W.*, Nov., 1924).

An article dealing with the operation and important details in the ordinary one-valve regenerative detector.

R343.—THE SUPER-HETERODYNE: ITS ORIGIN, DEVELOPMENT AND SOME RECENT IMPROVEMENTS.—E. H. Armstrong (*Proc. I.R.E.*, Oct., 1924).

Some improvements in super-heterodyne receivers, particularly in the reduction of the number of valves used. Wherever possible a valve is made to perform at least two functions. For instance, the separate oscillator may be abolished and its function filled by the first valve in the set. Dual amplification is made use of where possible. The work described is the result of an effort to bring this type of receiver within the demands of the pocket and manipulative ability of the ordinary broadcast listener. This paper would appear to be one of the few substantial contributions to the subject since Armstrong's original paper in 1919.

R344.—A HIGH-EFFICIENCY VACUUM TUBE OSCILLATING CIRCUIT.—D. C. Prince and F. B. Vodges (*Proc. I.R.E.*, Oct., 1924).

Description of a modified push-pull circuit in which approximately square waves of current are passed through the valves alternately. High efficiency is obtained by superimposing upon the grid circuit a voltage proportional to current variations in the plate circuit. The circuit gives high output and high efficiency without shortening the life of the valves.

R344.—PARALLEL OPERATION OF POWER TUBES.—J. H. Turnbull (*Q.S.T.*, Nov., 1924).

Account of some of the troubles experienced in running oscillator valves in parallel, with particular references to parasitic oscillations on wave-lengths of only a few metres. Experiments made by the writer indicate how these parasitic effects are caused and how they may be suppressed.

R344·3.—TRANSMITTING EQUIPMENT FOR RADIO TELEPHONE BROADCASTING.—Edward L. Nelson (*Proc. I.R.E.*, Oct., 1924).

A description of the standardised Western Electric broadcasting apparatus which has been installed and used in a number of American broadcasting stations. The technical demands of broadcasting as regards quality of reproduction, etc , are dealt with. It is interesting to note that condenser microphones have been standardised in the Western Electric Co.'s equipment as well as the more familiar carbon granule type.

R344·4.—PRACTICAL SHORT WAVE TRANSMITTERS.—(*Q.S.T.*, Nov., 1924.)

A few details of a valve transmitter for wavelengths of 20-22 metres.

R351.—OSCILLATING CRYSTALS.—O. Lossev (*W. World*, Oct. 22).

Some observations are given on the properties of the contacts of detecting and oscillating crystals, including the effect of temperature on a generating contact, variation of resistance with temperature, luminescence at the point of contact, the waveform of the generated oscillations and the generating characteristic of tinstone.

R356.—NOTES ON POWER TRANSFORMER DESIGN.—A. Castellain, B.Sc. (*Exp. W.*, Nov., 1924).

The notes comprise information enabling the reader to design the core and windings of a power transformer for high voltage on commercial frequencies.

R375. — SINGLE POINT DETECTORS. — James Strachan, F.Inst.P. (*W. World*, Nov. 12, 1924).

Account of some interesting experiments, showing how detecting contacts may be obtained with a number of everyday substances.

R375·09.—COHERERS AND CONTACT DETECTORS.—James Strachan, F.Inst.P. (*W. World*, Oct. 29, 1924).

A short account is given of the history of various coherers and detectors and the theory of their action. The author deals with the subject of coherers and their relationship to modern crystal detectors.

R386.—SELECTIVE RECEIVING CIRCUITS.—N. W. McLachlan, D.Sc. (*W. World*, Nov. 12, 1924).

An account of the use of resonant circuits and cascaded circuits to effect selective reception.

R400.—SYSTEMS OF WORKING.

R460.—DUPLEX TELEPHONY.—P. P. Eckersley, M.I.E.E. (*Exp. W.*, Nov., 1924).

An article outlining the problems of duplex telephony and describing a few methods of achieving and operating it.

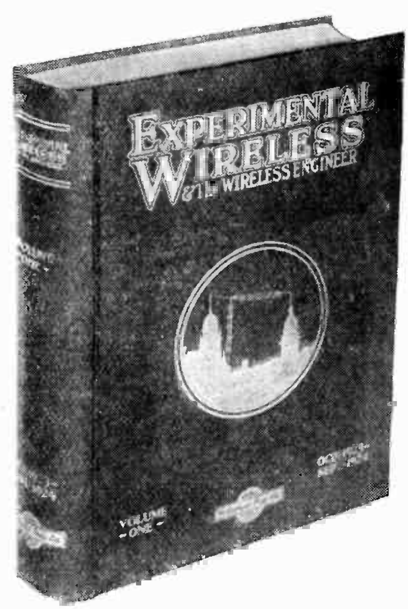
R500.—APPLICATIONS AND USES.

R510.—RECHERCHES RADIOGONIOMÉTRIQUES SUR LA MARCHE DES TYPHONS.—E. Gherzi, S.J. (*Onde Elec.*, Oct., 1924).

A series of experiments made at the Zikawei Observatory, Shanghai, for the purpose of studying the relation between atmospherics and the movements of typhoons. Tables of data are given showing directions of typhoon-centres, as given by the meteorological service, and simultaneous bearings of maximum atmospheric disturbances, as determined by a frame aerial.

An Omission.

By an unfortunate omission, which we regret, the name of Mr. H. Emmons did not appear beneath his article, "A Compact High-Power Super-Het," in last month's E.W. & W.E. Mr. Emmons' description of his set has attracted much interest.



The photograph gives an idea of the handsome appearance of the bound First Volume of "E.W. & W.E."

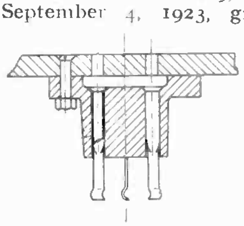
Some Recent Patents

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

[R008

INCREASED RESILIENCY.

Patent No. 219,826, Application Date, September 4, 1923, granted to A. P. Welch, describes a valve-holder suitable for mounting on the under side of a panel. Holes are drilled in the top of the panel so that they register with the valve sockets and thus enable the valve to be inserted. The object of the invention is to prevent the risk of short circuits between the various elements of the valve holder, and also to prevent the valve from being burnt out if an attempt is made to insert it incorrectly. The idea is illustrated by the accompanying figure and reminds us of the Mullard "Safety Disc."



A GAS-FILLED VALVE.

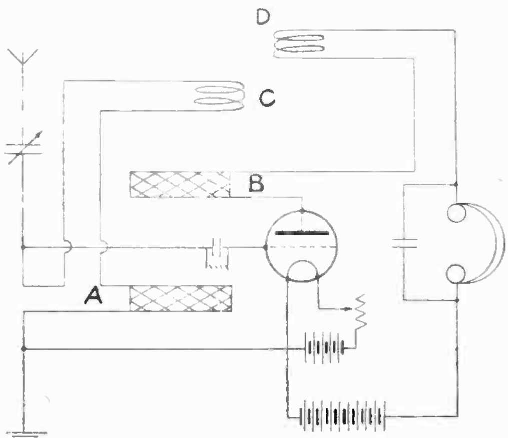
W. R. Bullimore describes in Patent No. 218,116, Application Date, July 17, 1923 (which is a patent of addition to No. 192,462, October 31, 1921), a gas-filled, or soft, valve in which means are provided to combat the effects of ionisation present in the ordinary type of valve. Normally it is found that when ionisation occurs, the ions take a "curved polar path between the filament and the anode, thus destroying the effect of the control of the grid." The inventor endeavours to avoid this effect by employing a spherical anode and grid, the arrangement of the filament also being almost spherical. The specification mentions the use of helium at a pressure of 0·6 mm. of mercury.

A DOUBLE FILAMENT VALVE.

A. P. Portway has been granted Patent No. 218,784, Application Date, May 2, 1923, for a three-electrode valve which contains two filaments. The valve is further fitted with two caps, each carrying four pins. One filament is connected to one cap, and the other filament is connected to the other cap, the grid and anode being common to each. When one filament burns out, the valve is removed from the holder and merely inverted so as to bring the other filament into use. An insulating cover is provided for the cap not in use to prevent accidental short circuit.

A REFINEMENT IN COUPLING.

J. Scott-Taggart describes in Patent No. 218,105, Application Date, January 2, 1923, a system of improved coupling. When two large inductances are coupled together, the inventor states that the slightest movement of one coil with respect to the other results in a very large change of coupling, the adjustment being far too coarse for most purposes. A small inductance is therefore connected in series or parallel with each of the two



main inductances, the variation of coupling being made between the two small inductances. This is illustrated in the figure in which A and B are the main inductances and C and D the subsidiary coils between which the variation of coupling is effected. The idea of coupling only a small part of an inductance to another inductance is, of course, quite old, and in many cases is sufficient when the total coupling has not to be very great.

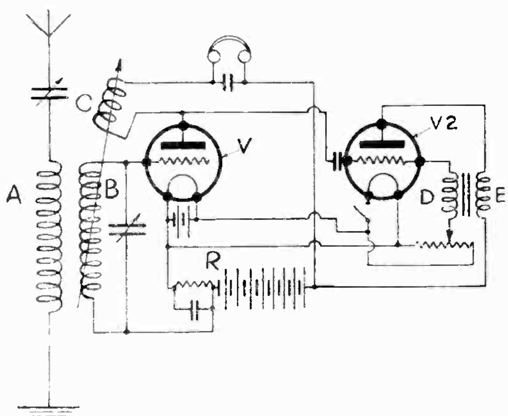
HEAT RADIATION.

P. W. Baker has been granted Patent No. 220,124, Application Date, June 27, 1923, for a rheostat in which the resistance element is wound on a metal core to assist in the distribution and radiation of heat. It is specially designed for panel use and is mounted on a flat, metal plate, the other side of which carries an insulated terminal bar.

PREVENTION OF OSCILLATION.

A very interesting scheme is detailed in Patent No. 218,336, Application Date, January 4, 1923, granted to Norman Lee, John Ree and Radio Communication Co., Ltd. The idea obviously relates to broadcast receivers and has as its object the prevention of interference by oscillation and radiation. Two arrangements are described, but that employing a subsidiary valve (shown in the accompanying illustration) will be dealt with. The valve, with its associated tuning circuits A, B, and reaction coil C, is simply an ordinary, single-valve reaction circuit, suitable for short wave reception.

It will be seen that the anode of the valve V is coupled by a small condenser to the grid of valve V2. This is associated with a grid coil D and an anode coil E, and the grid potential is determined by a potentiometer. The coils D and E and the potentiometer are so adjusted that the valve does not normally generate continuous oscillations. The coils are so chosen that should the valve oscillate, the oscillations would be of a comparatively low frequency. If the reaction coil C of the



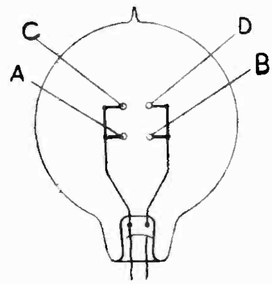
broadcast receiver is badly adjusted, so that the receiving valve V commences to oscillate, potentials of considerable value will be set up between the anode and earth and will be communicated to the grid of the valve V2. These potentials will be of sufficient magnitude to cause the valve to oscillate at a low frequency.

It will be seen that the anode circuit of the valve includes a resistance R, and accordingly these comparatively strong low frequency oscillations will cause big potentials to be set up across the resistance. This resistance, however, is in the grid circuit of the receiving valve, and will therefore communicate the potentials to the grid, completely wiping out the original high frequency oscillations. The low frequency oscillations will continue until they are stopped by opening the filament switch of the valve V2.

The idea is very ingenious, but would appear to require very careful design and original adjustment. Much interesting subject matter is included in the specification which it is not possible to mention here. In another arrangement the scheme is worked with only one valve, but would appear to be far more critical in adjustment.

A NEW DISCHARGE TUBE.

The accompanying illustration shows an improved form of discharge-tube described in Patent No. 199,732, Convention Date, June 21, 1922, granted to Naamlooze Vennootschap Philips' Gloeilampenfabrieken. It has been found that owing to volatilisation the electrodes are apt to disintegrate, thereby increasing the distance between them. This means that the starting potential for the particular tube will have to be increased as time goes on; and if only a limited voltage is available, it means that the tube will become useless after a certain time. This trouble has been eliminated by the use of two or more sets of electrodes (AB and CD), the distance between each pair being substantially the same. It is thus found that when one set becomes useless, the next will come into operation. The idea reminds us of the multiple-point sparking-plug with which our readers are no doubt familiar.

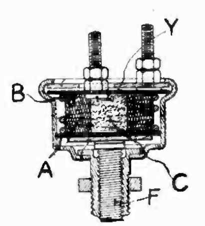


EFFICIENT CONTACT.

W. J. Davis and the Edison Swan Electric Co., Ltd. has been granted Patent No. 218,063, Application Date, May 8, 1923, for a rheostat of the ordinary type in which the contact arm is so constructed that it makes efficient contact with the resistance element owing to the fact that the two contact surfaces are suitably related. In other words, a slightly-concave, springy contact is used to bear upon the ordinary spiral resistance element.

THE "MICROSTAT" RESISTANCE.

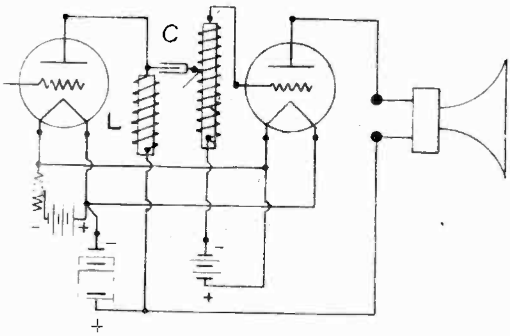
It appears from Patent No. 218,523, Application Dates, August 23, 1923 and January 22, 1924, that H. A. Yoward is the inventor of the well-known "Microstat" type of resistance. The construction is exceeding simple and comprises a compressible felt disc A, with a central hole filled with carbon granules C, which are kept in position by two plates X and Y. Between the two plates X and Y there is a spiral spring C.



The felt pad is enclosed in a metal case, at one end of which there is a screwed rod F, which is connected to the operating knob. On turning the rod, the felt pad will be compressed, and with it the carbon granules, the resistance of which will decrease. The connections are taken, of course, from the two metal plates, between which the resistance is caused to vary. On unscrewing the rod F, the pressure on the granules will be released, and the felt pad will be returned to its original condition by the spiral spring C.

A PECULIAR LOW FREQUENCY COUPLING.

E. A. Graham and W. J. Ricketts describe in Patent No. 218,066, Application Date, May 9, 1923, a rather peculiar form of valve coupling, which is illustrated in the accompanying figure. The specification states that the invention has for its object high voltage amplification with very little distortion in wave form. Referring to the figure, it will be seen that the anode circuit of one valve contains a choke L, and is coupled to the subsequent valve by a condenser C. The condenser is not connected directly to the grid of the valve, but is taken to a tapping on A which constitutes an auto-coupled transformer.



The illustration includes a loud-speaker, so it would appear that the circuit is intended for speech frequencies, but no indication is given of the values of either the choke or the auto-transformer windings. The specification states that there is little change in wave form, but this would seem to be directly determined by the actual windings of the components of the circuits. It would be interesting to examine mathematically the network L C A. The specification also provides for the shunting of the primary and secondary of the auto-transformer by high resistances, which further complicates the analysis of the operation of the device.

AN OLD IDEA.

R. H. Winter has been granted Patent No. 219,234, Application Date, December 6, 1923, in which is claimed a valve-holder so constructed that it may be attached to a panel so that the valve is parallel with the plane of the panel. The patent is essentially of a constructional nature, as there is obviously nothing novel in mounting a valve in the position indicated. We seem to remember using a valve-holder of this type on a certain Army set years ago, but we are, of course, open to correction.

A NEW RHEOSTAT.

Patent No. 218,020, Application Date, April 3, 1923, granted to C. Seymour and G. W. Harris, describes a rheostat in which there are two contact arms bearing on a resistance element wound in drum form, both the arms and the drum being capable of rotation. In another modification two or more drums are employed. The rheostat is obviously capable of being used in a variety of ways, but for general work we see no special advantages. No doubt the inventors had some special object in view.

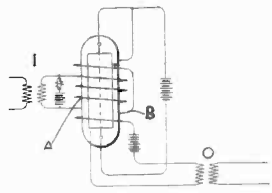
A FOOL-PROOF SET.

Patent No. 211,513, Convention Date, February 19, 1923, granted to the Marconi Co., Ltd. is a document which should be carefully studied by everybody who is connected with the manufacture of wireless sets. The description of the invention occupies some nine pages, and no less than thirty-one illustrations are required. The essence of the invention is involved in the first claim, which reads: "The combination of a single adjusting member, a receiving circuit having tuning elements . . . comprising a continuously variable capacity and inductance, the elements determining the reactance of the said tuning elements throughout their adjustment being co-operatively proportioned in a manner such that the relation between the square root of the product of the inductance into the capacity, and the movement of the adjusting member is substantially a straight line function, and a dial co-operatively associated with said adjusting elements and having substantially equal wave-length differences."

The specification describes how this is accomplished in a multi-valve receiver employing a separate heterodyne, and the construction of the receiver seems almost to include the use of every known device of spade, tuning square or other law condensers, gearing, linking and switching, the combination of which constitutes one claim of the invention.

A MAGNETRON AMPLIFIER.

The illustration shows a new magnetron amplification circuit covered by Patent No. 199,742, Convention Date, June 26, 1922, held by the British Thomson-Houston Co., Ltd. The magnetising field is provided as usual by the coil A, to which the currents to be amplified are supplied by means of the input transformer I. The anode circuit contains an output transformer O, the primary of which is in series with a coil B, adjacent to the magnetising coil A. The coil is so connected that the anode current tends to oppose that in the magnetising circuit.



It will be seen that if the magnetising current is increased by the initial currents to be amplified, the anode current will decrease. But this current passes through the coil B, which opposes the magnetising current, and consequently the effective value of the magnetising current will be materially strengthened. This obviously results in a much greater amplification, and the arrangement is comparable with the usual regenerative coupling in a three-electrode valve.