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POWER BUZZER AMPLIFIER

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JOHN BIDDLE,
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CONTENTS.

		PAGE
I.	Theoretical Considerations	3
II.	Transmitting Apparatus.—The Buzzer	8
III.	Receiving Apparatus.—The Amplifier	10
IV.	Bases	13
V.	Ranges	15
VI.	Compasses	16
VII.	Preparation of a Power Buzzer Station and power Buzzer Amplifier Station, for an Assault	16
VIII.	Method of Laying Out Stations	20
IX.	Precautions to be Taken	20
X.	Hints on Use of Power Buzzer and Amplifier	21

POWER BUZZER-AMPLIFIER.

I.—THEORETICAL CONSIDERATIONS.

If two earth plates, A and B, are sunk into the ground and a difference of potential is maintained between them, whether steady by means of a battery or alternating by means of a buzzer, the current through the earth cannot be regarded as flowing in a direct path from A to B, but through the whole earth. The whole earth may, therefore, be regarded as an infinite number of insulated conductors joining plate A to plate B.

Consider a battery connected up to the two earth plates, A and B, by means of insulated conductors, as in Plate I.

The value of the current flowing through C is equal to the arithmetical sum of all the currents flowing through the infinite number of insulated conductors of which the earth is considered to be constituted.

The current flowing through each of the infinite number of conductors is not equal, as the resistances of such conductors are directly proportional to their lengths, and it is only necessary to consider the conductors that lie in the immediate neighborhood of the direct line from A to B, the currents in the more distant conductors being so small as to be negligible. The dotted lines in Plate I represent the nearer insulated conductors.

Electrical energy has been dispersed to a considerable distance from the source, *i. e.*, the battery, and if it be possible to tap this energy a method of signalling would be obtained; or, in other words, following the same analogy as above, if it were possible to break one of the infinite number of conductors and lead it through a detecting instrument, signaling would be very simple.

In fact, it is possible to tap the energy in this manner, for though it is, of course, not possible to lead one of the infinite number of conductors through an instrument, it is possible to short-circuit a considerable length of it.

Imagine *a b c d e f* (Plate I) to be one of the infinite number of conductors and that a conductor of very much less resistance is put across from *b* to *e*, as shown in the chain-dotted line in the figure, then a far greater proportion of the total current flowing between *b* and *e* will pass along the chain-dotted conductor than along the conductor *b c d e*.

Considering the question from another point of view, there is a difference of potential between *b* and *e*, and there are two paths for the current to flow from *b* to *e*, one a low-resistance path (chain-dotted), and the other a high-resistance path (*b c*

d e). The chain-dotted path has practically short-circuited the path *b c d e*, and a very large proportion of the total current due to the difference of potential between *b* and *e* will flow along it.

In practice, this result is obtained by burying earth plates at *b* and *e* and connecting these plates by an insulated conductor.

In order to employ the electrical energy, it is necessary to insert suitable transmitting apparatus in the conductor between earth plates A and B, and to provide suitable apparatus for receiving the current passing through the conductor connecting the earth plates *b* and *e*.

The most practical and convenient type of apparatus for detecting very small currents is the telephone receiver, but the diaphragm of such a receiver would not be actuated by a constant current except that it would give a click whenever the circuit of which it formed a part was closed or opened, say, by the employment of a signalling key. Consequently, it is necessary to use a buzzer at the transmitting end, which will give a series of current impulses, and will cause the diaphragm of the telephone receiver to vibrate as long as the transmitting key is held down.

The range obtainable by means of a simple telephone receiver is far too small to be of any practical value, and some method of magnifying the strength of signals is therefore necessary.

The instruments actually used for signalling are:—

(i) A special buzzer, known as the Power Buzzer, for transmitting.

(ii) A Valve Amplifier, for receiving and amplifying the signals received.

(The Valve Amplifier used in this manner is simply a very sensitive relay.)

The earth plates are generally referred to as "earths," and may take many forms, the usual one being the earth-pin type. The insulated conductor connecting the two earth pins is generally referred to as an "earth lead," and the imaginary straight line drawn between two earth plates is known as the "base."

Referring again to Plate I, there is a fall of potential along each of the dotted lines representing a flow of current, and consequently points of the same potential exist on these lines. For example, points *g, h* and *i* are at the same potential as *b*. Curves can, therefore, be drawn through these points of equi-potential, and they assume the shape of the chain-dotted lines shown in Plate II.

By considering these chain-dotted lines, it is perhaps easier to see how signalling can be carried on, for if an earth-plate C be inserted on curve *q r s* and an earth-plate D be inserted on curve

x y z, curve *q r s* being at a different potential to that of *x y z*, a current will flow along the base connecting C to D.

It has been assumed above that the mass of the earth is homogeneous, but as this is not so, the lines representing current flow will not be of regular form, but will be distorted.

Ranges depend on the conductivity of the soil. Where the soil is of bad conductivity, the current flowing will be so small, owing to high resistance of the earth, that only small ranges will be obtainable.

A strata of non-conducting material below the transmitting base will tend to prevent the current passing to any depth into the earth; hence the current intensity through the surface soil will be greater, there being no alternative path.

A path of high conductivity, such as a stream between two bases, may reduce the range considerably. This is due to the fact that the lines of current flow have been short-circuited to a considerable extent.

In Plate III, if A B is a transmitting base, C D a receiving base, and E F a stream flowing between them, the current flow represented by line *a b e f* will divide at point *b*, one path being along the stream from *b* to *e* and the other along path *b c d e;* hence the strength of signals received at base C D will be considerably diminished. The base C D is not necessarily entirely screened.

Somewhat similar results are sometimes experienced in wet, boggy soils.

At first sight, it might appear that such soils, being of high conductivity, would be admirable for signalling purposes, but what often happens is that there are very high conductivity paths made by small streams, ditches, a series of puddles, or water-logged strata, etc., and the current concentrates through these paths instead of dispersing at a more equal intensity through the earth's mass.

An extreme case would be if both earths of a transmitting or receiving base were placed in a stream. The stream would have the practical result of providing a direct path back from one earth plate to the other of so low a resistance that almost the whole current would flow along it, and there would be practically no dispersion through the earth's mass.

A strata of low conductivity reaching to the surface of the ground between transmitting and receiving bases will give considerable screening effects.

The inferences to be drawn are as follows:

(i) The best results will be obtained in localities where the soil consists of a comparatively thin layer of light soil over a chalky substrata.

(ii) A thick, damp, loamy soil does not give such good results as the soil mentioned in (i), for although the soil is of high conductivity, the current flow is not confined to the surface.

(iii) Streams, and to a much lesser degree woods, metal fences and walls between transmitting and receiving bases will reduce ranges.

(iv) Only short ranges can be obtained in very sandy districts.

(v) Where the surface of the ground is broken up by shell-fire and its conductivity accordingly reduced, especially in chalky districts, ranges will be reduced.

(vi) Never put earths of either transmitting or receiving bases in places, such as a stream, which have direct high conductivity paths between them.

In order to get good results, the following points have to be considered:—

(i) The lengths of the bases.

(ii) The relative position of the transmitting base to the receiving base.

With regard to (i):—

It will be seen from Plate I that the farther apart the points *b* and *c* are, the greater will be the potential difference between them, and since the resistance of the earth lead is negligible when compared with the resistance between earth and earth plates, the greater will be the current flowing through the earth lead and the receiving apparatus.

The current intensity at any point will increase if the transmitting base is increased.

Hence, theoretically, the longer the bases the better; but practical considerations limit the base in a rear station (where facilities exist for careful preparation) to some 400 yards, and in the case of a station that is carried forward in an assault to about 100–150 yards.

With regard to (ii):

If a base were laid out with earths at points *b* and *g*, Plate I, practically no current would flow through the base, as points *b* and *g* are about at the same potential; similarly with the base laid out with earths at points *x* and *y*, Plate II.

Exhaustive experiments have shown conclusively that in order to obtain the greatest potential difference between any two earths the relative positions of the transmitting and receiving bases must be such that the imaginary straight line joining the earths of the respective bases makes equal angles with the bases, the best position being when the bases are exactly opposite and

parallel to each other. For example, in Plate IV, Figure 1, if A B is a transmitting base, the receiving base C D must be laid out so that the angle B E F is equal to the angle D F E. This knowledge is valuable for getting good results. When the direction of a transmitting base is known, it is always possible to lay out a receiving base in the best position quickly by means of a compass. As a matter of fact, it is generally possible by considering the line of advance that will be taken to lay out the two bases parallel to one another, as in Plate IV, Figure 2, but circumstances may arise, such as when two power buzzers are working to one amplifier, in which the line of advance is not at right angles to the rear base. In such cases, the two forward bases will have to be laid out at the correct angle, as described above. See, for example, Plate IV, Figure 3, where angle B E F is equal to angle E F D, and angle A E K is equal to angle E K G.

Plate V shows the results of an experiment carried out at comparatively short ranges. These results substantiate the theory described in the preceding paragraphs. Similar results have been obtained at longer ranges.

The following points should be noted:—

(i) In practice, it has happened that the rear base is generally regarded as the receiving base, and the front as the transmitting base; hence the receiving base is generally fixed and the transmitting base has to be laid out in the correct position with regard to the receiving base. The principles as enunciated above, where the transmitting base had been regarded as fixed, and the receiving base movable, are, however, applicable in cases where the receiving base is in the rear.

(ii) The impression may have been conveyed from the above that the insulated conductor joining two earth plates, *i. e.*, the earth lead, must be in a straight line. This is not so. The actual earth lead may be led into the receiving or transmitting apparatus in any way that may be convenient.

(iii) It must be remembered that resistances of earths and bases should be kept down to a minimum, as their function is to short-circuit the current passing through the earth in the case of the receiver, and to get as much energy into the earth as possible in the case of the transmitter.

A slight error in laying out bases in the correct position to one another will make no practical difference in strength of signals received. (*See* Plate V.)

II.—TRANSMITTING APPARATUS—THE POWER BUZZER.

The "Parleur" Power Buzzer, Type *2ter,* is shown in Plate VI. It consists of a specially designed spark induction coil with a laminated iron core C and a V-shaped soft iron armature A, which nearly closes the iron magnetic circuit. The primary and secondary coils of insulated copper wire are wound one over the other on one leg of the core, the whole being covered with insulating tape. The primary coil has a resistance of .25 ohm; the secondary coil has a resistance of 2.73 ohms, and the ratio of transformation is above 1.7.

The armature A is carried on a stiff spring arm B, which allows it to vibrate; this arm has screwed to it a flat piece of thin flexible steel D, on which is mounted one of the platinum contacts of the "Make and Break" at E. A variable weight W (of which a full-size view is given in Plate VII, Figure 1) can be clamped on the end of the arm. When working, the frequency of vibration (and therefore the note given out) is determined by the weight used. Three brass blocks of different weights are provided for this purpose with each Parleur, and will be found in the spare part receptacle. The second contact of the "Make and Break" is bolted to the extremity of a stiff brass arm F (Plate VI), above which, again, is another brass arm G, of stout construction, carrying the adjusting screw. The brass arms F and G are insulated from the remaining metal work by means of insulating washers at I and I_2, and an insulating collar round the bolt H at I_3. These insulating washers must be kept clean and dry; otherwise the "Make and Break" will be short-circuited.

The two microfarad condensers K_1 and K_2 are joined in parallel (making four microfarads in all), and they are joined in series with a small coil L across the "Make and Break," and tend to eliminate sparking and arcing when the break occurs. The condensers, coil, and their connections are mounted in the buzzer case underneath the key.

The "Parleur" works normally with a 10-volt battery on the primary; the secondary coil will then give about 70 volts on open circuit, but this voltage falls rapidly when a current is taken from the secondary, and is not more than 20 when the current is 1 ampere.

If a higher potential than 10 volts is applied to the primary, it is advisable to connect a resistance of about ½ ohm in series with the battery; this will prevent arcing at the interrupter con-

tacts and keep the note clear. The resistance of ½ ohm can consist of a short length of German silver or platinoid wire.

When the secondary is connected to earth leads by the terminals L, L_1, the current from it will depend on the resistance of the earths. It should be about .4 to .6 ampere; if it rises above .8 ampere, the current taken to the primary from the battery is excessive. Before the key is pressed, with the battery connected up, care must be taken to see that the adjusting screw has not been set so that the armature is clamped down on the core, thus preventing the "Make and Break"; this would practically short-circuit the battery. If one of the condensers is faulty, sparking will probably occur at the front stops of the key, and bad arcing at the "Make and Break" contacts.

A diagram of the connections is furnished in Plate VII, Figure 2.

Adjustment of the Vibrating Armature.

Connect the instrument up as for use with a 10-volt battery and connect its earth leads to two good earths. Slacken off the locking screw at the side of the top brass arm until the adjusting screw can just be turned; adjust this screw until on pressing the key a clear note is obtained; then tighten the locking screw so as to make it difficult to turn the adjusting screw.

If a clear note is not obtainable and a spluttering noise at the interrupter only is obtained, the battery voltage should be tested and then the following probable faults investigated:

(1) The line may be broken.
(2) The earths may have too high a resistance, owing to bad contacts or loose connections in the earth leads.
(3) A lower contact blade of the wrong frequency may have been fitted.
(4) The condenser may be faulty.

Adjustment of the Note.

(*a*) Fixed Note Parleur, Type No 2,

There are two types of this Parleur (1) with a frequency of 500 periods per second, (2) with a frequency of 800 periods per second. The note frequency is stamped on the adjusting screw arm of each instrument, and it is important to remember that the lower contact blades are not interchangeable—the contact blade for a 500-period instrument will not suit an 800-period one, and *vice versa.* Using the wrong type of contact blade will only cause bad working of the instrument.

(*b*) Variable Note Parleur, No. 2^{ter} Type.

The note is set by securing one of the special blocks (Plate

VII, Figure 1) on the slide of the vibrating armature. The nut must be tightened up with the spanner provided.

There are three blocks with each instrument, two small and one large, and the following frequencies are obtainable:—

With	no block	About 800
"	one small block right on	" 750
"	one small block just on	" 600
"	two small blocks just on	" 500
"	one large block right on	" 450
"	one large block just on	" 350
"	one large and one small block right on	" 300

Battery.

The standard battery for use with the Parleur is the Fuller Block, Type B L, 10-volt battery, with a capacity of 20 ampere-hours and weighing 26½ pounds.

More than 10 volts may be used, and 14 volts will give stronger signals; 20 volts will probably cause arcing at the contacts unless a resistance of about ½ ohm is connected in series with it. This arcing will destroy the note and reduce the energy put into the earth base.

The capacity of the Fuller Block Battery is sufficient to give continuous transmitting for 6 to 8 hours; this means that for signaling purposes it would have a life of from 72–96 hours.

III.—RECEIVING APPARATUS—THE AMPLIFIER.

The apparatus employed for receiving signals from the power buzzer is known as an "amplifier." The amplifier magnifies the strength of the incoming signals in a very high degree, and it is entirely due to this that signalling by power buzzer becomes a practical method.

The amplifier depends for its magnifying properties upon the valve. Currents which are picked up by earths and earth leads acting on the valve affect a local circuit consisting of a local battery and a pair of telephones which are connected to the valve. Inside the bulb of the valve (Plate VIII, Figures 1 and 2) are three elements—the plate A, the grid B, and the filament C.

The filament consists of a straight, very fine tungsten wire between two supports; the grid, a spiral of wire, is supported around it; and around the grid is the plate—a small cylinder of metal.

During the process of manufacture, air is pumped out of the bulb and a very high vacuum is reached. When the filament is brought to a high state of incandescence in this vacuum, if a

difference of potential is applied between the plate and filament, an electric discharge will take place from the filament to the plate; that is to say, a current will flow through the space between them. For example, in Plate VIII, Figure 3, where A, B, and C represent the plate, grid, and filament, respectively, D an accumulator for heating the filament, and E an H.T. battery, under the conditions referred to above, a current of a few milliamperes will flow along the circuit, *a b c d*, crossing the gap *b c*.

The relay action of the valve depends upon the grid, which will take up a certain difference of potential in relation to the filament while a current is flowing between *b* and *c*.

If the difference of potential is altered by external means, the value of the current flowing between these points will be altered. This alteration in potential is brought about by connecting up the grid and filament to the earth leads and earths of a receiving station. It is not practicable to connect up the earth leads directly to the filament and grid, but it can be done indirectly by means of a transformer, as shown in Plate IX, Figure 1, where *g h e f* represent a transformer, and the earth leads are connected to the terminals *g h* of the primary coil.

When a current flows through the earth leads and the primary of the transformer, the difference of potential between *g* and *h* is transformed to a still higher potential between *e* and *f;* that is to say, between the grid and filament.

The energy from the transmitter (*i. e.*, the power buzzer) takes the form of a series of impulses varying from 800 to 500 per second, according to the frequency of the power buzzer used; hence changes of potential difference between the grid and filament of the valve at this frequency, and, therefore, in the current strength of circuit *a b c d* are experienced.

Owing to the peculiar properties of the valve, the changes in current value in the latter circuit are greatly magnified, and are out of all proportion to the changes in value of the current picked up in the earth leads and passing the primary coil of the transformer.

By the introduction of a telephone in circuit *a b c d*, signals transmitted by power buzzer can be heard which would be quite inaudible without the amplification provided by the valve.

The ranges obtainable by the use of one valve only would be so small as to be impracticable, and therefore the signals obtained by the first valve are amplified by additional valves. Plate IX, Figure 2, shows how this is done. A transformer is inserted in the place of the telephone shown in Plate IX, Figure 1, and any variation in current strength in circuit *a b c d* is transformed to and magnified in *l m n o*. A third valve is introduced in the same

manner. In practice, the greatest number of valves that can be used is three.

The resistance required in the primary of the transformer *g h e f*, to give the best results, varies according to the resistance of the earths, and consequently it has been found advisable to provide tappings off the primary coil. Generally speaking, the same tapping will give the best results in any given locality.

It will be noted that in Plate IX, Figure 2, separate L.T. batteries for the filaments and H.T. batteries for the plates have been shown. This is not necessary, and a general diagram of amplifier connections is shown in Plate X.

At present there are several types of amplifiers in the service, which can be divided into two classes, English and French manufacture.

Those of English manufacture are the C. Mk. I. (a 2-valve amplifier) and the C. Mk. II. (a 3-valve amplifier). A third type, C. Mk. III., will shortly be introduced.

French amplifiers are of three types, one 2-valve and two 3-valve amplifiers.

The essential difference between the French and English types is that many of the 3-valve French amplifiers are provided with a special switch, marked H.F. and L.F. This switch must always be in the L.F. position for power buzzer-amplifier work.

The French amplifiers are not fitted with tappings off the primary coil of the first transformer, but tappings are provided in the C. Mk. I. and C. Mk. II. Instruments.

Some of the French 3-valve amplifiers are, however, provided with three line terminals; the two terminals that should be used for power buzzer working are marked T.P.S.

The C. Mk. I. and C. Mk. II. amplifiers require low-resistance (60 ohms) telephones, while the French amplifiers require high-resistance telephones.

There is another type of amplifier, of French design, which is obsolescent and is very large compared with the others. It is now only used for listening posts.

A 4-volt secondary battery is required for heating the filament, and an H.T. battery or about 60 volts for the plate filament circuit.

At present there are several types of H.T. batteries in the service, varying from a large 70-volt battery made up of X cells to a very small one of 100 volts consisting of 79 very small Ever Ready cells.

For working the amplifier, the only adjustments required are varying the strength of current through the filament, and hence the filament temperature, and the regulation of the high-tension voltage across the plate and filament. The former is done by

means of a stud resistance and the latter by plugging in different voltages.

In the case of the C. Mk. I. and C. Mk. II. amplifiers, there is the third adjustment of regulating the value of the primary of the first transformer. This is done by means of a stud switch.

To obtain best results, valves require a certain value of filament current in conjunction with a certain value of H.T. voltage. If increased above these values, the amplifier becomes very noisy; if reduced below these values, considerably less amplification is obtained.

Valves vary slightly with regard to best values.

It is to be noted, however, that signals will be heard at almost any position of the filament current resistance switch, but they can be very greatly improved by adjustment.

Generally, a pressure of about 60 volt H.T. will give good results.

Valves should always be inspected to see that neither filament, grid, nor plate are in contact.

A 4-volt, 60-a.h. battery has a life of about 24–36 hours.

IV.—BASES.

(i) *Earths.*

Any clean metallic conductor driven into the ground soil is suitable for an earth plate. It must be remembered that the current which will flow into the earth from the secondary of the power buzzer depends not only on the resistance of the earth base, but also on the resistance between the earth plates and the earth; to keep this resistance low, it is always advisable to use several contacts in parallel with each other rather than one contact at each end of the base.

Steel pins or bayonets make suitable earth contacts; at least three of these (the usual number is four) should be connected together by copper wire (R.4) and driven into the ground not less than 2 feet apart, the line of pins or bayonets being at right angles to the earth base, as shown in Plate VII, Figure 3. Watering the earth around the earth pins with a solution of common salt will improve them greatly.

In cases where time permits, very good earths can be made by means of:—

(1) Biscuit or petrol tins with bare copper leads threaded through holes or soldered to the tins.
(2) Shell cases with copper leads soldered on.
(3) Earth pipes well watered.
(4) Wire netting well covered up and trodden in.

Experiments have been carried out to find the resistance be-

tween various types of earth contacts on an earth base 100 yards long. At the time the experiments were made the ground was damp and 4 inches of snow lay on it. The measurements of resistance were made by a Bridge Megger and by a battery and millimeter. The results were as follows:

Nature of earth contact	Resistances in ohms		
	By millimeter	By Megger	Average
(*a*) 1 bayonet in fairly damp ground.....	444	469	456
(*b*) 2 bayonets 1 yard apart.....	260	264	262
(*c*) 3 bayonets 1 yard apart.....	190	184	187
(*d*) 1 earth mat buried 4 feet deep in very damp ground. Size of mat, 12½ feet by 2 feet.....	89.7	88	89
(*e*) 1 4-gallon petrol tin buried in fairly damp soil.....	318	347	333
(*f*) as in (*e*), but with very damp ground..	235	257	246
(*g*) 1 bayonet in ground much wetter than that used in (*a*).....	417 444 } 450 488	435 469 } 460 474	455

(ii) *Earth Leads.*

As stated above, the longer the base the better, but practical considerations limit the length of the base of the forward station to about 100 yards, owing to the difficulties of transport and maintenance of any greater length of earth lead.

At the forward station one earth is invariably placed quite close to the apparatus, while the other is placed some distance away, the base thus being formed by one long length of earth lead. This arrangement facilitates laying out and also maintenance, as in order to inspect the earth lead a man need only go out in one direction.

With regard to the rear station the case is different; generally speaking, there is time available to install the station with a considerable amount of care.

Bases up to 300 yards in length can therefore be used.

Earth leads should be buried or laid at the bottom of deep trenches. New cable should be used, as the insulation must be good.

D.5 or R.5 cable should be used as earth leads.

(iii) *Laying Out Bases.*

Theoretically, bases should be laid out as follows:

Case (*a*).—The simplest case is when one power buzzer is working to one amplifier, and the exact position where the power buzzer will be installed is known; the bases will then be laid

out as in Plate XI, Figure 1. Where A B is the power buzzer base and C D the amplifier base, *i. e.,* bases will be parallel to each other, with the line from the center of the amplifier base cutting the center of the power buzzer base at right angles.

Case (*b*).—Occasions may arise when the amplifier base has been installed, and it is found necessary to send the power buzzer out to a flank and not straight ahead. In these cases the power buzzer should be laid out as in Plate XI, Figure 2, where *f* is the point where the power buzzer is to be installed and *e f* is the line of advance.

The power buzzer base must be laid out so that angle D *e f* is equal to angle *e f* B.

Case (*c*).—Two power buzzers working to the same amplifier bases should be laid out as in Plate XI, Figure 3, where Q R is the second power buzzer. Here the angle D *e f* must be equal to the angle *e f* B, and the angle C *e g* must be equal to the angle *e g* Q.

Practically, unless the direction of advance is more than 30 degrees to a flank, the bases can be laid parallel to each other without much loss of efficiency.

The best method is to lay out several earths at the rear station. By the use of a commutator any pair of these earths can be used. Plate XI, Figure 4, shows such an arrangement; a base with earths A and B or A and C or B and C can be employed.

A similar but more elaborate arrangement is shown in Plate XI, Figure 5.

In either of these arrangements, if the forward party are instructed to lay out their base at right angles to their line of advance, it is always possible to find a good pair of earths to receive them on.

This system of multiple earths at a rear station is also very convenient for getting rid of interference from other power buzzers, as a selection can be made of the best base for the power buzzer it is desired to receive from which will probably not be the best for the interfering power buzzer.

The system is also very useful for keeping up flank communications.

Only one pair of earths should be used at any one time. Reception or transmission should never be carried out with several earths bunched together.

V.—RANGES.

Nothing definite can be laid down with regard to ranges, as they depend upon the nature of the soil.

In districts where the ground consists of a surface soil over

a substrata of chalk, reliable signalling has been obtained over ranges of 4 to 5 kilometers.

The range can only be settled by actual trials in the district. As a general rule, if no local information is obtainable, 2,000 yards may be taken as the maximum range, when using 100-yard bases at the forward station, and 150-200-yard bases at the rear station. It is safer to reduce this range.

It should be noted that an amplifier receiving from a power buzzer will be influenced by any earth currents which flow between its earth plates. Such currents may be from leaky telephone or power lines, or from wireless sets in the neighborhood. In order, therefore, to read the power buzzer signals through jamming, it may be necessary to get the power buzzer signals very loud by reducing the range.

VI.—COMPASSES.

Compasses are provided with power buzzer-amplifier sets to assist in the correct laying out of bases.

Different patterns are being used, but the principle is the same.

To lay out a line at any desired angle in the case of the French-pattern compass, which can be distinguished by its fixed luminous-headed arrow over the dial, proceed as follows:—

Suppose it is desired to lay out a base running in N.E.-S.W. direction. Move the dial by means of the milled ring until the fixed arrow head is on the N.E. line, then move the whole box until the N. point of the needle (the end painted with luminous paint) is on the N. point of the dial, *i. e.*, midway between the two luminous-painted dots; the length of the compass box with its lid open will give the N.E.-S.W. line.

VII.—PREPARATION OF A POWER BUZZER STATION, OR POWER BUZZER-AMPLIFIER STATION, FOR AN ASSAULT.

(i) *A Parleur Power Buzzer Station* requires the following stores:—

(*a*) Parleur power buzzer.

(*b*) Battery—10-volt.—20 ampere-hour capacity. Fuller block, Type B L.

(*c*) 2 battery leads, each 24 ins. long, of U.3, R.5 or other high conductivity cable.

(*d*) Reel cable, No. 2, with 100 yards of D.5 or R.5 cable.

(*e*) 12-ft. length of D.5 or R.5 cable for local earth connection.

(*f*) 20 ft. R.4 wire for earth pins.

(*g*) 8 earth pins or bayonets with terminals.
(*h*) Tin of insulating tape.
(*j*) Watch.
(*k*) Mallet.
(*l*) Compass.
(*m*) A forms.
(*n*) Pencils.
(*o*) Map.
(*p*) Satchel.

Extra Stores.

The following stores should be available as spares, etc.:—

(*a*) 1 or 2 10-volt. batteries fully charged.
(*b*) Reel cable, No. 2, with 100 yds. D.5 or R.5 cable.
(*c*) About 10 yds. of R.4 cable.
(*d*) Spare earth pins.

The object of the extra D.5 or R.5 cable is not only to replace damaged cable, but also to lay out more bases; it may be necessary to get into communication with a more forward station or one on a flank, in any case, it is desirable to have duplicate bases.

Personnel Required.

A power buzzer detachment will consist of three men. No. 1 is an N.C.O., if available; Nos. 2 and 3 are operators. It is their duty to keep in touch with the officer in charge of the party. In an advance it may be necessary to increase this personnel so as to provide against casualties, and ensure that the apparatus will all arrive forward.

No. 1 is in charge, and will keep constant watch to see that the earth base leads are in good condition. Nos. 2 and 3 will relieve each other at frequent intervals.

Preparation and Making Up of Stores.

The battery leads should be connected to the power buzzer terminals, the other ends being cleaned and ready for connection to the battery. The leads can then be tied to the carrying strap of the buzzer.

Prepare the main "earth" as follows:—

Connect 4 earth pins to an 8-ft. length of R.4 bare copper wire at 2-ft. intervals; at each earth pin a clove hitch should be made in the wire, passed over the stem of the terminal, and pulled down tight, the terminal nut being then screwed down tight on it with a pair of pliers.

The free end of the R.4 wire should then be sweated and secured to one end of the R.5 or D.5 cable shown in Plate XII, Figure 1. The other end of the R.5 or D.5 cable should be bared

and passed through the hole in the cheek of the reel and secured either by tying it to the cleat on the outside of the cheek or by simply tying a knot in it so that it cannot pass back through the hole.

The cable should then be wound tightly on the reel to within 8 yards of the outside end (*i. e.*, that to which the R.4 wire is attached); at this point it should be secured by means of a clove hitch to the handle of the reel; the last two or three turns round the reel should be secured by string to prevent them slipping; the string should not be too strong to prevent the turns being broken out by means of a jerk.

The earth pins should then be bundled together and the 8-yards length of R.5 cable leading from the reel should be tightly and neatly bound round them and finished off with three half hitches. For convenience in unreeling, a spindle for the reel must be improvised; a short length of round iron as shown in Plate XII, Figure *2*, is suitable.

Prepare the local "earth" as follows:—

Connect up the earth pins to an 8-ft. length of R.4 cable and secure this to the 12-ft. length of R.5 or D.5 cable, these connections being made similarly to those described in the preceding paragraph. The whole of the 12 feet of the R.5 or D.5 should then be wrapped round the pins as shown in Plate XII, Figure 3. The free end of the R.5 or D.5 should be bared and cleaned ready for connecting to the buzzer.

Method of Carrying the Apparatus.

A convenient method of distributing the apparatus for transport by the three men who comprise the personnel is as follows:—

No. 1 carries the power buzzer, with battery leads connected to it. In a satchel, he carries the compass, watch and insulating tape, also one pad of A forms, two pencils and a map (weight of load about 12–14 lbs.).

No. 2 carries the main "earth" (consisting of leads on reel and four earth pins), the local "earth" (consisting of 12 ft. of D.5 cable and four earth pins) and mallet (weight of load about 12 lbs.).

No. 3 carries the 10-volt battery (weight of load about 23 lbs.).

(ii) *A Parleur Power Buzzer-Amplifier Station requires the following stores:*

(*a*) Power buzzer.
(*b*) Amplifier.
(*c*) Change-over switch with leads attached.
(*d*) Portable H.T. Battery.
(*e*) Two Power Buzzer Battery leads, each about 24" long.

(*f*) Two Amplifier Battery leads, each about 24" long. These should be carried inside the Amplifier box, connected up to their terminals.
(*g*) Eight earth pins.
(*h*) Twenty feet of R.4 wire.
(*i*) Reed cable No. 2, with 100 yards of D.5 or R.5 wire.
(*j*) 12 feet of R.5 or D.5 cable for local earth connections.
(*k*) One 10-volt battery, Fuller block.
(*l*) One 4-volt battery (40–60 amp. hour capacity).
(*m*) Twelve porcelain or rubber insulators.
(*n*) Five yards of spare battery lead.
(*o*) Mallet.
(*p*) Compass.
(*q*) Watch.
(*r*) Tin of insulating tape.
(*s*) Spare valve box.
(*t*) Two pairs of telephones and telephone leads.
(*u*) Telephone bag.
(*v*) Satchel.
(*w*) A forms.
(*x*) Pencils.
(*y*) Map.

Extra stores are as follows:—

(*a*) Four-volt batteries ... 3
(*b*) Ten-volt batteries ... 2
(*c*) Commutator 1
(*d*) No. 1 reel with 200–250 yards of D.5 or R.5 cable.

Earth pins and cables are made up exactly in the same way as for the power buzzer station.

Personnel Required.

A power buzzer-amplifier detachment will consist of one N.C.O. and four men.

Method of Carrying the Apparatus.

No. 1 carries power buzzer (with battery leads), and satchel containing compass, watch, insulating tape, pad of A forms, pencils, map, and spare lead (weight of load 12–14 lbs.).

No. 2 carries main and local "earth" made up as described above, and mallet (weight of load about 12 lbs.).

No. 3 carries 10-volt battery (weight of load about 23 lbs.).

No. 4 carries 4-volt battery and 12 insulators (weight of load about 23 lbs.).

No. 5 carries amplifier (with battery leads), spare valve box, telephone bag, change-over switch and H.T. battery (weight of load about 24 lbs.).

NOTE.—Extra stores should be sent up in both cases about 10 hours after the forward station has been established.

VIII.—METHOD OF LAYING OUT STATIONS.

(i) *Power Buzzer Station.*

On arrival at the spot chosen for the station, No. 1 puts down the power buzzer, Nos. 2 and 3 place the 10-volt battery and local earth alongside it.

No. 1 determines by compass or otherwise the suitable direction of the earth base and points it out to No. 3. He then connects up battery and base leads to the power buzzer.

No. 2 drives in the local earth pins with the mallet, and then hands the latter to No. 3. He then takes up the base reel, handing the earth pins to No. 3. He holds the reel until the base lead is all run out when he hands the end of it to No. 1.

No. 3 takes the mallet and earth pins of the base lead from No. 2, and doubles off with them in the direction given by No. 1; when the base lead is fully run out he drives in the earth pins and returns to the station.

After the station is all connected up, No. 1 will test the power buzzer to see that all is correct, a clear note obtained, and a good current reading in the ammeter. He then reports to the officer in charge that the power buzzer is ready.

(ii) *Power Buzzer-Amplifier Station.*

Procedure is exactly the same as above; Nos. 4 and 5 putting 4-volt. battery and amplifier beside the power buzzer and assisting No. 1 to connect up.

IX.—PRECAUTIONS TO BE TAKEN.

(1) Do not bare the ends of the battery or base leads more than is necessary to make good connections with the terminals.

(2) Do not connect the battery leads to the battery first; the free ends are likely to touch and short circuit the battery.

(3) The D.5 or R.5 cable used for base leads must be in good condition; if the ground is very wet, there may be a leakage along the cable; this shortens the base and reduces the range.

(4) After the station has been started and the spare stores got up, duplicate bases can be arranged, longer or shorter than 100 yards according to the ascertained requirements as regards strength of signals and maintenance respectively.

(5) See that the insulating washers, I_1 and I_2 in Plate VI, are kept clean and dry, otherwise the make and break will be short circuited.

(6) Occasionally, change round the battery connections so that one terminal on the buzzer is not always positive; this will tend to give more uniform wear of the "Make and Break" contacts.

(7) It is essential that the stores required and the mthods of preparation and transport should be supervised by a responsible officer before the party sets out to carry the station forward.

X.—HINTS ON USE OF POWER BUZZER AND AMPLIFIER.

(1) *Power Buzzer.*

(*a*) Contacts must be clean and their surfaces must be even and parallel to each other; for truing up contacts, it is best not to use the file provided for the purpose, but to remove the contacts from the instrument and rub them gently over a piece of emery cloth laid on a flat surface.

(*b*) Before connecting up power buzzer to its battery be sure that the contacts are not actually touching.

(*c*) The French Parleur should give a clear note; a broken note indicates high resistance in the circuit caused by a broken base or very high resistance earth. A good, clear note suddenly changing to a broken note indicates that the base has been cut.

(2) *Amplifier.*

(*a*) Keep the amplifier insulated from the ground by resting it on porcelain bobbins or rubber feet.

(*b*) Keep the leads connecting amplifier to H.T. battery and sceondary battery as short as possible.

(*c*) The amplifier sometimes tends to howl; if this happens first see that all terminals are screwed up tight, or plug and socket connections are making good contact. Try touching the different terminals of the instrument in order to get rid of any static charge. If matters are not improved, remove the valves and slightly open the forked plugs; try changing valves round.

(*d*) There is always a certain amount of noise going on in an amplifier even if no signals are being received; if everything is quite silent there is something wrong; if one of the valves is tapped with the finger a noise should be heard in the telephones.

(*e*) Do not force valves into their sockets; they go in quite easily if put in the right way; when once inserted push them right home.

(*f*) All the valves in an amplifier must be burning.

(3) *Telephones.*

Faulty telephones are very often a cause of failure; always examine telephones and see that:

(i) Cords are firmly secured to and making good contacts with the telephones.

(ii) Conductors of the cords are not broken at telephone terminals.

(iii) Brown telephones have a milled screw for adjustment on the back; sometimes this gets screwed up tight, and, consequently, no signals are received. In such cases the milled head should be turned until a sharp click is heard; it should then be slightly turned in the other direction, adjusting for best signals.

(4) *General.*

All connections between power buzzers and secondary batteries and between amplifiers and H.T. and secondary batteries should be of high conductivity. Cable such as D.5 should not be used for these purposes.

All connecting leads should be cut to length, ends bared, and conductor cleaned all ready for connecting up; the insulation should be removed only sufficiently so as to be able to get the bare copper conductor round terminals quickly and easily. Everything should be as tidy as possible. Avoid unnecessary length of connecting leads.

Always see if contact surfaces of terminals are bright and clean; also that when connections are made that terminals are screwed up finger tight.

It is always worth while to examine the terminals and connections of the individual cells in the battery to see that they are tight.

Earth pins must be kept clean and free from rust.

Experience has shown that the value of power buzzer communication is enormously increased if an amplifier and power buzzer are provided at each station, so that two-way communication can be maintained; a reply to a message gives confidence, this is lacking in one-way working. Two-way working necessitates carrying forward more stores; in practice, it is really just as easy to get an amplifier forward as well as a power buzzer, if a little trouble is taken.

As a general rule, therefore, two-way working should always be aimed at.

Very great care should be taken in establishing the rear station.

The apparatus should be installed in a dugout; the various instruments and apparatus should be carefully arranged; wiring should be kept as neat and tidy as possible. Secondary batteries and high tension batteries should be kept insulated from the ground.

It is always worth while, after a rear station is installed, to test it out by transmitting to it from the rear, at a range similar to that which may be expected when an advance is made.

Cable forming bases should be buried, and great care should be taken in obtaining good earths.

Power buzzer ranges depend entirely on the soil. The ranges that can be relied upon can only be learned by actual experience and trial in any area.

With a 50–100 yard base, a D.3 telephone buzzer will give good signals on an amplifier up to some 500–700 yards.

It is quite possible to get through on a broken telephone cable with a power buzzer and amplifier by simply connecting up power buzzer or amplifier in place of the D.3 telephone.

A station should never be installed near any screening object, such as a wood.

The screening effect of any such object is very less marked the farther it is possible to get away from it. Better signals will be received by withdrawing some 200–300 yards from a wood, although the range is increased, than installing a station right on an edge of it.

If flat surface, such as opened out petrol tins, are used as earths, they should be placed vertically, with their surfaces towards the direction it is desired to transmit to, or receive from.

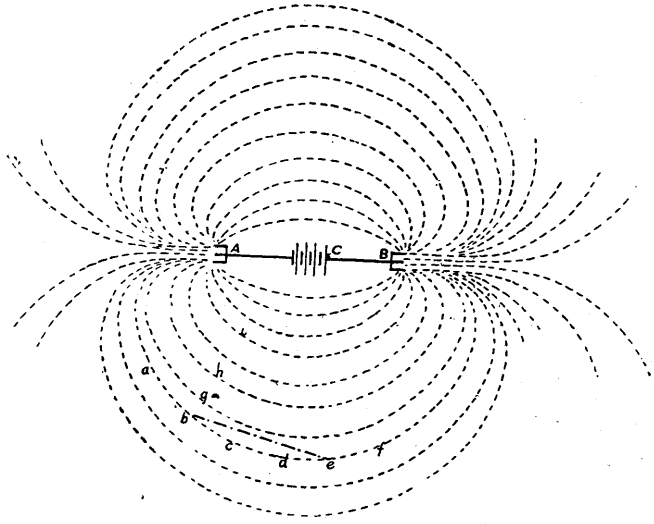


PLATE I.

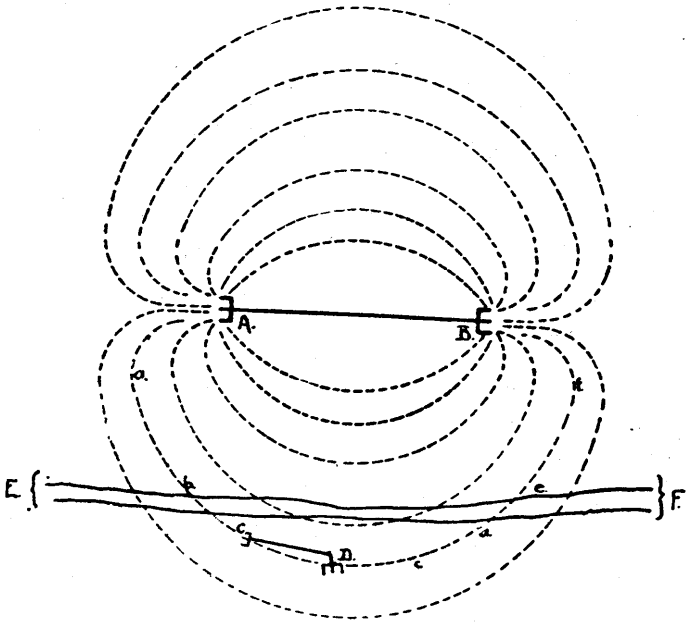


PLATE III.

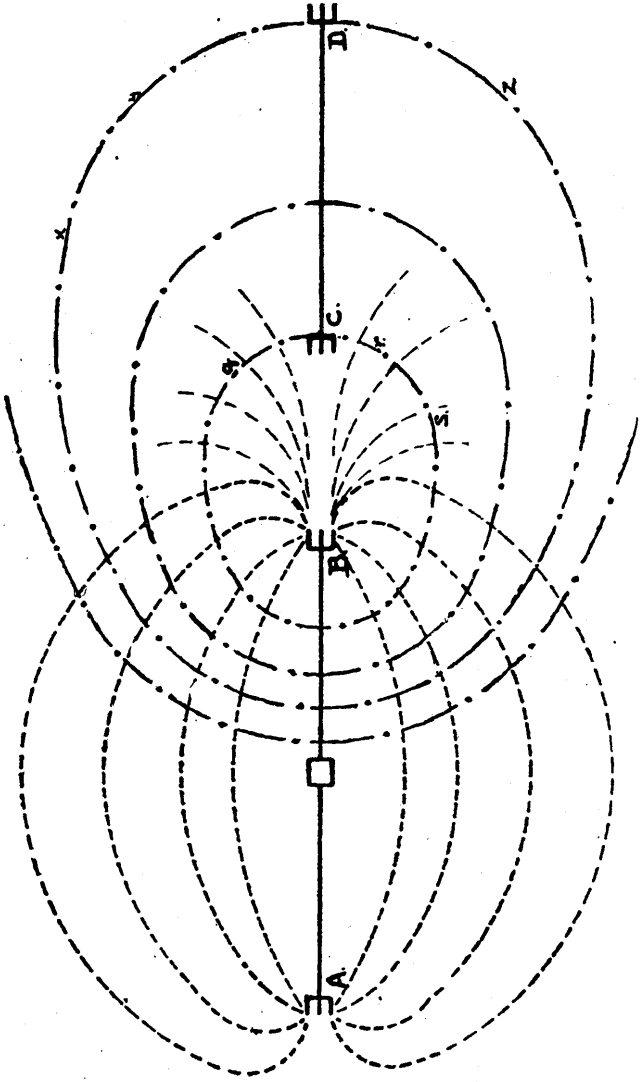


PLATE II.

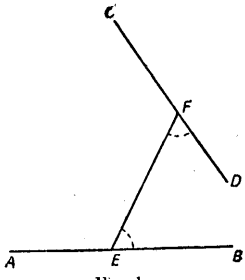


Fig. 1.

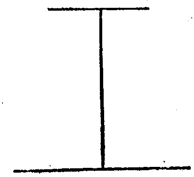


Fig. 2.

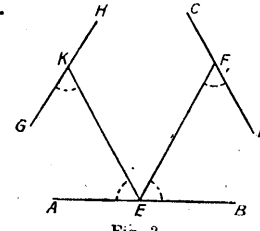


Fig. 3.

PLATE IV.

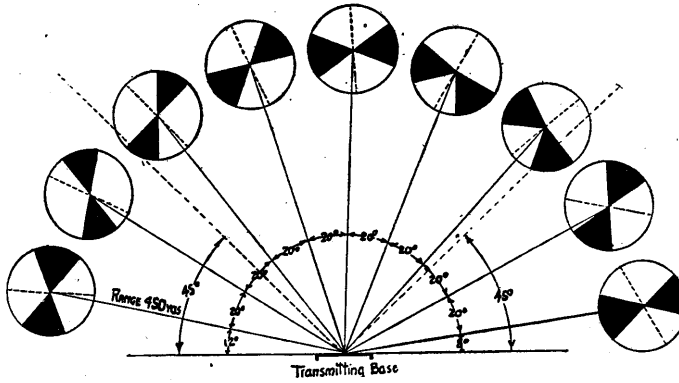


PLATE V.

Black Areas: Good Signals.
Dotted Lines: Min. "

Circuits :
Primary
Secondary
Condenser
L
K1
2 mfd
K2
2 mfd
+
-
Adjusting Screw
Primary and Secondary Coils
L
L1

PLATE VI.

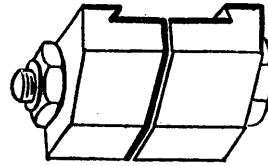


FIG. 1.

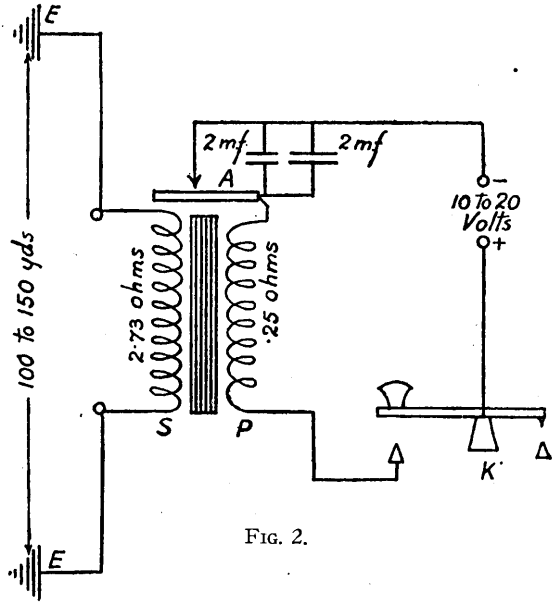


FIG. 2.

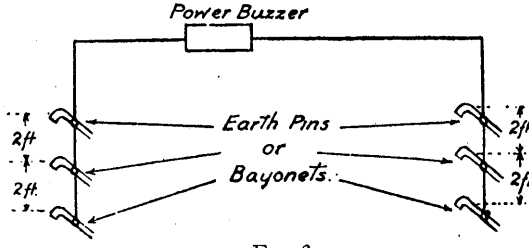


FIG. 3.

PLATE VII.

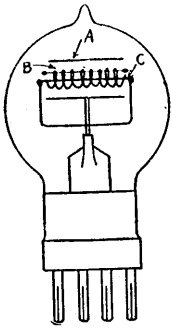


FIG. 1.

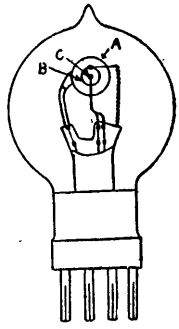


FIG. 2.

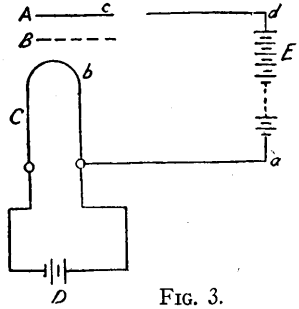


FIG. 3.

PLATE VIII.

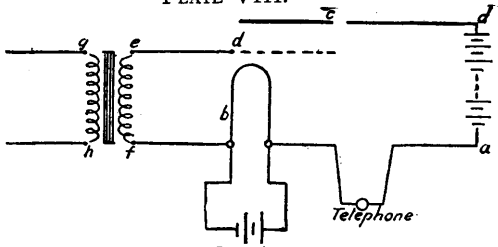


FIG. 1.

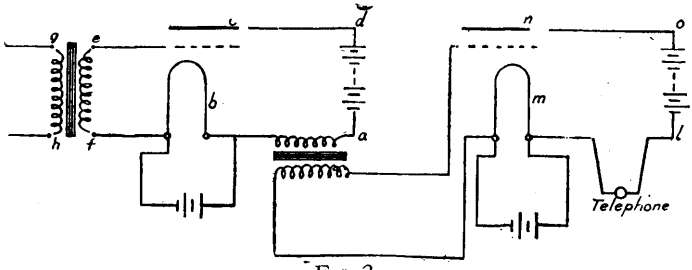


FIG. 2.

PLATE IX.

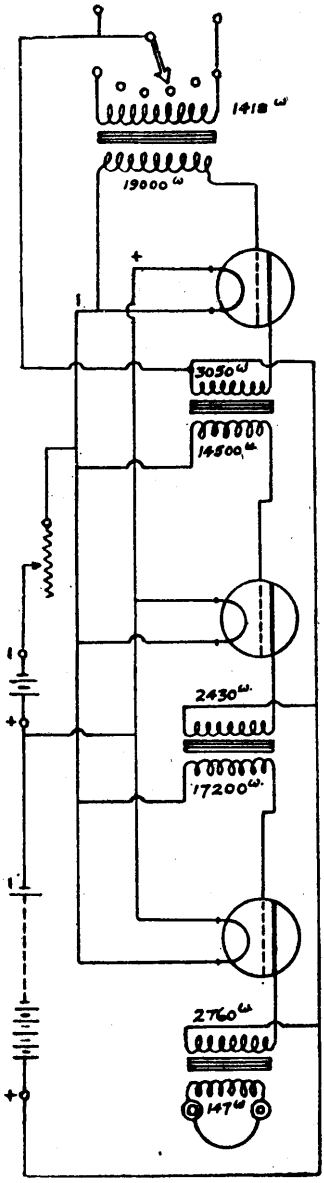


PLATE X.

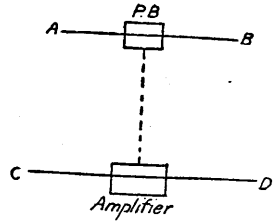


FIG. 1.

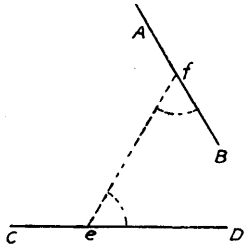


FIG. 2.

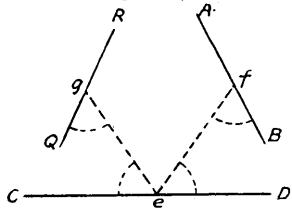


FIG. 3.

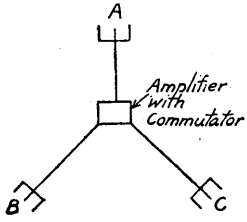


FIG. 4.

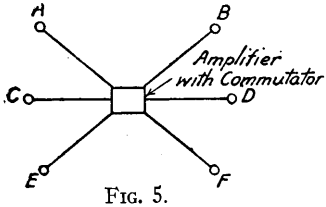


FIG. 5.

PLATE XI.

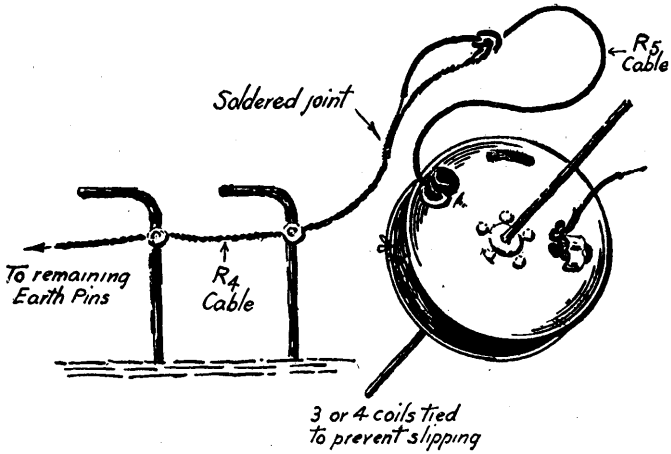


FIG. 1.

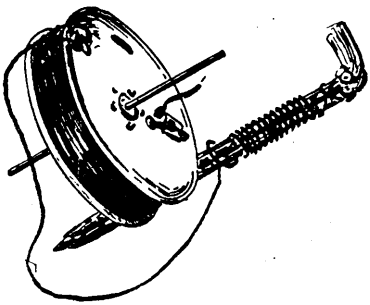


FIG. 2.



FIG. 3.

PLATE XII