FWO

INSTRUCTIONS
FOR
FITTING UP THE
STANDARD 1½ K.W. MARCONI W.T.
INSTALLATION IN ROYAL FLEET
AUXILIARIES

1914.

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INSTRUCTIONS

FOR

FITTING UP THE STANDARD 1½ K.W. MARCONI W.T. INSTALLATION IN ROYAL FLEET AUXILIARIES.

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1914.

INTRODUCTORY.

The following instructions have been prepared for the guidance of officers responsible for the fitting up of the Standard $1\frac{1}{2}$ k.w. Marconi W.T. Installation in Royal Fleet Auxiliaries.

Though the installation is exactly the same as that supplied to merchant ships, additional instruments have been provided, so as to enable Royal Fleet Auxiliaries to communicate, if necessary, with H.M. Ships on a 1,000-metre wave. These additional instruments would only be joined up for use when actually required.

The arrangement of the W.T. office in Royal Fleet Auxiliaries differs from the arrangement of W.T. offices in merchant ships in the following respects :—

(*a*) Reception takes place inside a silent cabinet, and all the transmitting instruments are placed on a bench outside the cabinet. In merchant ships the arrangement is just the reverse.

(*b*) The rotary converter is placed in a convenient position below the waterline, leads being brought up from it to the W.T. office. In merchant ships the rotary converter is accommodated in the silent cabinet.

2. A general description of the instruments and their method of working is included, for the information of the wireless operator, together with instructions to assist him in making good possible defects when other assistance is not available.

3. Certain of the diagrams and some of the descriptions of instruments and circuits have been taken from "Handbook of Technical Instruction for Wireless Telegraphists," Hawkhead, with the concurrence of the Marconi Press Agency, Limited.

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CHAPTER I.

The following ships are fitted with the Marconi standard $1\frac{1}{2}$ k.w. W.T. installation :—

"Petroleum."
"Burma."
"Mercedes."

In these vessels, the transmitting gear is enclosed in the silent cabinet, together with the rotary converter, reception being done at the bench in the office.

Present arrangements allow of additional vessels being fitted at a later date, and the instruments will be installed in such vessels so as to conform with the details given in this handbook.

Position of the Office.

The position selected for the W.T. office must satisfy the following requirements :—

(*a*) It must permit of a suitable lead being taken to the aerial.

(*b*) It must be as far away as possible from sources of noise.

(*c*) It must permit of suitable earth leads being taken from the office to the hull of the ship.

(*d*) It must admit of adequate ventilation, and not be subjected to great heat.

The minimum size of office is 9 feet long, 8 feet wide, and 7 feet 6 inches high, internal dimensions.

In ships having the old arrangement of office, viz., "Burma," "Mercedes," and "Petroleum," the office is 9 feet long, 6 feet 6 inches wide, and 6 feet $9\frac{1}{2}$ inches high.

Arrangements inside the Office.

All ships, with the exception of the three vessels mentioned previously, are provided with a silent cabinet, having external dimensions, 4 feet 2 inches wide, 4 feet 2 inches broad, and 7 feet 2 inches high.

Bench in Office outside the Cabinet.

The transmitting instruments are placed on and over a bench, under which is a shelf for the transformer. The bench is made of 2-inch teak, and is 4 feet 3 inches long, and 3 feet 1 inch wide. It must be so fitted that there is a clearance of 1 inch between its end and the silent cabinet.

The space overlooking the bench is provided with a 1-inch wooden lining, to facilitate mounting the instruments.

Frame Doors.

In order to prevent any person receiving a shock accidentally, two wooden frame doors, fitted with iron wire netting, are fixed at the sides of the bench, so that when closed no instruments in the high tension or oscillatory circuits are accessible.

Instrument Board.

All starters, switches and recording instruments are mounted on an instrument board, 4 feet 6 inches high by 3 feet 6 inches wide, situated opposite the door of the silent cabinet, so that they are within view of the operator.

Communications.

A navyphone is provided for communication between the wireless office and the bridge.

Ventilation.

A circulator with intake and exhaust arrangements is fitted, for supplying fresh air to the operator in the silent cabinet.

Minor Fittings.

A cupboard is provided under the instrument board, for the stowage of spare gear.

Earths.

Four earthing terminals, fitted in the deck over the office, and equally spaced at a radius of 6 inches round the deck insulator, provide the necessary earths for the transmitting and receiving instruments.

General Description of the Installation.

Alternating current is supplied from a $1\frac{1}{2}$ k.w. rotary converter, placed in a convenient position away from the W.T.

office. The rotary converter can be started, and its speed adjusted, by means of a starter and field regulator in the W.T. office.

From brushes bearing on the slip rings of the rotary, alternating current is led inside the W.T. office to the lower portion of the main switch on a switchboard, termed the "Iolanda switchboard." This instrument is mounted on the instrument board, and on it are situated an indicating lamp for showing when the A.C. circuit is complete, an A.C. ammeter, an A.C. voltmeter, and two fuses, one in each main.

From the lower ends of these fuses, leads are taken so as to supply a transformer, a low frequency iron core inductance, both of which are situated under the bench, and a morse key, situated in the silent cabinet. These instruments are connected in series. In shunt with, and close to, the morse key, is a magnetic relay key, whose duty is to assist in ensuring a clean break at the morse key, during rapid transmission. The high tension leads run from the secondary terminals of the transformer, which is oil cooled, through bench insulators to choke coils, and thence to either side of the spark gap.

In series with the spark gap is an adjustable primary inductance, the primary of a jigger, which is not adjustable, and the transmitting condenser, which is capable of giving values of ·016 microfarad to ·065 microfarad, *i.e.*, 14 to 58 jars, the dielectric in use being glass. For the transmission of the 1,000-metre wave, an additional adjustable primary inductance, having a larger value, can be substituted for the usual sliding inductance.

The aerial, which will usually take the form of two single silicon bronze wires, is connected to the top of a "leading-in" insulator. The lower end of this insulator is connected to one side of an aerial tuning inductance, which in turn is connected in series with a second and similar inductance. This latter instrument is in connection with the secondary of the jigger, whose free terminal is connected to earth, through an earth arrester spark gap, situated in the silent cabinet. The jigger and the aerial tuning inductances are enclosed in wooden boxes so that the contents cannot be seen, but the amounts of these instruments in use can be altered by means of plugs and socket connections on the outside of the box.

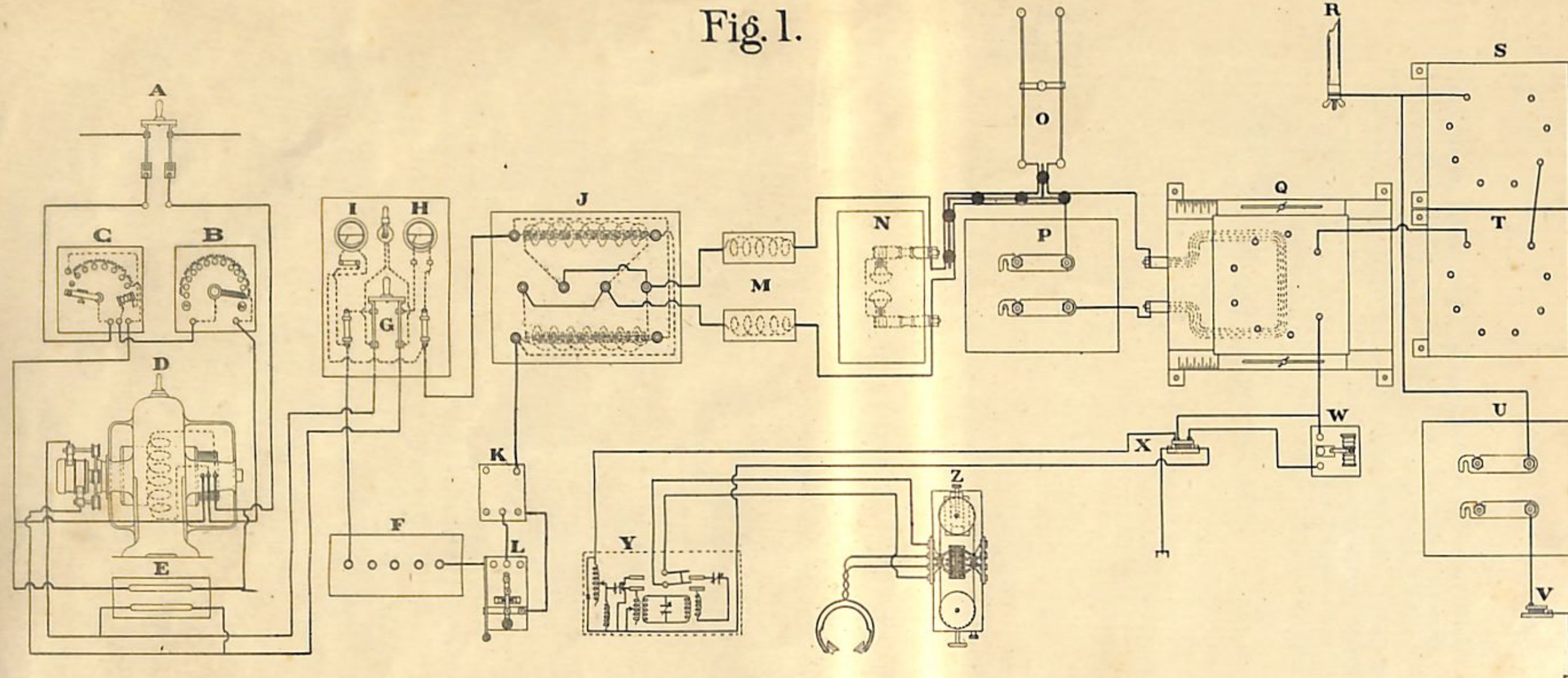
An additional transmitting condenser, precisely similar to the main transmitting condenser, and a second earth arrester spark gap, are provided for the transmission of the 300-metre wave.

The greater part of the receiving gear is comprised in a multiple tuner, which contains a somewhat elaborate arrangement of circuits, in a very compact form. By means of a change-over switch situated on the instrument, it is possible to receive on simple reasonance, a system which might be employed when not looking out for any particular wave length, or, if the switch is placed over in the opposite direction, the aerial circuit is made to influence an intermediate circuit, which in turn influences the detector circuit. This would be the normal method of reception on any particular wave length.

The receiving device is the magnetic detector, in conjunction with which are used low resistance telephones and a telephone condenser.

Fig. 1 shows the entire installation.

Fig. 1.



1½ K.W. MARCONI'S W.T. INSTALLATION.

A	MAIN SWITCH.	H	A.C. AMMETER.	O	ADJUSTABLE PRIMARY INDUCTANCE.	V	EARTH ARRESTER SPARK GAP Nº2.
B	FIELD REGULATOR.	I	A.C. VOLTMETER.	P	TRANSMITTING CONDENSER.	W	TUNING LAMP.
C	STARTER.	J	TRANSFORMER.	Q	JIGGER.	X	EARTH ARRESTER SPARK GAP Nº1.
D	ROTARY CONVERTER.	K	MAGNETIC RELAY KEY.	R	LEADING IN INSULATOR.	Y	MULTIPLE TUNER.
E	GUARD LAMPS.	L	MORSE KEY.	S	AERIAL TUNING INDUCTANCE Nº1.	Z	MAGNETIC DETECTOR.
F	L.F.I.C. INDUCTANCE.	M	CHOKE COILS.	T	AERIAL TUNING INDUCTANCE Nº2.		
G	A.C. SWITCH.	N	SPARK GAP.	U	SHORT WAVE CONDENSER.		

CHAPTER II.

The Direct Current Circuit.

The following instruments are in this circuit (*see* Fig. 1):—

Main switch.

Rotary converter.

Starter for rotary converter.

Field regulator for rotary converter.

The guard lamps.

The Main Switch.

This is a double-pole switch, constructed so as to be able to carry a current of 50 ampères.

The pole pieces are divided into two parts, by means of a spring, thus ensuring that the circuit is broken quickly. It is situated on the instrument board, and forms a ready means of supplying or cutting off the supply of direct current to the rotary converter.

The Rotary Converter.

This consists of a four-pole shunt-wound motor, having a commutator at one end of the armature shaft, and two slip rings at the other.

When direct current is applied to the commutator by means of four carbon brushes connected in pairs, the armature will revolve in accordance with the usual principles governing motors. As the armature coils are now being revolved between the pole pieces, they are cutting lines of force and consequently a difference of potential is set up at the ends of each coil, in accordance with the principles governing dynamos. This difference of potential is really the back E.M.F. of the coils, and is opposed to the applied E.M.F., which is being supplied to the commutator.

As the armature coils are connected in series at the commutator strips, by making internal connections to armature coils exactly 90 degrees apart, and by taking these tappings to two slip rings at the end of the armature shaft remote from the commutator, the total back E.M.F. generated by the whole armature may be collected by carbon brushes bearing on the slip rings.

The slip rings consist of two brass rings, mounted on and carefully insulated from the armature shaft. Four carbon brushes bear on the slip rings, being connected in pairs, one pair bearing on each slip ring.

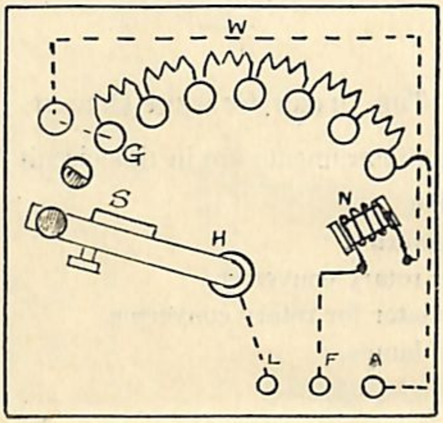


Fig. 2.—Starter.

The Starter.

The starter consists of a number of resistances, enclosed in an iron case, on the front of which is a slate face, fitted with brass studs, a no-volt release, and a starting handle. Tappings from the resistances are taken to the brass studs by internal connections (*see* Fig. 2).

To start the Rotary Converter.

The handle H of the starter is revolved against the pressure of a spring, so that the copper brush on its underside makes contact on stud G. At this moment current is being supplied direct to the field *viâ* W through the no-volt release N ; it is also flowing through all the resistances to the armature. The latter therefore starts to revolve slowly. After waiting a pause at this stop until the armature reaches a constant speed, the handle is moved round so that its brush makes contact on the next stud. A portion of the resistance has now been cut out of the armature circuit, but this portion has been inserted in series with the field. The armature therefore becomes a more powerful magnet, the field becomes weaker, and therefore the former revolves faster. After waiting a pause at this stop, the handle is moved on to the next one, and so on, until all the resistance is cut out of the armature circuit, and inserted in series with the field. The starting handle, which has a soft iron armature S on one side of it, is now held over by the no-volt release, which is energised since its windings are in series with the field.

When the starting handle it held over by the no-volt release, all the resistance is once more cut out of the field circuit, since the magnet winding is connected to the metal framework of the no-volt release. At this moment, the rotary will actually go slower than during the final stages of starting, but the speed can be adjusted by means of the field regulator.

In the event of the D.C. supply being cut off at the switchboard, the handle of the starter will fly over to the "Off" position, owing to the spring attached to the handle, thereby preventing the possibility of the rotary being started up, with all the resistance of the starter in series with the field.

It is important in starting the rotary, that the handle is not held too long on any one stop, as the resistances of the starter will then probably be burnt out. It is equally important that the handle is not revolved too quickly, as then too much current will be applied to the armature. Cut outs fitted to the lower portion of the main switch prevent an excessive current flowing through the starter, and where such cut outs are not provided, it is usual to fit the starter with an overload coil, which is an electrical device for short-circuiting the no-volt release, when the current which is being supplied to the starter arm exceeds a certain amount.

The general principle which necessitates the use of a starter for starting a shunt motor is that the resistance of the armature is very small, while that of the field is considerable. As the two are in shunt, most of the current will flow through the armature, with the result that if direct current was suddenly switched on to the brushes bearing on the commutator, the armature would be burnt out.

Now, when any motor revolves, the armature is generating a back E.M.F., since it is revolving in a magnetic field, and the faster it revolves the greater will this back E.M.F. become. This back E.M.F. opposes the E.M.F. applied to the brushes bearing on the commutator, and so as the armature speeds up, there is more opposition to the applied E.M.F., and so less current is allowed to flow through the armature.

Connecting this explanation with the operation of starting, it will be seen that, at first, when the handle is touching the stop G, only a very small current can safely be supplied to the armature, as it is only revolving slowly, and has not had time to generate any back E.M.F. When it reaches its constant speed, however, it is safe to apply a slightly larger current to the armature, and so on, until at last it is safe to apply the full working current to the armature through no resistance at all, since the armature is by this time revolving at such a speed that the back E.M.F., which it is generating, can limit the current flowing through the armature to a safe amount.

The Field Regulator.

The field regulator is similar in appearance to the starter, and consists of a number of resistances connected to brass studs situated on the face of the instrument. This face is made of slate, and carries a handle at the centre, and two terminals at the base. The left-hand terminal is connected by an internal connection to the handle, the right-hand terminal is connected internally to the last stud, which is labelled "Out." The first stud is labelled "In."

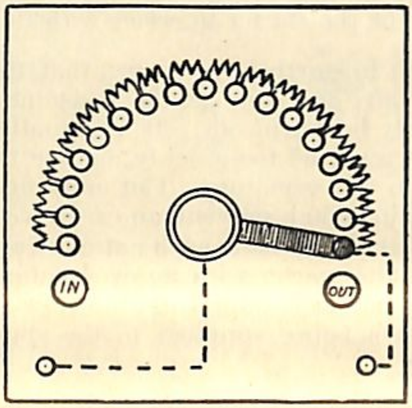


Fig. 3.—Field Regulator.

The handle of the field regulator has no spring attached to it, as there is no danger in starting up the rotary with resistance in series with the field. It is usual, however, to put the handle over to "Out" when finished with the machine, so that the rotary is started up under fair conditions when next required.

Fig. 3 shows a diagram of the field regulator, with its internal connections.

Use of the Field Regulator.

After the rotary converter has been started, it is necessary to so adjust its speed that resonance is obtained in the charging circuit. As a rough guide to ascertain the speed at which the rotary should run, it is usual for the operator to put on the telephones, and pressing the key, to listen to the note produced by his installation, a shrill clear note being the one aimed at.

Another indication as to the correct speed of the machine may be gained by watching the rotary itself. If it speeds up on pressing the key it is already running too fast and resistance should be cut out from the field regulator by turning the handle of that instrument to the right.

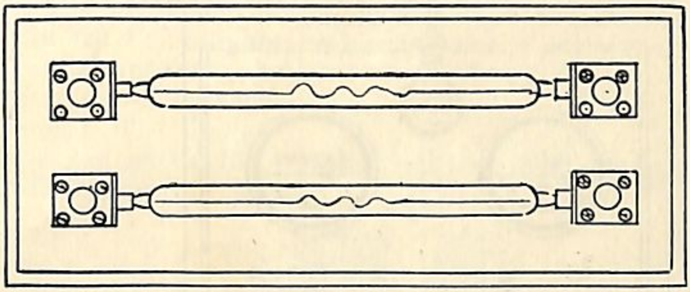


Fig. 4.—Guard Lamps.

The Guard Lamps.

These consist of 150 volt, 8 C.P. straight filament carbon lamps mounted on a board between spring clips (*see* Fig. 4).

They are connected, one in shunt across the armature leads, and the other across the field leads of the rotary converter, to protect the respective windings from any damage when the starter is suddenly thrown off.

CHAPTER III.

The Low Tension A.C. Circuit.

The following instruments are in this circuit:—

Iolanda switchboard.
Morse key.
Magnetic key.
Transformer (primary).
Low frequency iron core inductance.

Iolanda Switchboard.

This consists of a slate panel mounted on a cast-iron frame and fitted with an ammeter with short-circuiting plug, a voltmeter with key, a double-pole switch, fuses, and a pilot lamp.

The double-pole switch is of a similar type to that already described in the D.C. circuit.

Fig. 5 shows the connections of the switchboard. The A.C. mains are brought from the brushes which bear on the slip rings to the lower portions of the switch.

The Pilot Lamp.

The pilot lamp is permanently connected across the lower portions of the main switch so that when the rotary converter is supplying alternating current to the switchboard the pilot lamp should glow whether the switch is made or not.

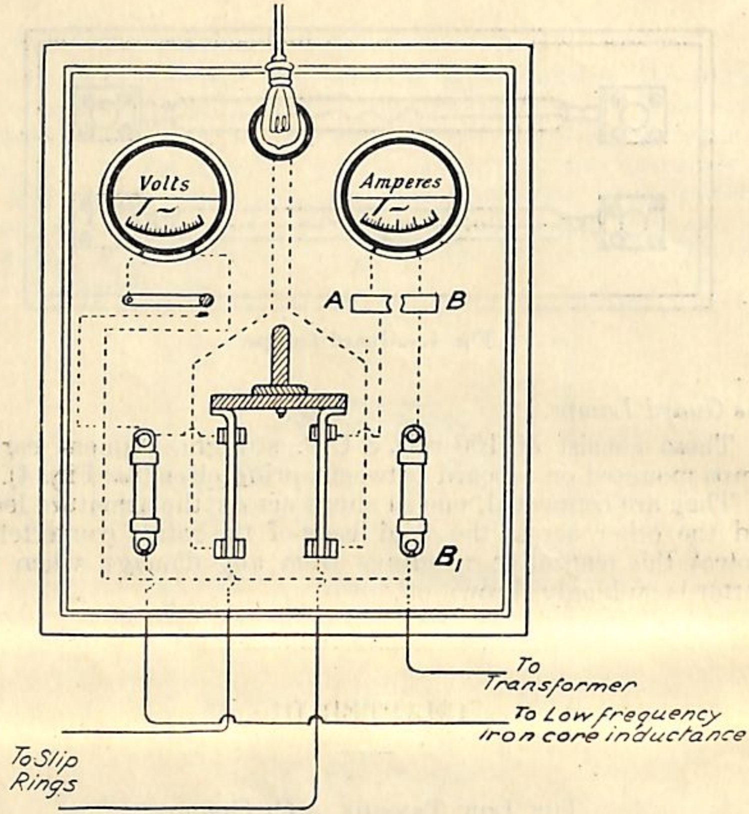


Fig. 5.—Iolanda Switchboard.

The sockets of the switch, into which the upper ends of the poles fit when the switch is closed, are connected as follows:—

The left-hand socket is connected to the upper end of a fuse and the right-hand socket to the upper end of another fuse, passing first through the A.C. ammeter shunt.

Fuses.

These are of the cartridge type and are capable of taking 30 ampères. The fuse wire is contained in a cardboard cylinder, fitted with brass terminal lugs at either end. The space between the wire and the case is filled with asbestos.

The A.C. leads supplying the low tension A.C. circuit are taken from the lower ends of these two fuses.

One side of the voltmeter is connected to the bottom of the right-hand fuse and the other side is connected to the voltmeter key, the nipple of which is connected internally to the top of the left-hand fuse.

The Low Frequency Iron Core Inductance.

This consists of two bobbins, each wound with 360 turns of No. 12 D.C.C. copper wire, wound in three layers. An open ended iron wire core completely fills the interior of each bobbin.

The two are mounted side by side in a teak box and connected in parallel, tappings being taken from suitable points to five terminals mounted along the centre of the box.

The limits of inductance obtainable vary from ·001 to ·01 of a henry. The figures 1, 1, ½, ½ are stamped between the terminals and refer to the amount of wire between the respective terminals reckoned in layers.

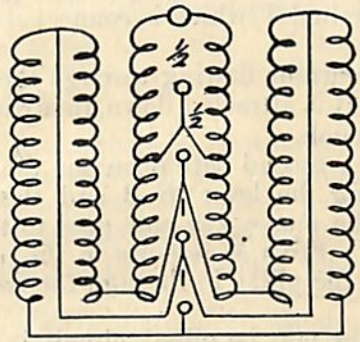


Fig. 6.—Low Frequency Iron Core Inductance.

Fig. 6 shows diagrammatically how the connections inside are made, each layer being represented as a separate coil for the sake of clearness.

The Magnetic Relay Key.

The key consists of two coils of No. 14 D.C.C. wire wound on boxwood bobbins, which are mounted in parallel on two slotted soft iron cores fixed to an iron yoke in the base. A slotted armature is mounted above these coils on a brass arm, which is attached by means of a flexible spring J at one end to brass supporting pillar F, and which carries on the under side of the other end a platinum contact K. Immediately under this contact is a second one, which is fixed at the top of another supporting pillar N. A third pillar P carries a screw adjustment, by means of which the play between the two contacts may be adjusted.

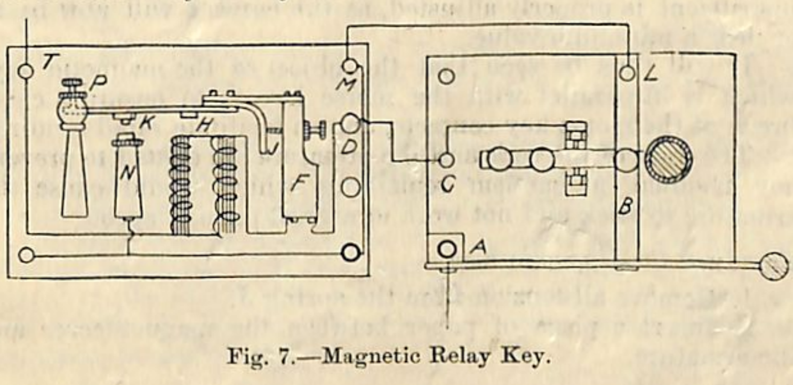


Fig. 7.—Magnetic Relay Key.

Fig. 7 shows the internal connections between the various parts of the key, also the method of connecting up.

Action of the Key.

On pressing the morse key, current flows from A, along the side lever, through the main contacts to C. From C it flows to the terminal D in the magnetic key, and from D to F by an internal connection. From F it flows through the two coils in parallel to the terminal T, which is connected to the transformer primary.

The result of current flowing through the coils, however, is that the armature H is attracted down, thus causing the platinum contacts at K to touch.

There is now a second path open for the current. It may flow from A, along the lever to B and thence straight to L, where it leaves the morse key and goes to the terminal M on the magnetic key. From M it flows to the pillar N, across the contacts at K, to the pillar F, through the two coils in parallel, and so to T.

If the morse key now be raised, circuit is at once broken at the key contacts. The two cores, however, do not at once lose their magnetism, and consequently the circuit is not at once broken at K.

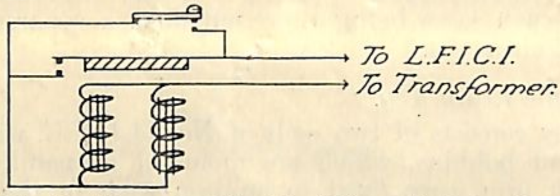


Fig. 8.—Theoretical Sketch of Magnetic Relay Key.

The effect of inductance in any circuit is to oppose the rising and dying down effect of a current in the circuit, and this effect is usually seen in the form of a spark when the main contacts of the morse key are broken. Here, however, any sparking will take place at the magnetic key contacts since they break last, and this sparking will not be excessive if the instrument is properly adjusted, as the current will now be at or near a minimum value.

It will thus be seen that the object of the magnetic key, which is in parallel with the morse key, is to ensure a clean break at the morse key contacts, and so facilitate rapid sending.

The cores of the coils and the armature are slotted to prevent any residual magnetism remaining which would cause the armature to stick and not work at a great enough speed.

To adjust the Magnetic Key.

1. Remove all tension from the spring J.

2. Insert a piece of paper between the magnet cores and the armature.

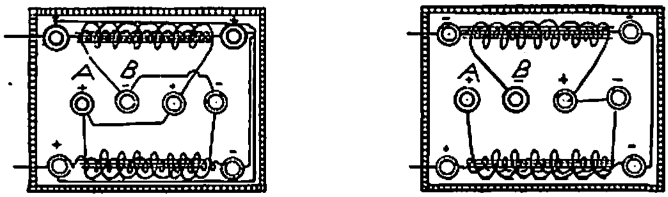


Fig. 10.—$1\frac{1}{2}$ K.W. Transformer Connections.

Primaries in Parallel.
Secondaries in Parallel.

Primaries in Series.
Secondaries in Series.

connect the primary windings always in parallel, the secondary windings being in series when the two condenser elements are arranged in the series position, and in parallel when the condenser elements are arranged in parallel.

When the coils are first supplied they are covered with paraffin wax. When the transformer is in position the teak container is filled with insulating oil, which dissolves the wax.

With the primaries in parallel and the secondaries in series, the step up in voltage is 300 : 1.

CHAPTER V.

The Primary Oscillatory Circuit.

The following instruments are in this circuit:—

Transmitting condenser.
Jigger (primary).
Additional primary inductance (if required).
Primary sliding inductance.
Spark gap.

The Transmitting Condenser.

The transmitting condenser consists of two elements contained in galvanised iron cradles, the whole standing in a lead-lined teak box.

Each element consists of 36 glass dielectrics, 34 of these being under strain when the condenser is charged, with 35 zinc plates $13\frac{1}{2}$ inches by $5\frac{1}{2}$ inches, one on either side of them.

At each end of each element is a paraffined white wood packing piece, and a glass dielectric with no plate on the outer side of it, placed there for insulating purposes. The two outside sheets of glass are therefore not under strain when the condenser is charged up.

The glass dielectrics, which have been tested to stand a pressure of 27,000 volts, and are $\frac{1}{10}$ of an inch thick, stand on cork, which in turn rests on treated wood packing pieces.

The zinc plates are all the same, and have two tabs spaced as shown in Fig. 11.

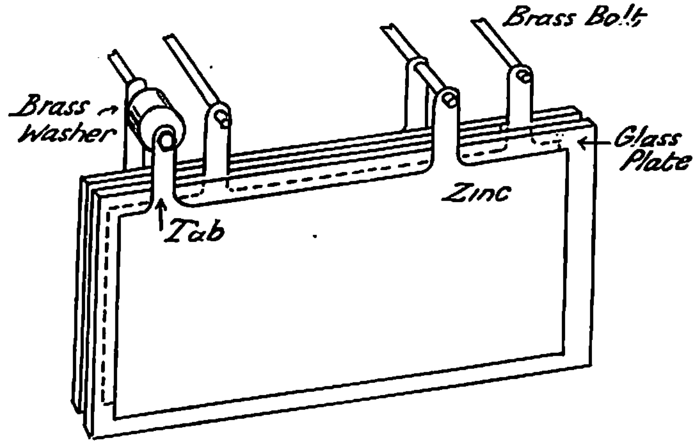


Fig. 11.—Arrangement of Plates in Main Condenser.

In building up the condenser, neighbouring plates are turned round so that their tabs are out of line. Fig. 11 shows the position of tabs when the element is built up.

Lines of tabs opposite each other are held together by brass bolts passing through them, brass washers $\frac{1}{16}$ of an inch thick being situated between tabs so that they do not have to be bent out of shape.

In Fig. 12, AA and A^1A^1 represent the tabs of one set of plates, BB and B^1B^1 represent the tabs of the other set of plates.

Twisted copper strips fixed midway along the brass bolts previously referred to connect to the under side of three ebonite bushed brass terminals which pass through the lid of the box. A permanent connection inside the box joins the "A" plates of one element to the "A" plates of the other element. A similar connection joins the "A^1" plates of the two elements permanently together.

There is a dummy fourth terminal which protrudes through the lid not connected to anything, which is placed symmetrically as regards the other three terminals, for the purpose of facilitating change of connection.

The tops of the four terminals are stamped respectively 17, 17, 36, 0, indicating the number of plates connected to each.

To enable the two elements to be connected either in series or parallel, two brass connecting straps are provided. These are slotted at one end and drilled at the other, so as to swing on two of the terminals.

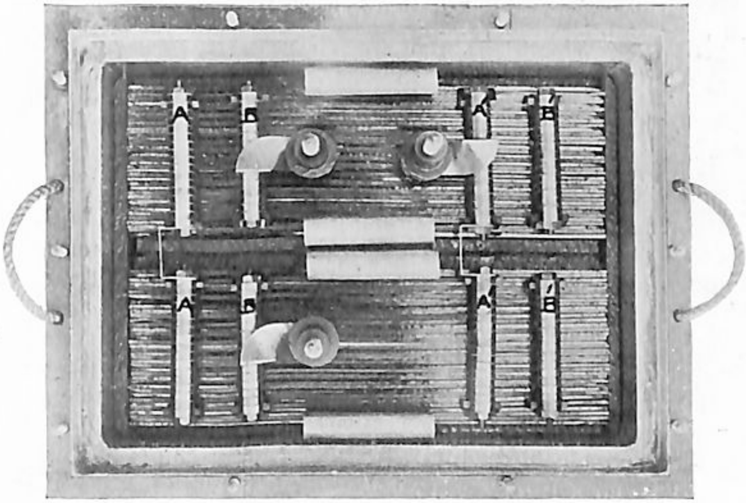
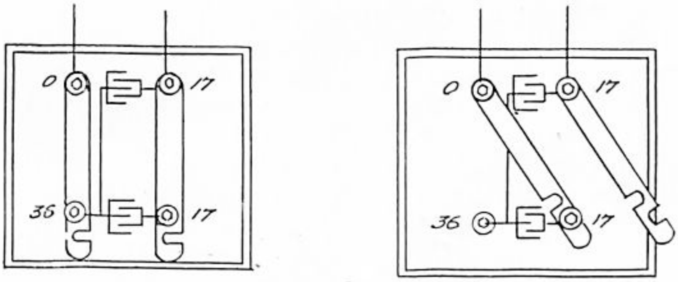


Fig. 12.—Transmitting Condenser.

To connect elements in series (*see* Fig. 13), one strap only is required, and this is placed diagonally as shown.

To connect elements in parallel, the two straps are placed parallel to each other, as shown in Fig. 13.

It will be seen that by this system of connection the dummy terminal and the "17" terminal at the same side of the box are in each case the main condenser terminals.



Parallel
A

Series
B

Fig. 13.—Main Condenser Connections.

For use, the lead-lined box is filled with insulating oil having a flash point at about 300° and specific gravity about ·85. Care should be taken that this oil is not exposed to moisture, or its insulating properties will be impaired.

For the transmission of the short wave (300 metres) the elements should be joined in series, giving a capacity of about ·016 microfarad (14 jars).

For the transmission of the long waves (600 and 1,000 metres) the elements should be joined in parallel, giving a capacity of about ·065 microfarad (58 jars).

To test a Condenser.

If a spark cannot be obtained and a fault in the condenser is suspected, it will very likely be due to a broken glass dielectric. To locate this, remove the lid of the condenser box, disconnect No. 2 element, and join up No. 1 element in the primary oscillatory circuit. Put on a 1 mm. spark and press the key. If a spark is obtained, this element is correct; No. 2 element will probably then be faulty. Connect it up as was done in the case of No. 1 element, temporarily removing one of the terminals from the other element for the purpose, and try to obtain a spark as before. If this is not obtainable, observe the element closely while the key is pressed; a very small spark will very likely be noticed between two plates. This will indicate the broken dielectric.

To replace a broken Glass Dielectric.

Ease up on the connecting bolts which run through the tabs, and push out the broken one by inserting a new one, care being taken not to damage the zinc plates on either side during the operation.

The Jigger (Primary).

This instrument consists of a primary winding of one turn and a secondary of eight turns. The primary winding, when the instrument is connected up, forms the fixed inductance of the primary oscillatory circuit, and its duty is to influence the secondary and so impart oscillations to the aerial circuit.

The primary consists of 63 strands of No. 20 L.S.G. copper wire, each strand being cotton insulated, and the whole impregnated with paraffin wax and shellac. It is wound round a wooden former, square in shape, and the two ends are led through heavy ebonite bushes through the bottom of the teak box in which it is contained, and are soldered into terminal sockets.

The Additional Primary Inductance (see Fig. 14).

This consists of a heavy copper spiral of square cross section, and it takes the place of the primary sliding inductance when it is necessary to transmit on the 1,000-metre wave. A highly insulated ebonite handle, supplied with a flexible copper contact at the end of a brass screw of the same pitch as the spiral, is used to vary the amount of inductance in the circuit. Two terminals are provided on the base of the instrument for connecting up.

The Primary Sliding Inductance.

This consists of two brass rods, mounted on four ebonite pillars on a wooden base, bridged by a sliding brass clamp, by means of which the inductance can be varied.

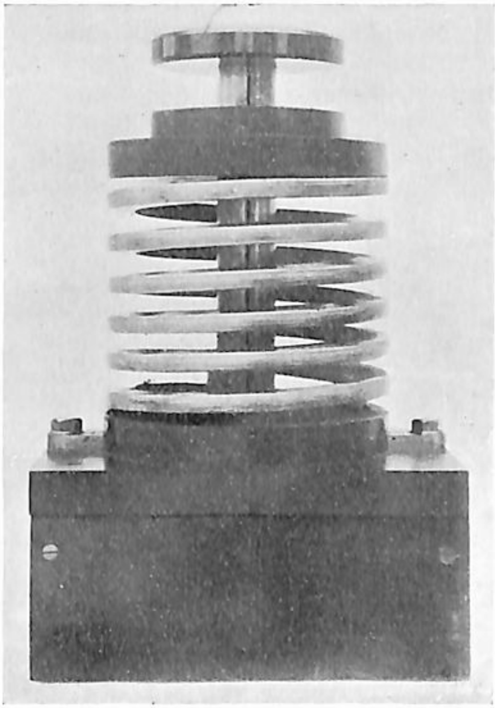


Fig. 14.—Additional Primary Inductance.

The minimum inductance is zero, when the two rods are short circuited, and the maximum is about 26 microhenries.

This inductance is the only adjustable portion of the primary oscillatory circuit, if the condenser be regarded as fixed at either the series or parallel position, and its use is to enable oscillations of the required frequency to be obtained.

The Spark Gap.

The spark gap consists of two mushroom shaped cast-iron balls, mounted on two horizontal brass spindles supported on vertical brass rods. These brass rods pass through heavy ebonite pillars, which are brought to the outside of a teak container, and are supplied on their upper extremities with suitable washers and nuts for making the required external connections.

The box itself is made of $1\frac{1}{2}$-inch teak, lined first with asbestos, and afterwards with lead, in order to deaden the sound of the spark. A zinc tray is placed at the bottom of the box, in which quicklime is placed to absorb the moisture and gases produced when the spark is taking place.

The balls are screwed on to the horizontal spindles, the thread on which is of such a pitch that one half turn gives an adjustment of 1 millimetre. Lock nuts are provided so that when the balls have been set a proper distance apart they can be permanently fixed in position.

Two brass safety spark points are mounted immediately under the balls, thereby preventing all danger of the condenser breaking down due to an excessive voltage.

To adjust them, set the spark balls to the distance apart mentioned in (*a*) and (*b*) below (either 4 or 8 millimetres), and then separate the safety spark points until the safety gap just does not spark across.

Adjusting the Primary Oscillatory Circuit.

(*a*) Short Wave (300 Metres or 1,000 Feet).

The transmitting condenser is connected up in the series position. The spark gap is adjusted to approximately 8 millimetres for full power, and the primary sliding inductance is adjusted in accordance with the instructions left by the engineer or officer who tuned the installation. As a rule this inductance will be at "short circuit."

Note.—The transformer secondaries must be in the series position.

(*b*) Long Wave (600 Metres or 2,000 Feet).

The transmitting condenser is connected up in the parallel position. The spark gap is adjusted to approximately 4 millimetres, and the primary sliding inductance is adjusted as directed by the officer who tuned the installation.

Note.—The transformer secondaries must be in the parallel position.

(*c*) 1,000 Metre Wave (approximately 3,300 Feet).

The transmitting condenser and spark gap are adjusted as for the 600-metre wave. The primary sliding inductance is replaced by the additional primary inductance, and the latter is adjusted as directed.

Note.—The transformer secondaries must be in the parallel position.

CHAPTER VI.

THE SECONDARY OSCILLATORY CIRCUIT, OR AERIAL CIRCUIT.

The following instruments are in this circuit:—

Jigger (secondary).
Aerial tuning inductance, No. 1.
Aerial tuning inductance, No. 2 (if required).
Short wave condenser (if required).
Earth arrester spark gap, No. 1.
Earth arrester spark gap, No. 2 (if required).
Tuning lamp.

The Jigger (Secondary).

This consists of a coil of eight turns of cable made up of 21 strands of No. 20 L.S.G. copper wire, each strand being cotton covered. A coil of rope is wound between the turns of this winding, the whole arrangement being wound over a square wooden former, and afterwards treated with shellac.

Tappings to eight brass sockets placed on the face of the box in which the secondary is contained are taken through ebonite insulating bushes.

For practical purposes there are seven turns, each one being a trifle more than one actual turn, in order that the tappings may be suitably disposed round the face of the container. The right-hand socket is connected to the turn nearest the primary winding, and is marked "Earth." The inductance of the winding commencing from this "earth" terminal and adding one turn at a time is 1·4, 4, 7·5, 10·8, 16·4, 21, and 25·8 microhenries.

The box containing the secondary is made to slide over the box containing the primary, thus permitting of a variation of the coupling.

A scale on the primary box indicates to a certain extent the percentage of coupling, but this indication cannot be considered as accurate.

Aerial Tuning Inductances, No. 1 and No. 2.

Each instrument is precisely the same, and consists of 20 turns of rubber insulated cable made of 19 strands of No. 20 L.S.G. wire, wound round a square wooden former.

Tappings are brought from various points to 8 brass sockets arranged on the face of the teak containing box, through ebonite insulating bushes. The number of turns between the various sockets is shown in Fig. 31. It will be seen that it is possible to obtain any number of turns from 1 to 19 by placing spills in the various sockets.

The inductance measured from the right-hand terminal, and taking one additional section at a time, is 1, 3·25, 8·5, 17, 52, 94·4, and 150·6 microhenries.

As in the case of the jigger secondary, there is really one more turn than is accounted for by the numbers marked on the face of the box, the object of this being to provide that all the tappings occur at a fraction over the complete turn, so that they do not come directly under each other.

The Earth Arrester Spark Gaps, No. 1 and No. 2.

These two are precisely the same. The instrument consists of two brass circular plates separated at a distance of $\frac{1}{100}$ of an inch from each other, by means of a mica disc, each plate being supplied with four terminal nuts.

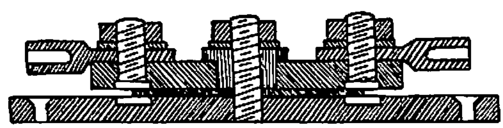


Fig. 15.—Earth Arrester Spark Gap, Mica Disc Type.

The upper plate is kept in a rigid position with respect to the lower one by means of a brass pin fixed in the centre of the latter, which passes through an ebonite bushed hole in the centre of the former, a lock nut being screwed on to the upper extremity of the pin. A circular groove is made in each plate coinciding with the edge of the mica disc to prevent sparking and burning at the edge of the mica. Fig. 15 shows a section through the diameter of the arrester.

Tuning Lamp (*see* Fig. 16).

This consists of a 4-volt lamp in series with an adjustable inductance coil mounted on a teak base. The inductance coil

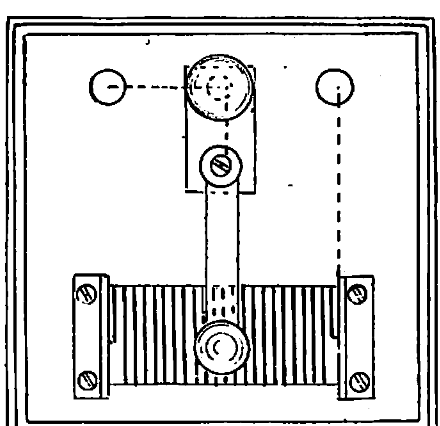


Fig. 16.—Tuning Lamp.

is wound with 8 feet of bare No. 16 L.S.G. copper wire on a grooved boxwood core. One end of the winding is free, and the other is connected to a terminal on the base board. A second terminal is connected to one of the lamp contacts, the other contact been connected to a pivoted brass arm, the extreme end of which may be moved over the copper wire inductance.

The use of the tuning lamp is to indicate whether the two oscillatory circuits are accurately in tune.

To test the tuning, use a loose coupling of the transmitting circuits, and place the tuning lamp switch in such a position that the lamp just glows feebly. If an increase or decrease of one turn on the aerial tuning inductance makes the lamp glow less brightly, the circuits may be considered as properly tuned. More marked results will be obtained with a tighter coupling.

The Short Wave Condenser.

This is precisely the same as the main transmitting condenser, and may be used to replace the latter in case of a breakdown.

Normally, it will only be used when it is required to transmit a 300-metre wave from an aerial whose natural wave length is greater than this.

N.B.—There must always be at least two turns in the jigger secondary, in order to influence the aerial circuit.

CHAPTER VII.

The Receiving Circuit.

This circuit contains the following instruments :—

The magnetic detector.
The multiple tuner.
The telephone condenser.
The telephones.

The Magnetic Detector.

The magnetic detector consists of two ebonite discs, one being mounted on a spindle which is revolved by clockwork, contained in the body of the instrument, and the other on a brass plate which can be slid along a bed piece, by turning a screw at the side of the instrument.

A soft iron band consisting of 70 strands of No. 40 L.S.G. iron wire is stretched round the circumference of the wheels, and is thus caused to revolve when the clockwork is started.

Situated so that the band revolves through it, is a glass tube on which is wound a primary winding made of No. 36 L.S.G. copper wire. The two ends of this primary winding are taken to terminals situated at the front of the instrument and marked aerial and earth respectively. Over the primary winding is a secondary wound on an ebonite bobbin, and having a resistance of 140 ohms. The ends of the secondary are taken to two terminals, close to the primary terminals, and marked "T."

Mounted on a wooden block over the primary and secondary windings are two permanent horse-shoe magnets, one pair on each side of the instrument.

The instrument is supplied with a handle for winding up, and a brass knob for stopping the clockwork. If fully wound up, the detector should run for roughly two hours, without requiring to be rewound.

Action of the Magnetic Detector.

For use, aerial and earth are connected respectively to the two ends of the primary winding, the telephones being connected to the two secondary terminals marked "T."

Due to the horse-shoe magnets, a magnetic field is set up in the vicinity of the soft iron band. Owing to the hysteresis of this soft iron band, the magnetic field is distorted in the direction in which the band is revolving.

When a wave train cuts the receiving aerial small oscillatory currents flow in the aerial circuit, and so through the primary winding of the magnetic detector.

The effect of these currents is to destroy the hysteresis of the soft iron band, with the result that the magnetic field resumes its normal position. When this happens lines of force cut the secondary winding, setting up at its ends a difference of potential. As its ends are connected through the telephone windings a current will flow in the telephone circuit, thus attracting the diaphragms of the telephones, and enabling signals to be read.

The Multiple Tuner.

This instrument contains the variable inductance and capacity for the aerial receiving circuit, the whole of an intermediate circuit, and the variable inductance and capacity for the detector tuning circuit.

The inductance coils are contained in a teak box, with an ebonite top and front. On the top are three condensers, one for each circuit, a two-way switch, and a micrometer spark gap.

On the left front of the instrument is an ebonite handle carrying a brass arm which can be rotated over a number of brass studs, thereby adding inductance to the aerial circuit.

To the right of this handle is another one connected by means of ebonite coupling strips to three brass arms, so that the movement of this handle enables proportionate adjustments to be made in each of three circuits at the same time. This is called the tuning switch.

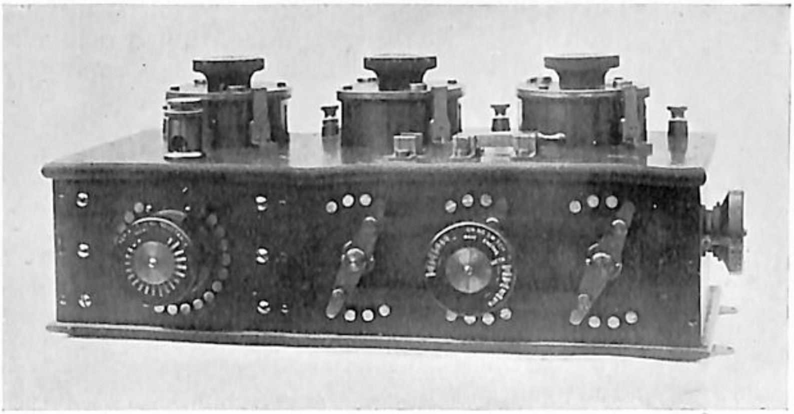


Fig. 17.—The Multiple Tuner.

Each of the two handles is calibrated, the aerial inductance being marked in microhenries, and the tuning switch showing the limits of the receivable wave lengths on the respective stops.

On the right-hand side of the instrument there is a third ebonite handle, called the intensifier handle, a portion of the side of the handle being marked in degrees.

The use of this handle is to alter the position of the inductances in the intermediate circuit, with reference to the inductances in the aerial and detector circuits, and so to vary the coupling between these circuits.

Fig. 18 shows the internal connections of the multiple tuner.

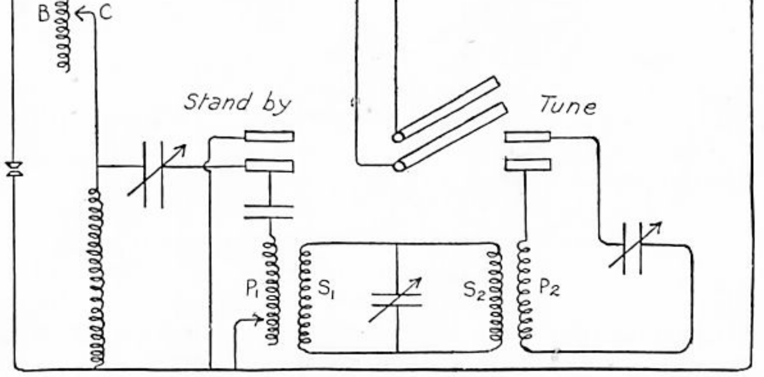


Fig. 18.—Multiple Tuner. Change Over Switch Connections.

Circuits.

For the purposes of explanation, the circuits may be treated separately as follows:—

(*a*) The aerial circuit, consisting of—

(1) A circuit from the aerial through the micrometer spark gap to earth. The use of this circuit is to protect the receiving instruments from the effects of lightning, or currents at very high voltages. High frequency currents, of sufficiently high voltage, will complete their circuit to earth through the resistance of the gap, rather than through the inductance of the receiving instruments. One complete revolution of the micrometer spark gap screw moves the contact through $\frac{1}{100}$ of an inch.

This is the distance which should separate contacts, when the micrometer spark gap is in adjustment.

(2) A circuit from the aerial through the adjustable aerial tuning inductance, through an aerial condenser, and another adjustable inductance to earth. The use of this circuit is to form the main passage for the incoming wave, and the duty of the last-mentioned adjustable inductance is to provide the necessary coupling between this circuit and the intermediate circuit.

(3) A circuit from the aerial through the adjustable aerial tuning inductance, through a coil of high inductance, value 80,000 microhenries, to earth. The use of this circuit is to act as an atmospheric drain, thereby assisting to relieve the operator of interference due to atmospherics.

(*b*) The intermediate circuit.

This consists of two fixed inductances, joined in parallel across an adjustable condenser. The inductance shown on the left in Fig. 18 acts as the secondary to the primary in the aerial circuit, and the other inductance acts as the primary to the secondary in the detector circuit.

(*c*) The detector circuit.

This consists of a fixed inductance, an adjustable condenser, and the primary winding of the magnetic detector.

Adjustment of the Receiving Circuit. (*See* Fig. 18.)

A variation of the aerial tuning inductance handle alters the position in "B" at which the tapping "C" is taken off.

A variation of the position of the intensifier handle alters the position of the coils S_1 and S_2 with respect to the coils P_1 and P_2.

A variation of the tuning switch handle makes variations as shown in Figs. 19, 20, 21, and 22.

It will be observed that there are four stops for the metal portion of the tuning switch handle to make contact on.

1. For Wave Lengths of 80–150 Metres.

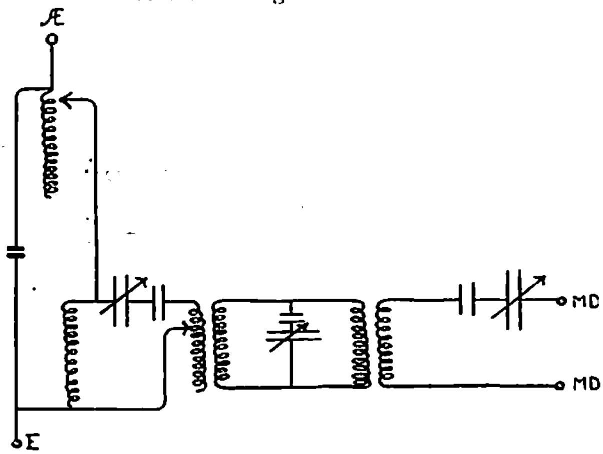


Fig. 19.

On the First Stop. (*See* Fig. 19.)

For receiving waves from 80 to 150 metres a small block condenser is placed in series in each circuit. Since the result of placing two condensers in series is to give a capacity which is less than the least of them, such an arrangement reduces the product LS in each circuit, and so enables short waves to be received.

2. For Wave Lengths of 150–1,600 Metres.

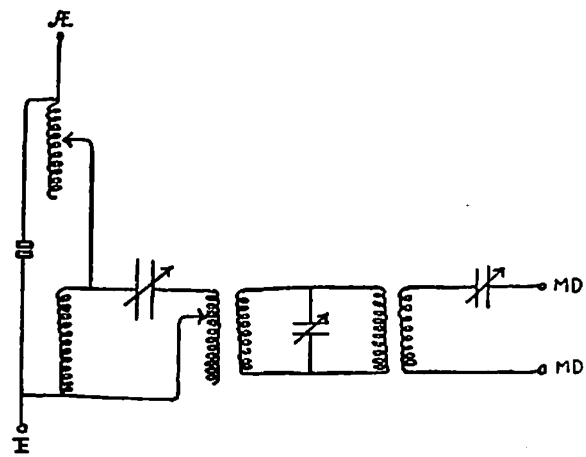


Fig. 20.

On the Second Stop. (*See* Fig. 20.)

For receiving waves from 150 to 1,600 metres, the small block condensers mentioned in the previous paragraph are cut out of each circuit.

3. For Wave Lengths of 1,600–2,000 Metres.

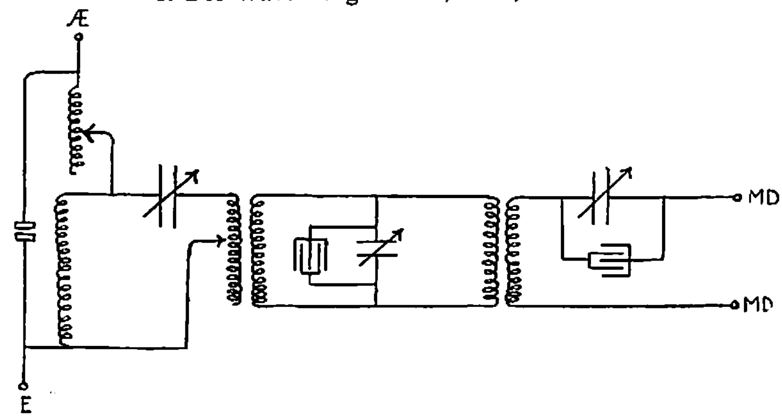


Fig. 21.

On the Third Stop. (*See* Fig. 21.)

For receiving waves from 1,600 to 2,000 metres, inductance is introduced in the aerial circuit, and small block condensers are placed in parallel with the variable condensers in the intermediate and detector circuits. Since the result of placing two inductances in series with each other, or two capacities in parallel with each other, is obtained by adding, such an arrangement provides for the reception of longer waves.

4. For Wave Lengths of 2,000–2,600 Metres.

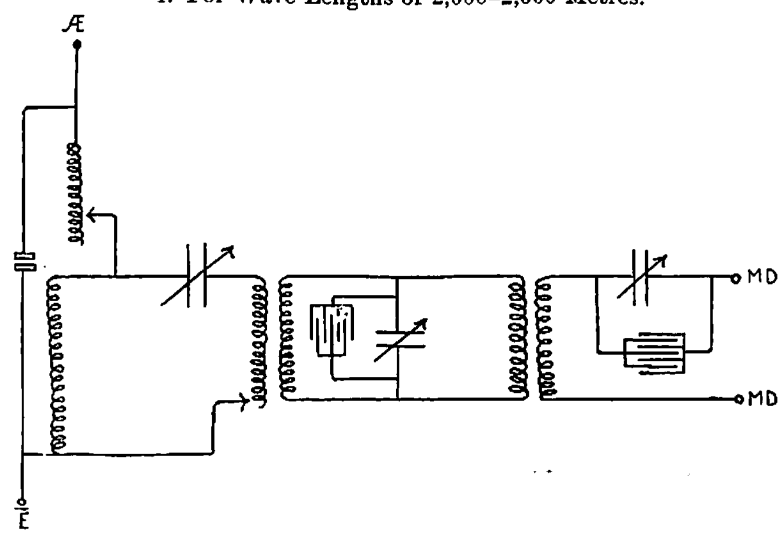


Fig. 22.

On the Fourth Stop. (*See* Fig. 22.)

For receiving waves between 2,000 and 2,600 metres, the value of the added inductance and added capacity is increased. This arrangement provides for the reception of long waves.

The Switch on the top of the Instrument.

This switch is used to change over from a "Stand by" position, when waves of widely varying length are audible, to a "Tune" position, which is done when it is desired to cut out other signals, which may be interfering with reception. Fig. 18 shows how this is done.

"*Stand by.*"—With the switch in this position, the primary of the magnetic detector is placed in the aerial circuit. The only portions of the whole instrument which affect the tuning of this circuit are then the aerial tuning inductance and the aerial condenser.

Tune.—With the switch in this position, the primary of the magnetic detector is in the detector circuit, which is its normal position. All three circuits are now in use, and will have to be in tune with the incoming wave before signals can be received.

The maximum value of the three variable condensers is 10 jars.* The top of each condenser is marked with a scale showing readings of one-tenth of a jar.*

Each condenser consists of two sets of semi-circular zinc vanes, one set being fixed, the other set being capable of revolution by means of a handle. The dielectric between the two sets of vanes consists of thin circular sheets of ebonite. When the zinc vanes are entirely interlocking, a maximum amount of dielectric is under strain, and therefore the maximum capacity, *i.e.*, 10 jars,* is being obtained. When the vanes do not interlock, no dielectric is under strain, and so no capacity is being inserted. A brass contact piece is attached to the movable vanes, and if the handle be turned a little beyond the maximum capacity point this contact piece touches a stop thereby short-circuiting the condenser.

The block condensers placed in circuit by means of the tuning switch increase the capacity of the intermediate and detector circuits to a maximum of 30 jars,* the value of each being 20 jars.*

The Telephone Condenser.

This condenser consists of sheets of tinfoil, separated by dielectrics composed of mica. It is divided into three parts, varying amounts being placed in the circuit by means of plugs. The three parts having approximate values of 50, 100, and 200 jars* respectively are fixed by means of paraffin wax in a wooden box. Fig. 23 shows the internal connections of the condenser.

* One jar $= \frac{1}{900}$ microfarad, *vide* page 49.

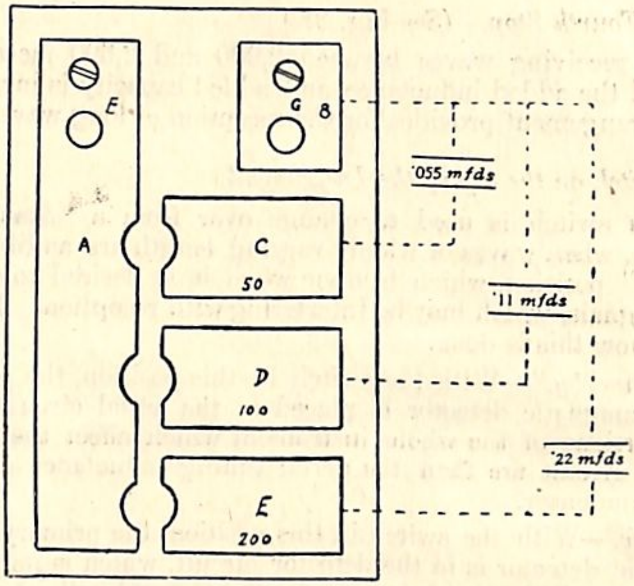


Fig. 23.—Telephone Condenser.

One side of each portion of the condenser is permanently connected to the top block "B," the other sides being joined respectively to "C," "D," and "E."

Three brass plugs are provided by means of which any separate condenser or combination of condensers may be joined across the terminals "F" and "G."

For use the telephone condenser is connected across the secondary terminals of the magnetic detector.

Action.—In the description of the action of the magnetic detector it was seen that owing to the destruction of the hysteresis of the soft iron band in that instrument by the small aerial current, a D.P. was set up at the ends of the secondary winding. As the telephones and the telephone condenser are both connected to these two terminals a small current will reach both. That part which flows through the telephone windings will cause the diaphragm to be attracted and so enable signals to be read.

The portion which reaches the telephone condenser charges up that instrument. It now discharges itself and helps to prolong the time during which the diaphragm is vibrating. It thus alters the pitch of the note, but does not as a rule increase the strength of signals.

The Telephones.

The telephones consist of two receivers in series attached to the ends of a steel spring, called the telephone headgear.

Each receiver consists of a thin soft iron diaphragm, held firmly at its edges over the poles of an electromagnet. The core of the magnet is permanently magnetised and consequently the diaphragm is attracted towards the poles.

By passing a current through the coils of the electromagnet the force of attraction is increased or decreased according to the direction of the flow of current. Thus if an alternating current be passed through the electromagnet coils the diaphragm will vibrate and sound will be produced in the receivers.

The telephones used with the magnetic detector are low resistance telephones, the windings of each receiver having a resistance of 70 ohms. Since they are connected in series the total resistance is 140 ohms, which is approximately the same as that of the secondary of the magnetic detector.

Short Circuiting Device on Morse Key.

As previously explained in the description of the morse key, two brass strips protrude from the right-hand side of the morse key, and these are pressed together by an ebonite cam attached to the bar of the key, when the latter is pressed.

By connecting these two strips to the telephone condenser or secondary of the magnetic detector, and by suitably adjusting the key, the telephones are short circuited at the moment when a spark takes place, and consequently the operator does not hear the loud sounds in the telephones.

Through the spacing of the operator's morse, however, he is able to receive signals.

Adjustment of the Receiving Circuit.

When obtaining adjustments for any particular ship or station for the first time, the operator would have the change-over switch on the multiple tuner in the "Stand by" position.

If receiving a wave length shorter than the natural wave length of the aerial, none of the tuner aerial tuning inductance would be in use, and the condenser in the aerial circuit would be adjusted to give loudest signals

If receiving a wave length longer than the natural wave length of the aerial, the aerial condenser would be out of use, and the tuner aerial tuning inductance would be adjusted to give loudest signals.

The circuit is now adjusted for receiving on simple resonance.

As, however, ships sending in the vicinity on other wave lengths may cause such interference that reception will be difficult or impossible with the circuit so arranged, it is necessary to have adjustments which will enable this interference to be cut out, when the change-over switch is put over to the "Tune" position.

To obtain these adjustments, the change-over switch is put over to "Tune," the intensifier handle is placed so as to indicate an angle of 90 degrees, and the tuning switch is placed on that stop at which loudest signals are obtained. The markings on the handle of the tuner aerial tuning inductance will indicate approximately the length of the incoming wave, and similar markings on the tuning switch handle will facilitate adjustment of the tuning switch.

The condensers in the intermediate and detector circuits are then varied together, until loudest signals are obtained. It is important that these condensers should be varied together.

A further slight alteration of the aerial condenser or tuner aerial tuning inductance may now be found to increase the strength of signals.

If interference is still troublesome, the intensifier handle can be rotated so as to couple the three circuits more loosely together. Finer adjustments of the three circuits will now have to be made, the strength of all signals will decrease, but the interfering waves will decrease in strength more than the one which it is desired to receive.

CHAPTER VIII.

Installing the Instruments, and Wiring.

1. *The Direct Current Circuit.*

(*a*) Instruments outside the W.T. Office.

The Rotary Converter.

This should be below the waterline, and if possible near to the W.T. office, so as to avoid having very long leads.

The place selected for the rotary converter should be easily accessible, well ventilated, and the lighting arrangements should permit of close examination of moving parts.

A wall socket with plug connection is supplied, and this should be wired into the lighting circuit, so as to enable a wandering lead to be brought close to the machine.

The shaft of the rotary converter should lie in a fore and aft direction, so as to reduce the strain on the shaft due to gyroscopic action to a minimum, when the ship is rolling.

In no case should the rotary converter be within—

30 feet of the standard compass.
30 feet of the steering compass.
20 feet of the chronometers.

(*b*) Instruments inside the W.T. Office.

All the instruments belonging to this circuit in the W.T. office are mounted on the instrument board. Fig. 24 shows these instruments and their relative positions, to scale.

Instrument Board.

This consists of a $1\frac{1}{2}$-inch teak lining, 4 feet 6 inches high and 3 feet 6 inches wide, situated opposite the door of the silent cabinet. It is secured to the side of the wireless office 2 feet 6 inches above the deck, and under it is a cupboard for the stowage of spare gear.

Wiring the D.C. Circuit.

Fig. 25 shows the method of joining up the rotary converter with its starter, field regulator, and guard lamps.

Positive and negative mains are brought from the most convenient junction box to the lower terminals of the main switch. From one terminal of the main switch a lead is taken to the "line" terminal on the starter.

The "field" terminal on the starter is connected to the left-hand terminal of the field regulator, the terminal on the right of that instrument being connected to the "field" terminal of the rotary converter.

INSTRUMENT BOARD.

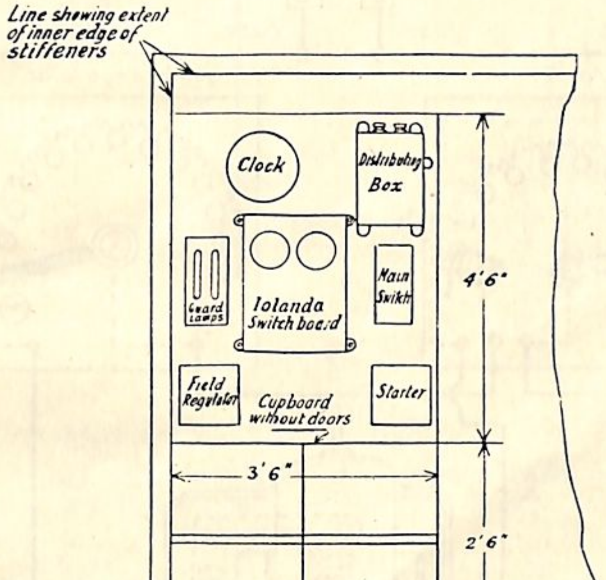


Fig. 24.

A lead is taken from the "armature" terminal of the starter to the "armature" terminal of the rotary converter, and another lead is taken from the "line" terminal of the rotary converter to the opposite side of the main switch.

Across the two last-mentioned leads is connected one of the guard lamps. It will be observed from the diagram of the rotary converter shown in Fig. 25 that this guard lamp is connected across the field of the rotary converter.

The second guard lamp is connected, as will be described later, across the slip rings.

Fuses are inserted at the top portion of the main switch. As the starter is not supplied with an overload coil, these fuses act as safety arrangements, preventing an excessive current from flowing in this circuit.

For wiring up the leads connected to the field regulator, also the guard lamps, $\frac{3}{32}$ india-rubber vulcanised braided lead-cased cable, which is supplied for the purpose, will be used. All other leads will be of the $\frac{7}{16}$ I.R.V.B. lead-cased cable.

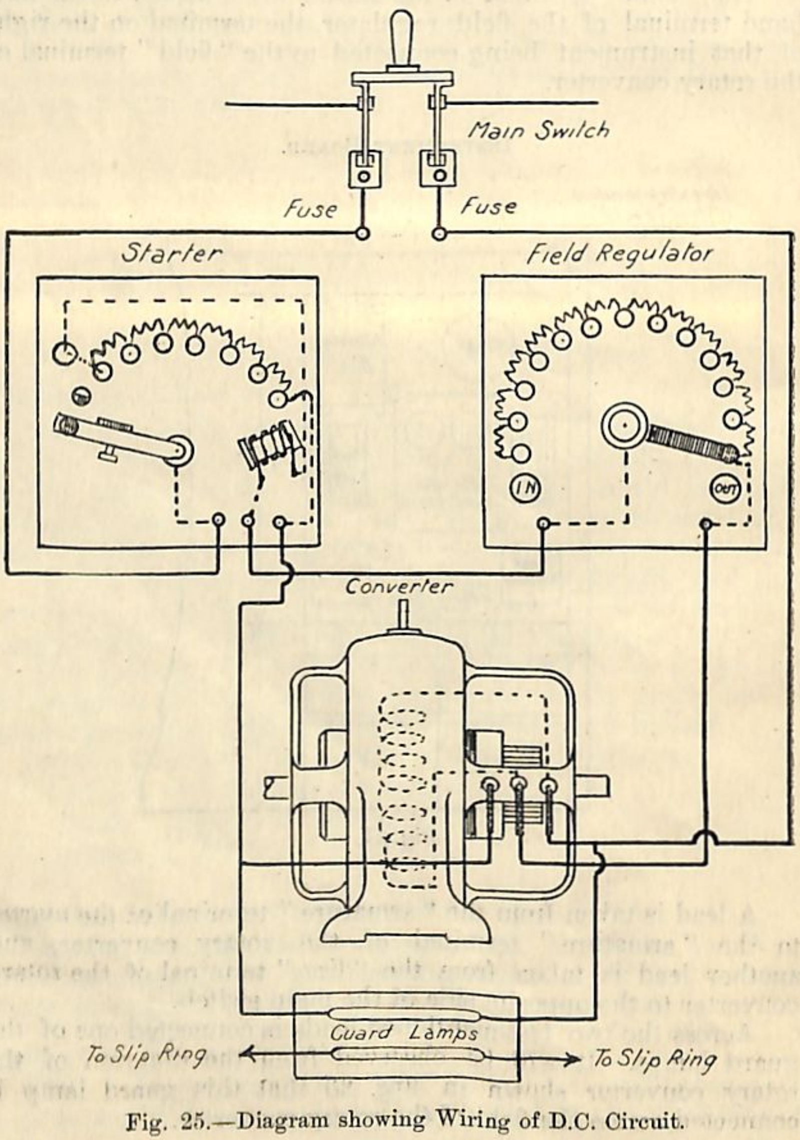


Fig. 25.—Diagram showing Wiring of D.C. Circuit.

2. *The A.C. Low Tension Circuit.*

The Iolanda Switchboard.

The position of this instrument on the instrument board is shown in Fig. 24.

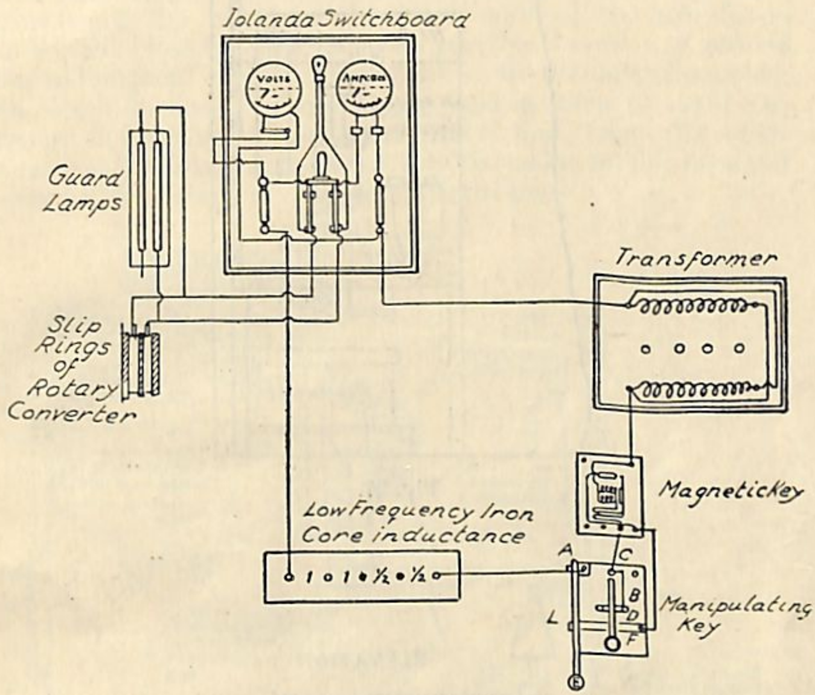


Fig. 26.—A.C. Low Tension Circuit.

The Transformer.

The transformer stands on a wooden shelf, 5 inches from the deck, under the bench, on the side remote from the silent cabinet.

The Low Frequency Iron Core Inductance.

This instrument is screwed to the under side of the bench, over the transformer.

The Morse Key.

The morse key is screwed down on the right-hand side of the small wooden bench in the silent cabinet, in a convenient position for operating.

The Magnetic Key.

This is mounted on the wooden bench in the silent cabinet, close alongside the morse key.

END VIEW.

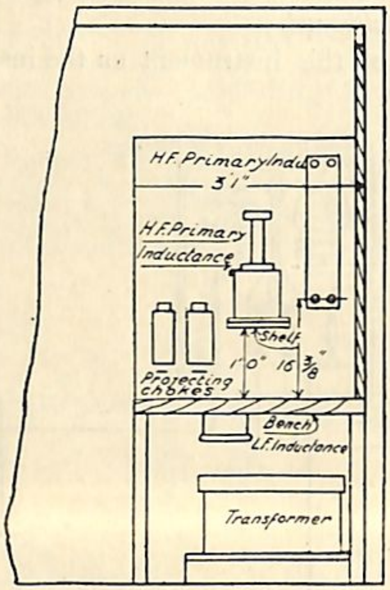


Fig. 27.

ELEVATION

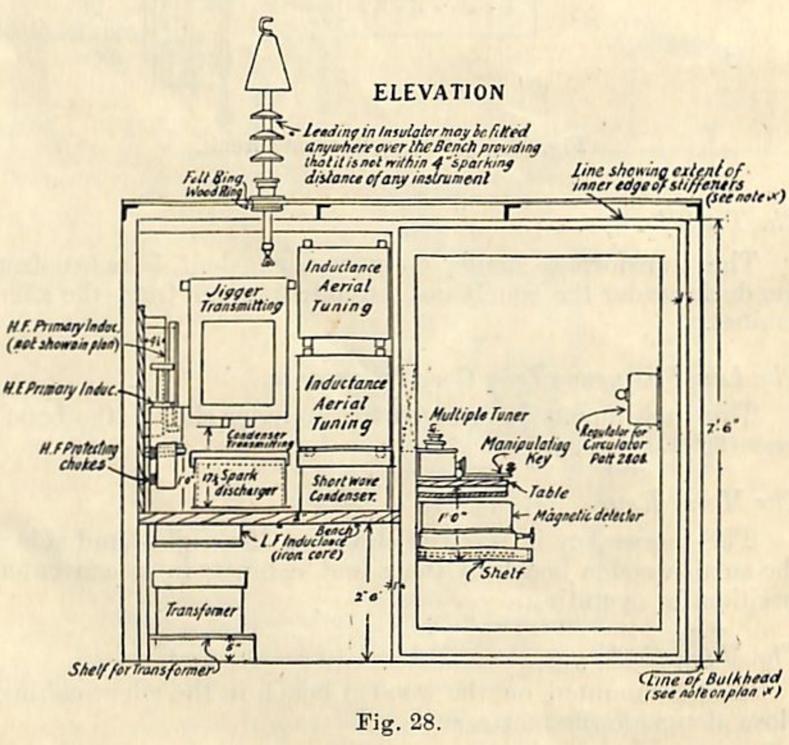


Fig. 28.

Wiring the A.C. Low Tension Circuits. (*See* Fig. 26.)

Leads are taken from the two A.C. terminals at the slip ring end of the rotary converter to the lower portions of the switch on the Iolanda switchboard, the actual connections being at the back of the board. The internal connections of the switchboard have already been described in Chapter III. The A.C. mains leave the board at the lower ends of the two fuses, and are led close together as far as possible, in order to reduce their inductance. One main is taken to the low frequency iron core inductance. From here a lead is taken to one of the primary terminals of the transformer, and from the other transformer primary terminal a lead is taken to the terminal marked "Transformer" on the magnetic key.

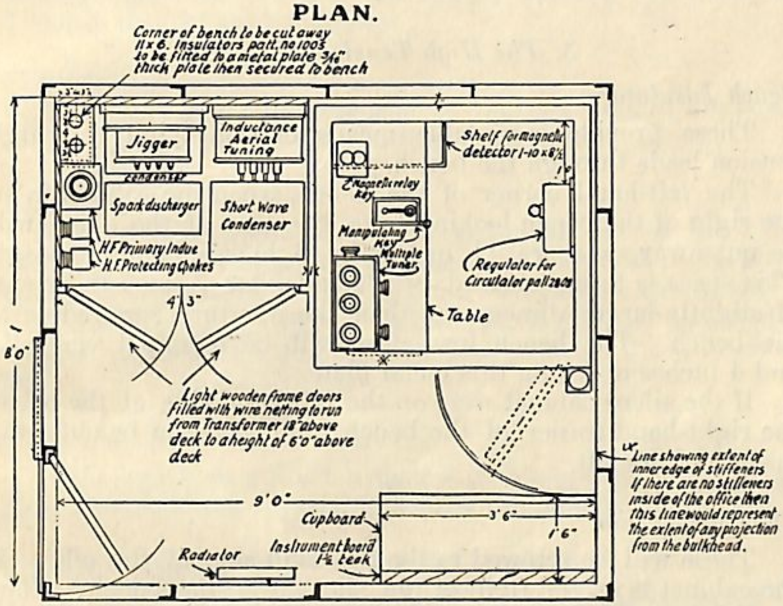


Fig. 29.

Two leads are taken from the morse key terminal marked "Mag. key No. 1" to the magnetic key, one being connected to a terminal marked "Alternator," and the other being connected to a terminal marked "Key 1."

The terminal on the morse key marked "Mag. key No. 2" is connected to a terminal similarly marked on the magnetic key. The terminal at the right-hand corner of the morse key is not required.

The return main to the Iolanda switchboard is taken from the terminal on the morse key marked "Main" to the lower end of the other fuse.

In running these leads, care must be taken that the lead casings of all leads are earthed where they enter the W.T. office.

All lead-cased cables where they enter the silent cabinet must do so at one place, convenient to the majority (such a place is marked ※ in Fig. 29). Here they are clamped by special cable clamps, which are to be screwed to the lead lining of the cabinet, part of which must be exposed for the purpose.

To ascertain which terminals of the low frequency iron core inductance to make use of, run the rotary converter at the correct speed, and connect to different terminals until the maximum spark length is obtained at the spark gap.

When the correct terminals have been decided on, it will be found that if the inductance be decreased, there will be a larger reading on the A.C. ammeter, on pressing the key, but the spark length obtainable will be decreased.

3. *The High Tension Circuit.*

Bench Insulators.

These provide a suitable means of conveying the high tension leads through the bench.

The left-hand corner of the bench, when the cabinet is on the right of the bench looking from the door of the office, will be cut away, a space 11 inches by 6 inches being exposed. This space is to be enclosed by a metal plate $\frac{3}{16}$ inch thick and of slightly larger dimensions than the aperture, screwed on to the bench. The bench insulators will be mounted centrally and 4 inches apart, on this metal plate.

If the silent cabinet were on the left-hand side of the office, the right-hand corner of the bench would have to be cut away instead of the left.

The Choke Coils.

These will be screwed to the left-hand side of the office (if the cabinet is on the right of the office), over the bench. They should be 4 inches above the bench, and there should be 4 inches clearance between them and the frame doors.

To run the High Tension Leads.

Two flexible leads of No. 10 bare copper wire are connected to transformer secondary terminals marked "A" and "B" (*see* Fig. 10), and these are led through the bench insulators to the lower terminals of the choke coils.

Insulators pillar terminal, patt. 465, will be used for running these leads.

From the upper terminals of the choke coils leads are taken to either side of the spark gap.

Care must be taken that the high tension leads are 3 inches apart. It will be necessary to secure them to two porcelain insulators placed under the shelf which supports the additional primary inductance.

4. *The Primary Oscillatory Circuit.*

All the instruments in this circuit will be arranged on or over the bench.

Transmitting Condenser.

The transmitting condenser must be placed on the bench with its shortest side 10½ inches from the left-hand side of the office, and the longer side as far away from the edge of the bench as it will go.

Jigger.

The jigger will be mounted immediately over the transmitting condenser, so that the jigger primary terminals are 2 inches clear of the condenser.

Spark Gap.

The spark gap will be placed so that its longest dimension is close up against the transmitting condenser.

Adjustable Sliding Inductance.

This will be mounted on the left-hand side of the office, overlooking the bench, so that the metal portion of it is not closer than 2 inches to the jigger. To reduce the length of the leads for joining up this instrument, it must be mounted on wooden projections standing out 4½ inches from the side of the office.

Additional Primary Inductance.

This stands on a wooden shelf 9 inches above the bench, and close alongside the adjustable sliding inductance.

To join up the Primary Oscillatory Circuit.

It is essential that the inductance, and consequently the length of the leads in this circuit, should be reduced to a minimum, otherwise it will be impossible to transmit a true 300-metre wave, without reducing the value of the jigger primary, which is very undesirable.

The "0" terminal of the transmitting condenser is connected to the right-hand jigger primary terminal. The other jigger primary terminal is connected to one side of the adjustable sliding inductance, and the other side of that instrument is joined to one side of the spark gap. The other side of the spark gap is joined to the "17" terminal of the transmitting condenser on the same side as the "0" terminal.

All these connections should be made of copper ribbon, the strips being arranged non-inductively as shown is Fig. 30. For the reasons already mentioned, it is very important that this system of connection should be adhered to. Strips of the necessary length, and bent to the correct shape, should be cut

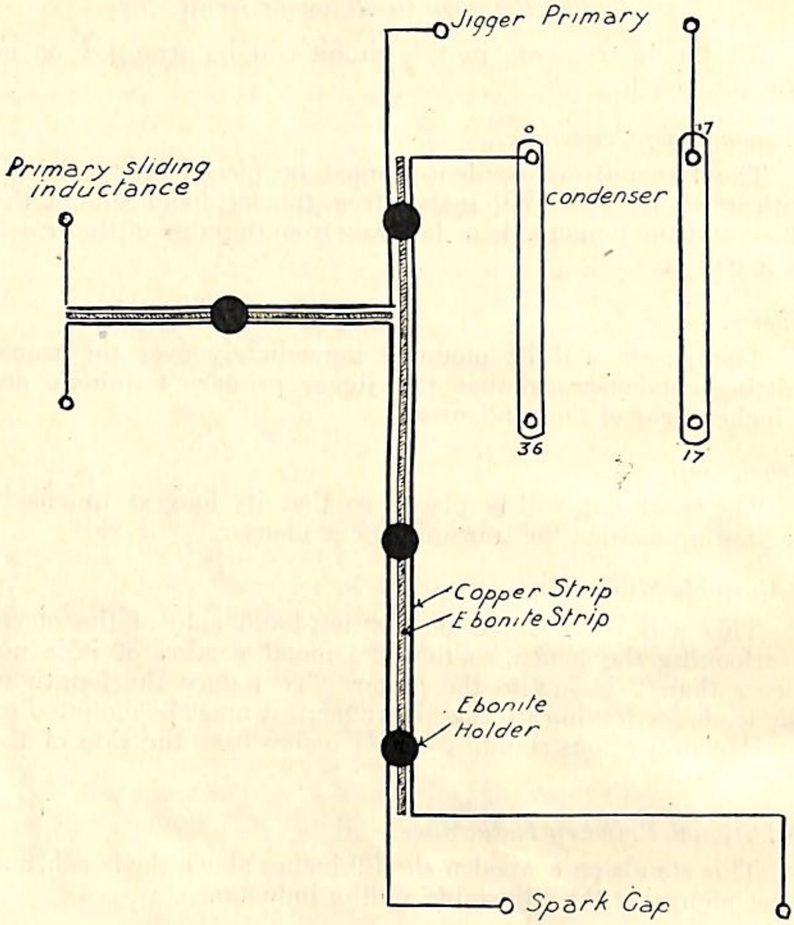


Fig. 30.—Primary Oscillatory Circuit Connections.

Scale ¼-inch to 1-inch.

from the copper sheeting supplied, pieces of ebonite sheeting being placed between the copper strips, the three thicknesses being held together by the ebonite holders supplied.

5. *The Secondary Oscillatory Circuit.* (*See* Fig. 28.)

Aerial Tuning Inductance No. 1.

This is screwed to the wooden lining, so that the body of the instrument is 1 foot above the bench, in the space between the jigger and the silent cabinet.

Aerial Tuning Inductance No. 2.

This is mounted immediately over aerial tuning inductance No. 1.

Leading in Insulator.

The exact position of this instrument is immaterial, but the lower end of it should be at least 4 inches clear of earth, or any instrument. Since the insulator is connected to the tuning inductances, it should, if possible, be so placed that it is over that side of the bench where the aerial tuning inductances are mounted.

Short Wave Condenser.

This is placed on the bench, so that its larger dimension is close up against the woodwork of aerial tuning inductance No. 1.

Earth Arrester Spark Gap No. 1.

This is mounted in the right-hand corner of the silent cabinet, over the small bench.

Earth Arrester Spark Gap No. 2.

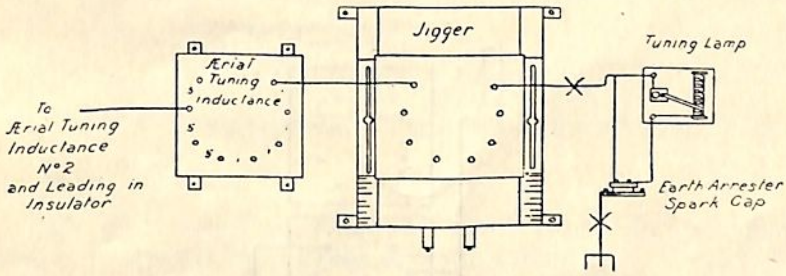
This is screwed to any convenient position on that side of the silent cabinet overlooking the bench.

Tuning Lamp.

This is mounted in the silent cabinet, in front and to the right of the operator's table, in such a position that the lamp can be easily seen.

Joining up the Secondary Oscillatory Circuit.

A special flexible lead consisting of 70 strands of No. 40 L.S.G. copper wire, to one end of which is attached a wooden handled brass plug, is taken from the deck insulator to the required socket of the aerial tuning inductance No. 1.



× Leads which pass into Silent Cabinet.

Fig. 31.—Secondary Oscillatory Circuit.

A second flexible connection with a similar plug at either end connects the aerial tuning inductance with the secondary of the jigger, the earth terminal of which is connected by a similar cable passing through the silent cabinet to the upper plate of earth arrester.

The lower plate of the earth arrester is connected by means of $\frac{7}{16}$ india-rubber V.B. cable to earth, the lead passing through the silent cabinet.

Short ebonite tube insulators are provided for leading the aerial and earth leads through the silent cabinet.

The two terminals on the base board of the tuning lamp are connected to two points, about 6 feet apart, on the wire connecting the earth terminal of the jigger to the upper plate of the earth arrester.

Special Connections for transmitting the 1,000-*metre Wave.*

For transmitting the 1,000-metre wave, it will be necessary to make use of the aerial tuning inductance No. 2 in addition to No. 1.

The spill at the end of the lead from the deck insulator will be placed in the first socket of aerial tuning inductance No. 2, and an additional flexible connection will be taken from the last socket of tuning inductance No. 2, to the required socket of No. 1. In other respects the circuit remains unaltered.

Special Connections for transmitting the 300-*metre Wave from an Aerial whose natural wave length exceeds this.*

For transmitting the 300-metre wave from such an aerial it will be necessary to make use of the short wave condenser.

A lead is taken from the deck insulator, as shown in Fig. 32, to one side of the short wave condenser. The value of the condenser, and so the terminals to be used, will be determined by the tuning officer or engineer. The other terminal of this condenser is connected to earth, through earth arrester spark gap No. 2.

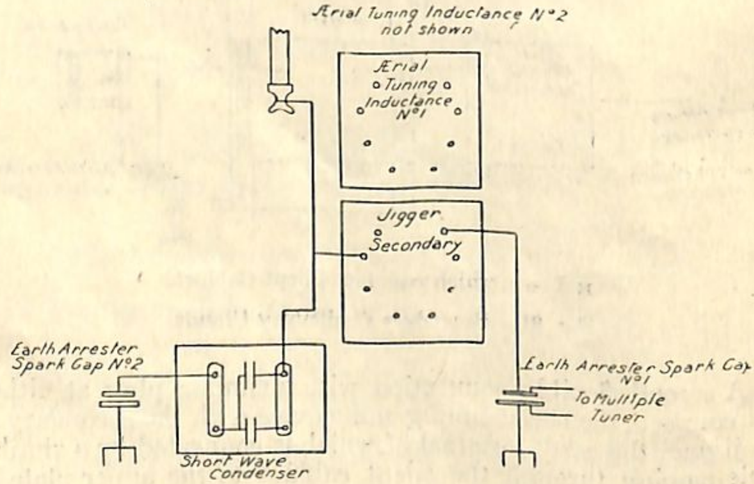


Fig. 32.—Special Connections for transmitting 300-metre Wave.

It may be found best to use none of the aerial tuning inductance, in which case aerial tuning inductances Nos. 1 and 2 will be left out of the circuit altogether, a lead being taken from the deck insulator to one end of the jigger secondary, and from the other side of that instrument to earth, through earth arrester spark gap No. 1. Such an arrangement is shown in Fig. 32.

Use of separate Arresters.

If only one arrester were used, the circuit would be as shown in Fig. 33.

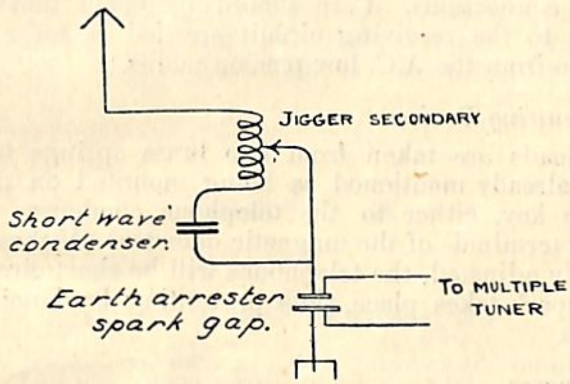


Fig. 33.—Circuit showing the necessity of separate Arresters.

This being a closed oscillatory circuit, an incoming wave having a similar frequency to that of the circuit, would oscillate here instead of passing on to the receiving circuit.

6. *The Receiving Circuit.*

All the receiving instruments are inside the silent cabinet.

The Multiple Tuner.

This is screwed down to the small bench in the silent cabinet, to the left front of the operator's chair.

Magnetic Detector.

This is placed on a wooden shelf, which is attached to the right-hand side of the silent cabinet, 1 foot below the bench.

Telephone Condenser.

This can be screwed up in any convenient position facing the operator's chair.

Wiring the Receiving Circuit.

Two leads are taken from the upper and lower electrodes of the earth arrester spark gap No. 1, to the terminals marked respectively "Aerial" and "Earth" on the multiple tuner.

Two leads are taken from the two "detector" terminals of the multiple tuner, to the primary terminals of the magnetic detector, which are marked "AE" and "E" respectively. The two secondary terminals of the magnetic detector, which are each marked "Tel.," are connected to the two terminals of the telephone condenser, and the telephones are connected to the same two terminals.

Bare copper wire, or stranded insulated wire, may be used for these connections. Care should be taken that all leads belonging to the receiving circuit are led as far away as is practicable from the A.C. low tension mains.

Short Circuiting Device.

Two leads are taken from two brass springs fitted with contacts, already mentioned as being mounted on the side of the morse key, either to the telephone condenser or to the secondary terminals of the magnetic detector. If these contacts be properly adjusted, the telephones will be short circuited just before a spark takes place, thus preventing loud noises in the telephones.

Testing Buzzer.

For testing the receiving circuits and obtaining receiving adjustments, a buzzer and small key and two dry cells are supplied.

The following method of joining these up is recommended:—

Disconnect the high tension leads from either side of the spark gap, and connect in their place two leads (which should be kept as short as possible) from the aerial and earth terminals of the buzzer. Between terminals "B" and "K" on the buzzer, connect the key and one dry cell in series. Put on the transmitting adjustments for one of the waves, and a tight coupling at the jigger.

On pressing the key, the primary oscillatory circuit is set in oscillation. The weak oscillations are imparted to the secondary or aerial circuit, and since the voltage is insufficient to cause a spark at the earth arrester spark gap, these oscillations pass into the receiving circuit.

If the change-over switch on the multiple tuner be now placed in the "Stand by" position, and the handle of the tuner aerial tuning inductance be rotated, a position at which signals are a maximum strength will be obtained.

If the change-over switch be now placed in the "Tune" position, no signals will be heard until all three circuits of the multiple tuner are accurately in tune.

Since the transmitting circuits have been carefully tuned to the three waves used, accurate receiving adjustments can by this means be easily obtained for these waves.

It will probably be most convenient to instal the small buzzer key and cell inside the silent cabinet, within reach of the operator, the leads from cell and key being taken to two French terminals outside the cabinet.

When it is desired to make use of this arrangement, the buzzer will be placed on the top of the spark gap box, and flexible leads taken to the terminals on the buzzer marked "B" and "K," from the French terminals.

If, when obtaining these adjustments, it is found that signals are inconveniently loud, loosen the coupling of the receiving circuits by means of the intensifier handle. If, on the other hand, they are too weak, use two cells instead of one.

CHAPTER IX.

Definitions, Formulæ, &c.

A condenser consists of any number of conductors or "plates" separated by non-conductors or "dielectrics."

The capacity of a condenser is the property it possesses of storing up electrical energy in the dielectrics which separate the conductors. The symbol denoting capacity is "S."

The practical unit of capacity is the farad.

A farad is that capacity which is charged to a pressure of 1 volt, when 1 ampère flows for 1 second.

As this is a very large unit, a smaller one, the microfarad, is more usually met with. The commonest unit of all, however, is the jar. The relation between these three units is as follows:—

1 microfarad - - -	$\frac{1}{1000000}$ farad.
1 jar - - - -	$\frac{1}{900}$ microfarad.

The result of placing two capacities S_1 and S_2 in series is obtained as follows:—

$$\frac{1}{S} = \frac{1}{S_1} + \frac{1}{S_2} = \frac{S_2 + S_1}{S_1 S_2}$$

$$\therefore S = \frac{S_1 S_2}{S_2 + S_1}.$$

The result of placing two capacities S_1 and S_2 in parallel is obtained as follows:—

$$S = S_1 + S_2.$$

The capacity of a condenser varies directly as the area of the dielectric under strain, and the material of the dielectric, and inversely as the thickness of the dielectric.

The inductance or self induction of a conductor is the property it possesses of opposing the starting, stopping, increasing, or decreasing of a flow of current through that conductor.

The symbol denoting inductance is "L."

The scientific unit of inductance is the henry.

When an increase of current of 1 ampère per second through a conductor sets up an opposition of 1 volt, the inductance of the conductor is said to be 1 henry.

As this unit is very large, a smaller unit is sometimes met with, viz., the millihenry. The commonest unit of all, however, is the microhenry.

The relation between these three units is as follows :—

1 millihenry - - -	$\frac{1}{1000}$ henry.
1 microhenry - - -	$\frac{1}{1000000}$ henry.

The result of placing two inductances L_1 and L_2 in series is found as follows :—

$$L = L_1 + L_2.$$

The result of placing two inductances L_1 and L_2 in parallel is found as follows :—

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} = \frac{L_2 + L_1}{L_1 L_2}$$

$$L = \frac{L_1 L_2}{L_1 + L_2}.$$

The inductance of a conductor depends on the shape of the conductor, and on the surrounding medium.

The back E.M.F. across an inductance, measured in volts, depends on—

(*a*) The frequency of the alternating current flowing through the conductor (or the number of times per second that the circuit is made and broken, if the current is intermittent).

(*b*) The value of the inductance.

(*c*) The magnitude of the current flowing.

Resistance.—The practical unit of resistance is the ohm. The resistance of a conductor is said to be 1 ohm, when a pressure of 1 volt causes a current of 1 ampère to flow through the conductor.

The result of placing two resistances R_1 and R_2 in series is obtained as follows :—

$$R = R_1 + R_2.$$

The result of placing two resistances R_1 and R_2 in parallel is obtained as follows :—

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}.$$

$$R = \frac{R_1 R_2}{R_1 + R_2}.$$

Cycle.—A cycle is the completion by an alternating current or alternating E.M.F., of all its values from 0 through maximum positive and maximum negative, back to 0 again.

Frequency is the number of cycles per second.

Period is the duration of one cycle in seconds.

The relation between the frequency of an alternating current and the speed at which the rotary converter or motor alternator producing it is running is—

$$f = \frac{\text{Revolutions per minute}}{60} \times \text{No. of pairs of poles.}$$

Wave Length is the distance between two points in space at which the same action is taking place (or, more simply, the distance between two successive crests of a wave). The relation between the wave length emitted by an oscillatory circuit and the product of L and S in that circuit is—

Wave length in feet $= 206 \sqrt{LS}$ microhenries and jars.

Wave length in metres $= 62{\cdot}8 \sqrt{LS}$ microhenries and jars.

This is the formula always employed for calculating the wave length sent out by the primary and secondary oscillatory circuits.

Units of Length.—The French system of units is the metric system. In this system—

1 centimetre = $\frac{1}{100}$ metre.

1 millimetre = $\frac{1}{1000}$ „

The connection between the British and French systems is as follows :—

1 metre = $39{\cdot}37$ inches.

1 inch = $2{\cdot}54$ centimetres.

CHAPTER X.

The Aerial.

The following articles are supplied for the construction and fitting of the aerial and feeders :—

3 ash spreaders.

2—1,200 feet lengths of 49/28 silicon bronze wire.

12 pairs of ebonite, coned, strain insulators.

8 vulcanised strop insulators, each fitted with $2\frac{1}{2}$-inch shackles.

1 Bradfield deck insulator.

The aerial consists of two silicon bronze wires, supported and kept apart by ash spreaders. If the vessel to be fitted has three masts, and the whole span between fore and main is to be made use of, three spreaders will be necessary, otherwise two will be required.

In deciding the length of the aerial the main consideration is to be able to transmit an efficient 600-metre wave without a large amount of aerial tuning inductance in the office, this wave being the one generally in use.

In Royal Fleet Auxiliaries, therefore, it will generally be advisable to put up as long an aerial as possible, provided that in doing so it is not brought very close to the funnels or earthed objects.

The points at which the feeders join the actual aerial will depend largely on the position of the W.T. office and of ship's funnels, stays, &c.

From the point of view of the aerial leads the best position for the W.T. office will be just before the funnel, as then trouble will not be experienced with hot funnel gases, &c. The feeders can then generally be connected to the aerial at about the centre. Such an aerial is commonly referred to as a "T" aerial.

Where the W.T. office, however, is abaft the funnel, and the masts are low, it will probably be necessary to bring the feeders from one end of the aerial. Such an aerial is commonly referred to as an "L" aerial.

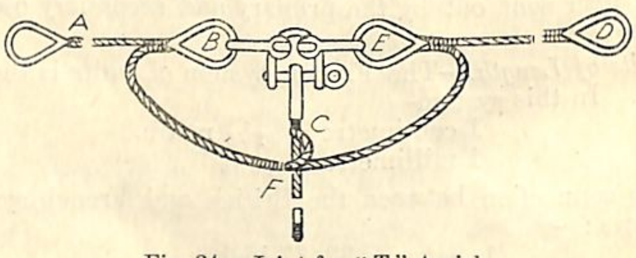


Fig. 34.—Joint for "T" Aerial.

Where the latter type of aerial is used, the aerial and feeders may consist of complete lengths of wire without joint; where the "T" type of aerial is employed, joints will, of course, be necessary. Fig. 34 shows the method of making these joints. The advantage of this form of connection is that all strain is brought off the point of junction. In soldering, do not overheat the wire, as this weakens it.

Where the "T" type of aerial is employed there is less liability for the spreaders and the aerial assuming a vertical instead of a horizontal position. Where this occurs, insulated downhauls, or steadying guys, will have to be used.

A bridle of $2\frac{1}{2}$-inch tarred hemp rope, fitted at the ends with a thimble, is connected, either direct to the lugs of the spreader bands or else to the ends of the strop insulators, the other ends of which are attached to the spreader. The bight of the bridle is fitted with a thimble, and the length of the rope is such that the distance between the bight and the spreader is not more than 6 feet or less than 3 feet.

Fig. 34 shows the arrangement of spreader and bridle. The aerial halyards are attached to the thimble in the bight of the bridles and are passed through the blocks.

Where it is of importance to make use of every inch of the distance from fore to main, in order to put up a good aerial, the strop insulators may be placed in the bridle, in which case the aerial wires will stretch from spreader to spreader, otherwise the strop insulators had better be placed between each end of the aerial and the spreaders. In either case the ends of the aerial wires will be fitted with thimbles to facilitate connection at the ends.

In constructing the aerial, measure the distance between the masts and subtract from this 5 per cent. for the stretching of the wire, and 14 feet allowance for the space taken up by the bridles. If the strop insulators are placed in the space between the masts an additional 3 feet must be deducted. An allowance of 6 inches must be made for each thimble fitted.

The length of the feeders will have to be roughly calculated. If the height of the mast is ascertained this should present no difficulty, but allowances may have to be made for staying out. When the aerial is hoisted the feeders are cut to the required length and connected to the top of the deck insulator, as much strain as possible being taken off the point of connection by means of insulated guys.

For insulating outhauls, guys, &c., the ebonite coned rod insulators should be used, and they should be fastened in such a manner that, when in position, the cone points upwards so that the cone protects the insulator from getting wet.

Bradfield "Leading-in" or "Deck" Insulator.

Fig. 35 shows a section of this instrument. A $\frac{1}{2}$-inch steel rod M passes through a long ebonite tube N of $1\frac{1}{4}$ inches external diameter Each end of the rod is threaded, the lower end being fitted with a brass end piece supplied with a butterfly nut O and the upper end with a shackle head P, a double terminal brass lug Q, and locking nuts. A zinc cone Z is fitted over the steel rod, and rests on the top of the ebonite tube, being held in position by means of the locking nuts, the joint being made watertight by an asbestos washer. The use of the zinc cone is to keep part of the insulator dry in wet weather. The anti-spark discs R, which are fitted at intervals along the tube, assist in preventing sparking over the surface of the insulator in wet weather.

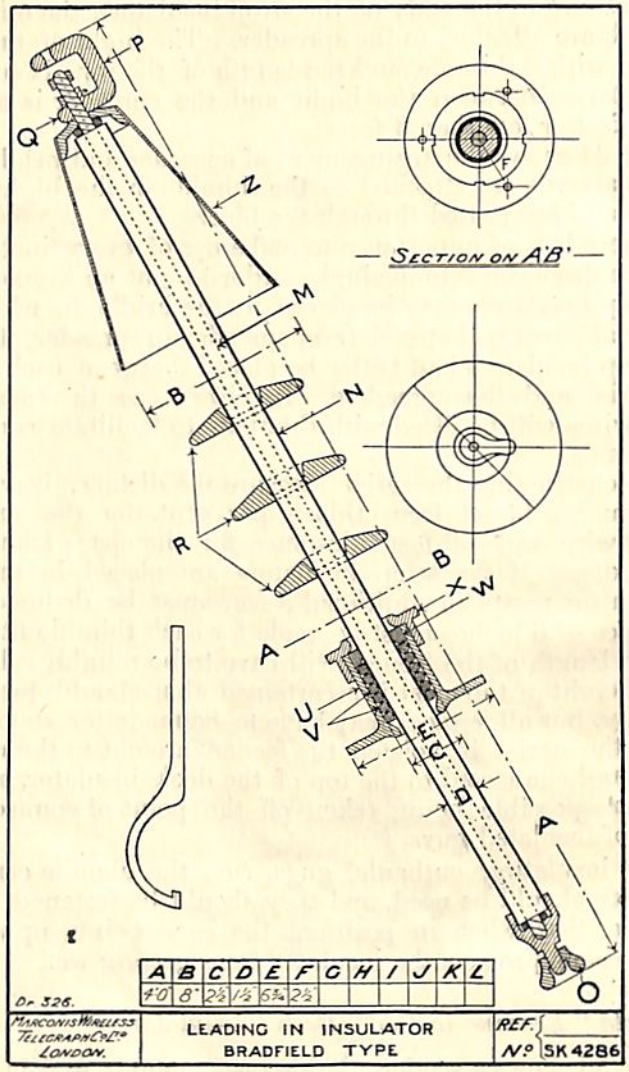


Fig. 35.

The insulator is led into the W.T. office through a stuffing box, which consists of—

(*a*) A hollow brass casting U, through which the tube passes, the space between the inner face of the casting and the tube being occupied by seven asbestos packing rings V.

(*b*) An ebonite ring W, which fits over these asbestos rings, and which, when pressure is brought to bear on it, packs the asbestos rings tight.

(c) A flanged brass ring X, which screws on the outside of the casting, and so presses down on the ebonite ring W.

This brass ring has four notches cut round its circumference, and the gland key shown in Fig. 35 is used to screw it hard home, in order to fix the insulator in a rigid position in the gland.

The casting U is secured to the roof of the office.