O.U. 5327 (3).

W/T RECEIVING HANDBOOK.

CHAPTER III.

TUNERS.

August, 1924.

This chapter is to be kept in the Binder Cover provided.

The fact of its insertion is to be noted in the space provided on the receipt form inside the cover.

The receipt form will also act as the index of contents.

This chapter supersedes O.U. 5159 "Handbook for W/T Receiving Sets, Models C, Ca, Kc, Ke, and L." Chapters 1, 2 (pp. 18–33), 3, 4, 5 and 6, which are to be marked "Cancelled by O.U. 5327 (3)."

ADMIRALTY
(SIGNAL DEPARTMENT),
G. 14294/24.

TUNERS.

I. Model "C."

1. **Introductory.**—This model may be regarded as a typical tuned receiving circuit and consideration of the conditions obtaining in this circuit will be equally applicable fundamentally in the case of all other tuned receiving circuits. Model "C" will therefore be dealt with in detail and the remainder only in so far as they differ in arrangement. The theory of acceptor and rejector circuits is fully dealt with in the W/T Handbook and it will be necessary, therefore, only to describe the circuits and their method of employment.

MODEL "C" CIRCUITS.

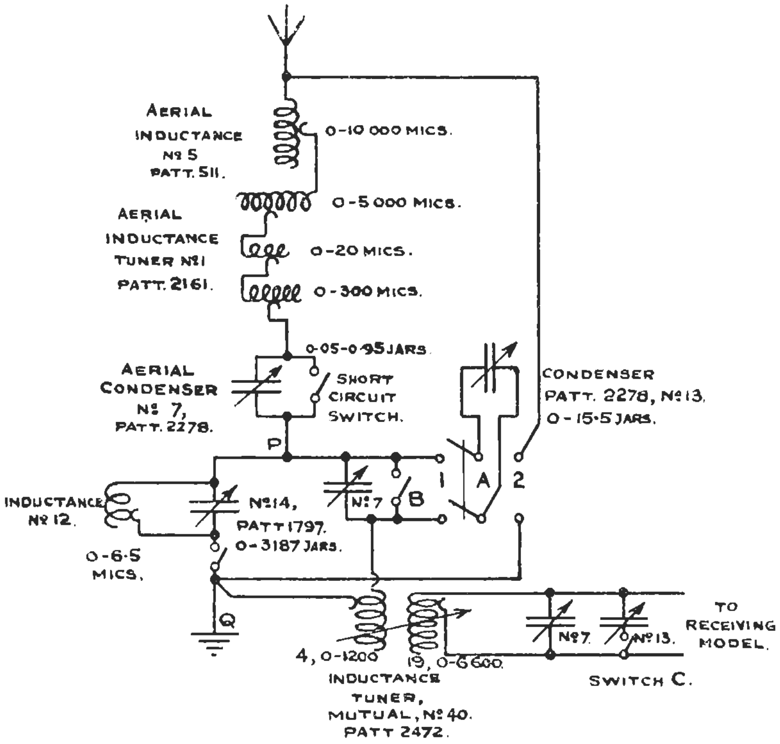


Fig. 1.

The circuit is shown diagrammatically in Fig. 1. It consists essentially of four parts :—

(*a*) The aerial circuit, which includes the aerial transmitting inductances—that is to say, the aerial coil and, in the case of spark sets, the mutual coil, the aerial tuning coil (Nos. 1 and 5), and the aerial condenser (No. 7) inside the cabinet.

(*b*) The acceptor circuit, comprising a variable condenser and inductance.

(*c*) The rejector, consisting of a large variable condenser and a small inductance, which may be placed in parallel with the acceptor.

(*d*) The secondary circuit. This consists of the secondary of the inductance tuner mutual (I.T.M.), a No. 7 condenser and one No. 13 condenser, which may be added in parallel for the reception of long waves. (At present ships have two condensers No. 8 and also one No. 13, giving a total available capacity of $2 \times 0{\cdot}67 + 16{\cdot}4 = 17\frac{3}{4}$ jars approximately, which is far more than would be required. Condensers No. 8 will not in future be supplied after the existing stocks have been exhausted.)

2. **Action of the Circuit.**—The action of these circuits will most readily be understood by considering the switch connecting the rejector to earth, known as the "Red" switch, to be open. Under these conditions the aerial and the acceptor circuits are joined in series and to earth, the secondary circuit being inductively coupled to them.

Each of these circuits is separately tuned to the frequency of the incoming wave to be received. With the "Red" switch open there are two acceptors in series, the two circuits acting as a simple resonant circuit.

Now, it is possible to tune the circuits as a whole to the LC of the wave to be received without tuning the acceptor and aerial circuits separately. Signals can then be received, but only so long as the rejector is left out of the circuit. A glance at the diagram will show that signals cannot be heard with the rejector in unless the aerial circuit and acceptor are tuned—anyhow, approximately—to the correct LC.

The chief uses of the acceptor circuit are :—

In the first place, it allows the use of the rejector, which acts as a drain to frequencies other than that to which it is tuned. Further, the selectivity of the whole circuit may be varied by altering the relative values of the capacity and inductance in the acceptor. It also provides a suitable inductance to which the secondary circuit may be coupled.

The aerial condenser is only used when the wavelength of the signal to be received is shorter than the natural wavelength of the aerial. The condenser acts as a capacity in series with the aerial capacity and so has the effect of reducing the total capacity of the circuit. Normally this condenser is kept short-circuited.

3. **Selectivity.**—The combination of aerial and acceptor circuits admits of a certain amount of selectivity, especially when the acceptor circuit is made as stiff as possible—*i.e.*, maximum of inductance in proportion to the capacity, and when the coupling to the secondary is kept as loose as possible. However, this will not deal with interference from stations transmitting on power near at hand. It is to overcome this that the rejector is fitted.

4. **The Rejector.**—As already stated both the acceptor and rejector are tuned to the LC of the incoming wave. Consequently, the only oscillating voltage to be applied between the points P and Q in Fig. 1 to maintain the oscillatory current is that

required to overcome the effective resistance of the acceptor and secondary circuits combined. So we see that the point P is very nearly at earth potential. When the "Red" switch is made the rejector is put across the point P and Q (earth). For reasons explained in the W/T Handbook we know that if an alternating voltage is applied across a condenser and inductance in parallel, at the particular frequency to which the circuit is tuned, very little current will flow. If the frequency is above that to which the rejector is tuned, most of the current will flow through the condenser, and, if below, through the inductance.

If, then, the rejector is tuned accurately to the frequency of the acceptor, for voltages of the frequency of the acceptor, only a very little current will flow through the rejector and consequently signals will not in theory be reduced in strength.

On the other hand, voltages of frequency differing from that of the tuned circuits will produce large currents in the rejector, which thus makes an easy path to earth. At the same time the currents produced by the same voltage in the acceptor will be very small and the effect on the secondary circuit and the receiver will be very greatly reduced.

The effect, then, of an acceptor-rejector circuit on out-of-tune frequencies is exactly the converse of its action at in-tune frequencies. In the first case, small voltages produce large currents in the rejector and leave the acceptor and receiving gear unaffected; in the second case, small voltages produce large currents in the acceptor for receiving purposes and only a very small current can leak away to earth through the rejector.

The efficiency of the condenser is an important factor of the rejector, as the action depends theoretically on there being no resistance in the circuit. Consequently, with large rejector condenser values which give, of course, the greatest selectivity, there will be a marked falling off of signal strength, usually. On the other hand, a rejector, under certain conditions, will give a distinct increase in signal strength. This is achieved by closing the red switch and tuning the acceptor and aerial accurately to the wavelength. If the aerial and acceptor circuits are thus tuned, the signal strength will probably be greater than that obtained when the rejector circuit is added, but, if the rejector is slightly mistuned to a degree dependent upon the wavelength, the strength will increase above that obtained without the rejector. In this condition the rejector is not working at its best condition for eliminating interference normally. If the acceptor is slightly mistuned, however, the insertion of the rejector will increase the strength of signals to a degree dependent upon the accuracy with which it is tuned to the correct wavelength. It is sometimes possible on short waves, however, to "bring in" a station by making the red switch and at the same time to clear what had been heavy interference. The quality and pitch of signals are also altered by the rejector, when used in this manner.

Owing to its greater persistence, C.W. is less amenable to rejector elimination than spark.

5. **Description of the Instruments.**—*Inductance No.* 1 (*Tuner, Large*), *Patt.* 2181.—This consists of a variable inductance divided into three parts. Each section is tapped at frequent intervals and will give very nearly mic. by mic. an inductance from 0 to 5,320 mics. except on high values where gaps appear due to tappings being equally spaced while inductance increases as the square of the turns. The three sections have values respectively of 5,000, 20 and 300 mics.

Inductance, Aerial, No. 5, *Patt.* 511.—This inductance is used to supplement No. 1 for long waves. Its values are as under :—

Contact No.	Turns.	Inductance.
0	Start	0
1	83	1,600 mics.
2	130	3,250 ,,
3	173	5,320 ,,
4	212	6,670 ,,
5	250	8,660 ,,
6	286	10,000 ,,

Acceptor Condensers.—These consist of two condensers in parallel—viz., No. 13, which is a mica condenser having values, cut in by switches, of 0·5, 1, 2, 4, 8 jars, and No. 7 (Patt. 2486A) which is an air vane condenser ranging from 0·05 to 0·95 jar. The whole of the acceptor capacity is therefore 16·4 approximately. The graduations on the top of the No. 7 condenser may be taken as approximately accurate.

Inductance Tuner Mutual, No. 40, *Patt.* 2472.—This is made in two parts, that with the primary winding of the acceptor circuit sliding inside that upon which the secondary is wound. The two parts may be separated from each other, and in order to admit of very loose coupling the baseboard is made 11 inches in length. The two windings are tapped, the primary in four points and the secondary in eleven. The values of the coils taken separately from one another are as under :—

Primary.		Secondary.	
Stop.	Inductance.	Stop.	Inductance.
a	40	*a*	190
b	110	*b*	650
c	400	*c*	1,200
d	1,200	*d*	1,700
		e	2,400
		f	3,200
		g	3,800
		h	4,300
		i	5,100
		j	6,000
		k	6,600

When the primary and secondary are coupled the effective inductance is reduced as in the manner of the ordinary transformer and the above values would be too big. Also, when adjusting these circuits in practice, it will be found that as the coupling is tightened the value of the secondary condensers will have to be decreased. This is on account of the mutual capacity of the two coils which acts as if it were in parallel with, and therefore adding to, the secondary LC.

Rejector Condenser No. 14, *Patt.* 1797.—This is a mica condenser consisting of separate blocks which can be put in parallel by means of switches. The values of the various components are 4, 8, 25, 50, 100, 200, 400, 800, 1,600 jars (approximate values).

Rejector Inductance—Inductance Adjustable, No. 12, *Patt.* 2279.—This is in two parts which comprise a coil having 18 tappings and a multi-contact switch, and having values by practically equal steps from 0·4 to 5·5 mics. This coil is in series with a copper ring fitted with a radial rotating arm, so that any arc of the ring may be included in the tuning. The inductance of the arm varies from 0·09 to 0·5 mics. A short-circuiting switch is fitted so that the coil may be cut out of the circuit if required. The great point about this part of the circuit is that the resistance must be kept low. Fig. 2 shows the inductance of a typical rejector.

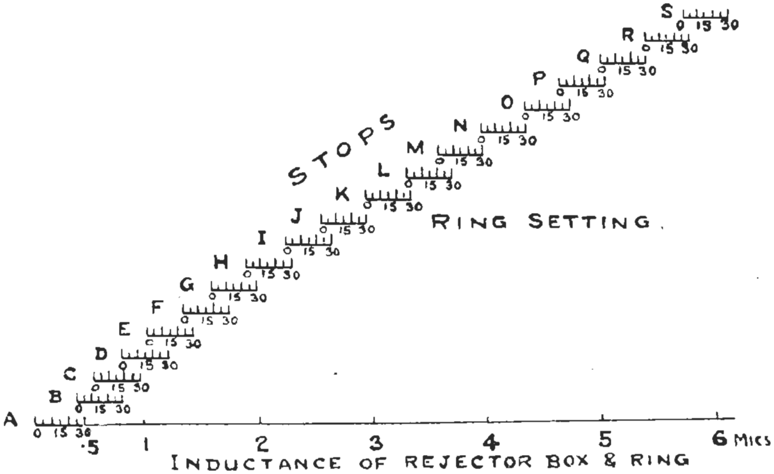


FIG. 2.

Crystal Detectors.—Crystal detectors are obsolescent in the Service. As destroyers are still fitted, however, to save their batteries which cannot always be put on charge when necessary, a short description of the set is given. The rectifying action of crystals and the function of the potentiometer are dealt with fully in the W/T Handbook and it is therefore necessary only to describe the particular articles supplied and to add notes on their practical management.

Detector and Switch No. 2 fitted, Patt. 1186.—This consists of two instruments :—

(*a*) Detector, Dennis, Patt. 309, or Detector, No. 3, Patt. 309A, and Patt. 4657 Switch 3 Contact.

(*b*) Switch, protecting, No. 2, Patt. 1138.

Detector, Dennis, Patt. 309.—This is arranged to hold three crystals, any one of which can be put into the circuit by means of a plug. This article is obsolescent.

Detector No. 3, *Patt.* 309A, *on Patt.* 1406 *base, and Patt.* 4657, *Switch* 3 *Contact*, is similar to Patt. 309, but is arranged with switches instead of plugs to connect any individual crystal, and the crystal holders being insulated from one another to allow of balanced crystal working.

Each detector consists of a brass cup containing the carborundum crystal secured to the body of the holder, and a steel-rounded point mounted on a spring.

The carborundum is fitted centrally in its cup, but the cup is mounted eccentrically on the spindle securing it to the body of the holder, thus allowing the contact to take place on any part of the carborundum. The pressure is regulated by the ebonite-head adjusting screw.

Replacing Detector Stones.—This can be done by removing the cups, and fitting in new stones as required.

Carborundum is supplied in small crystals ready to be inserted into the cup of the detector holder ; the marked end should be inserted into the fusible metal. The steel point in use must be kept clean and free from rust.

Trials having shown that carborundum is the most reliable crystal, owing to the fact that it is sufficiently sensitive and very stable, it has been introduced into the Service as the standard detector.

The carborundum is selected in H.M. Signal School and is issued to ships as crystal "D."

When fitting the crystal, if the sensitive point cannot be found at one end of the crystal, the crystal should be reversed in the cup. When once adjusted on a really sensitive point the detector should not need adjusting for some considerable time, and it should be touched as little as possible.

Care must be taken not to break off the points of the crystal, as although carborundum is a very hard substance, it is at the same time rather brittle.

Choice of the Crystals and Contact.—This is of the greatest importance, but no definite rules can be laid down. The best results are usually obtained with close-grained carborundum—that is, pieces in which the constituent crystals are small and packed closely together. Pieces chipped from the mass in such a way that one end is "fused"—that is, has a fine crystalline structure on the outside of the blocks—usually give good results when the "fused" end is embedded in the fusible metal.

The steel which is in contact with the carborundum may be a flat surface, a rounded or sharp point. A rounded point appears on the whole to give the most satisfactory results. It may be noted that copper, brass, and graphite have also been used instead of steel with good results.

A sensitive point is usually one of medium resistance. Very conductive points, or ones of very high resistance, rarely give satisfactory results. The mechanical pressure between the steel and the crystal should be adjusted for the best results, and is generally greater than that required with any of the zincite combinations.

Holders for the crystals in which the crystal is merely clipped between the springs are not satisfactory. It is important that the crystals should be mounted in fusible metal in such a way that there is a large area of contact between the metal and the crystal. A very low resistance contact between the fusible metal and the crystal appears to be quite as important as the choice of the point of the crystal in contact with the steel. The length of the crystal should not be too great, as the resistance of the body of the crystal is probably of no assistance to the rectifying action, and should therefore be reduced as far as possible.

As at present arranged, carborundum crystals are being issued under the name of "Crystal D" in boxes of four tested crystals; one box to each Patt. No. 309 holder. These crystals have been tested before issue and found to be up to the standard strength. The end of the crystal to be embedded in the fusible metal is indicated by a small paint mark. Great care should be taken to see that the crystals are put into the holders the right way about, as very few of them give good results when reversed.

In the event of no sensitive points being found on the crystal, or if it is of an inconvenient size, the end of the crystal should be broken off. Some care is necessary in breaking off an insensitive point so as to leave a clean crystalline end to the crystal. To simply cut off the end with a pair of pliers is not generally satisfactory, as it leaves a flat shiny surface, consisting of a mass of crystals which have been broken transversely. A better method is to apply the cutting edge of the pliers diagonally, removing the crystal from the cup as necessary. A new surface can then generally be got with projecting crystals whose points have not been broken off. The cutting should be done in such a way that the new crystalline points do not scrape the side of the jaws of the pliers. If they do they are apt to scrape off minute particles of iron which stick on the points and render them insensitive. After a good point has once been obtained care should be taken not to damage it. Actually, the crystals are generally very robust and with reasonable care in handling no damage should be done.

Increasing the mechanical pressure at the contact usually tends to reduce the potentiometer voltage required.

The adjustment of the No. 7 condenser varies slightly with the different crystals—a matter of one or two divisions on the condenser scale.

A rough method of finding the sensitive potentiometer adjustment is to move the potentiometer slide along until a well-marked "click" is heard in the telephones when the switch or plug in the detector holder is put in and out. The best adjustment is the one corresponding to the point at which the loudness of this "click" first starts to increase rapidly.

The crystal "D" is very insensitive to an untuned testing buzzer, but can be best adjusted with a tuned buzzer circuit, or by signals.

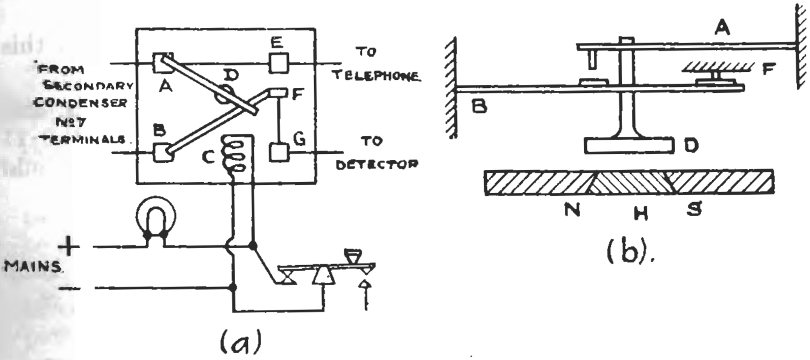
The potentiometer adjustment is in most cases critical. With some stones there are two possible adjustments of the potentiometer, one being much better than the other.

The working faces of the crystal must be kept dry and free from grease. They must not, therefore, be touched by the fingers when adjusting the contacts.

Switch, Protecting, No. 2, *Patt.* 1138.—The protecting switch consists of an electrically operated switch enclosed in a metal case fitted with a plate-glass top and mounted on a wooden base.

The switch is designed not merely to break the detector circuit but also to short-circuit and earth the secondary of the induction tuner, so that the condensers cannot become permanently charged above earth potential.

SWITCH, PROTECTING, No. 2 PATT. 1138.



A.—Spring Contact carrying Armature "D."
B.—Spring Contact.
C.—Magnet Coil energised when Key is pressed.
D.—Soft Iron Armature.
E.—Terminal common with "A."
F.—Terminal and Fixed Contact connected to "G."
H.—Copper Spacing Block between Poles N & S.

Fig. 3.

Referring to Fig. 3 (*a*) and (*b*), when the electro-magnet is energised the iron armature "D" is attracted, causing the spring contact "A" to make contact with the spring contact "B." This short-circuits the detector and receiving circuit. The armature "D" being still further attracted, the contact between the spring contact "J" and the fixed contact "F" is next broken, which breaks the circuit to the detector; finally the armature "D" is brought up on the face of the electro-magnet, thus earthing the receiving circuit and one pole of the detector at this point. When the current to the electro-magnet is broken the above operation takes place in the reverse order. The break in the detector circuit takes place in one pole only, but since the other pole is earthed, this is satisfactory. Owing to this fact, however, it is particularly important that the detector and switch shall be connected up correctly, *i.e.*, exactly as shown in the diagram, so that the lead from the telephone condenser, which would in any case be at approximately earth potential, is connected to that pole of the detector which is earthed, and not to that pole which is broken.

To prevent the switch from sticking down after the current to the electro-magnet is broken, the iron armature "D" is faced with thin sheet copper, which is soldered to it. The thickness of this copper sheet is so adjusted that when sending very rapidly with the Morse key the protecting switch does not rise to the receiving position, excepting in the longer intervals between letters. By carefully grinding the copper face of this armature a little on a flat surface with fine emery, the switch can be made still more sluggish in rising. All switches, however, will be adjusted before being sent out, and one of the chief advantages of the switch is considered to be the fact that it should scarcely ever need re-adjusting or altering.

Paper should never be inserted under the armature as this prevents the circuit being earthed.

The coil used in the switch is the same for all voltages, and is approximately 280 ohms resistance. It requires about 0·11 of an ampere to operate it, and the series resistance lamps should be as follows :—

In an 80-volt ship	-	One $2\frac{1}{2}$ c.p. 80-volt lamp.
In a 100-volt ship	-	Two lamps in series, each lamp being an 8 c.p. 100-volt.
In a 220-volt ship	-	One 8 c.p. 220-volt lamp.

The above figures for the series lamps apply only to those cases in which the new protecting switch is the sole instrument being operated from the toe contact of the Morse signalling key.

Arrester for protecting Receiving Circuits, Patt. 4939.—This is an adjustable safety gap, which is supplied to replace the break-down fuze.

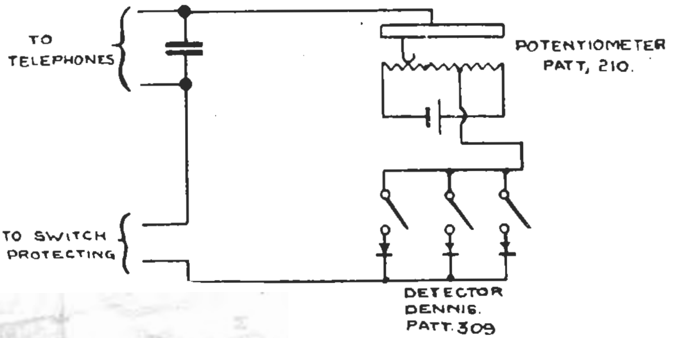
Potentiometer, Patt. 562.—Is of 250 ohms resistance approximately.

The insulation of the cells is an important item, and the cells should be mounted on a piece of ebonite at least $\frac{1}{4}$ inch thick.

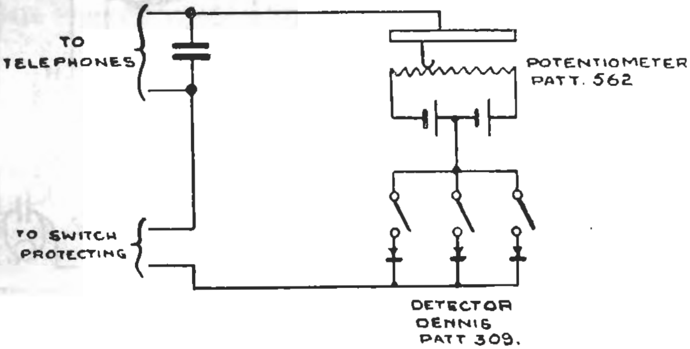
A distance of at least ¼ inch must be maintained between the case of the shell, or any metal strap securing the cell, and earth.

METHOD OF WIRING POTENTIOMETERS.

Patts. 210 and 562.



A.



B.

FIG. 4.

Fig. 4 shows one potentiometer of each pattern joined up, though some ships may have two of Patt. 210 or two of Patt. 562.

The new potentiometer is operated by means of a rack and pinion, with the result that an exceedingly fine adjustment can be made.

Copper Strips forming Receiving Leads.—In the Type 1 W/T offices, where only one silent cabinet is fitted and the new pattern operating switch and cabinet switch are fitted, two parallel strips are arranged to form the receiving leads (aerial and earth) between the deck insulator and the silent cabinet. When transmitting, these copper strips are short-circuited by means of the operating switch at the one end and the cabinet switch at the other end.

In Type 1 W/T offices, where two silent cabinets are fitted, three parallel copper strips are arranged to connect the one silent cabinet with the other. Midway between the two silent cabinets, these three copper strips are coupled up to two copper strips from the deck insulator, by means of the somewhat complicated system of link connections shown in Fig. 5. The three copper strips are supported at intervals on Patt. 1133 porcelain pillars in the same manner as are the two copper strips in the older W/T offices.

COPPER STRIPS FORMING RECEIVING LEADS.

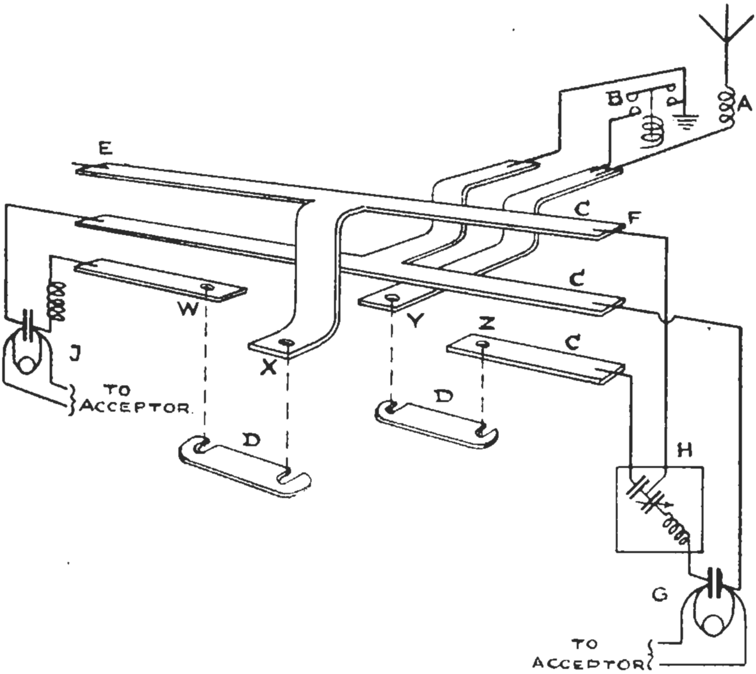


FIG. 5.

The object of this particular arrangement of receiving connections is to render it easy for the ships to fit their main reception in either silent cabinet and to tap off their second reception at the correct point.

Referring to Fig. 5, when the links " D " connect " W " to " X " and " Y " to " Z " the main reception is in the silent cabinet at the right-hand side of the sketch. If now the links " D " be arranged to connect " W " to " Y " and " X " to " Z " then the main reception can be transferred to the silent cabinet at the left-hand side of the sketch, in which case, of course, the double reception box " H " would have to be transferred to the other silent cabinet.

The introduction of the three copper strips described necessitates a special cabinet switch to connect the three strips together at each silent cabinet. This switch will be supplied to ships fitted with two cabinets fitted for double reception.

Other ships will be supplied with the ordinary cabinet switch, Patt. 1923.

6. **Wiring of Model " C."**—The detailed lay-out and wiring for cabinets and central receiving rooms is given elsewhere, but certain points should be borne in mind when wiring up sets.

It must be noted in particular that the lead from the aerial condenser be taken straight to the common bar of the rejector, although it is, electrically speaking, connected directly to the acceptor condenser. If the instruments are not wired in this way the extra lead from the acceptor condenser to the rejector will be put in series with the latter's inductance and will make adjustments for short waves, or on large condenser values, unreliable.

The lead from the earth terminal of the primary of the Inductance Tuner Mutual to the earth block of the rejector should be run close to the lead from the rejector to the acceptor condensers. The object of this is to minimise its inductance. This lead must be taken from the right-hand terminal facing the switch.

Secondary circuit leads should be as short as possible, and the right-hand terminal should always be connected to the grid of the receiving model.

Bare copper wire of large gauge is the most suitable for making receiving instrument connections.

7. **Practical Use of Model "C."**—There are three ways by which the circuit may be tuned to a given wavelength. Firstly, if the wavelength is known, reasonably probable adjustments may be set by calculation and improved as soon as the station is heard. Secondly, by means of the wavetester, and thirdly by means of the heterodyne unit K5.

To take the case where no apparatus for tuning is available, and only the roughest idea of the wavelength is known.

See that the red switch is broken. Remember that to pick up a signal the circuit should be made as unselective as possible and that to make the weak signal produce as much current in the secondary as possible, the step up should be large and the coupling fairly tight. The aim, then, is to arrange a balance of these three factors to give the best probability of hearing the signal.

Use large condenser values and small inductances. Use a low stop on the primary of the I.T.M. and a medium stop on the secondary.

Knowledge of the LC value required will give an idea of the value at which to set the acceptor condenser. If the wave to be received is shorter than that to which the transmitting aerial is set, the aerial condenser must be brought in. If not required, it must be short-circuited. If the wave is between 300 and 2,000 metres, a 10-jar adjustment on the acceptor condenser is recommended while the whole of the condenser should be used to pick up longer waves than this. Put the primary on "A" stop for waves under 2,000 metres, and to "B" for those longer up to about 4,500, and "C" beyond this. Set the secondary at 0·2-jar on the condenser, and "D" on the secondary of the I.T.M. for waves under 1,000 metres, and about "H" or more for waves over this. This will give a good step up. Then alter the Aerial Tuner until signals are heard. The secondary condenser should be varied at the same time to give a larger range of search. When the signals have been picked up and brought up to greatest strength by the tuner and secondary condenser, note the value of the latter, as that multiplied by the value of the inductances of the secondary of the I.T.M. will give an idea of the LC of the wave.

Re-tune the acceptor to this value and tune the tuner and secondary condenser again to increase signals, and then close the red switch. Set the rejector condenser at about 50 to 200 jars and try to pick up signals. If they cannot be heard at any position on the inductance, work the aerial tuner and acceptor condenser together, keeping signals as strong as possible until they can be heard with the rejector in. Improve the rejector tuning by the inductance ring. If the tuning of the rejector gives a step-up of signals then the three circuits are not strictly in tune, although signals may be quite strong. At times this may be advantageous, although interference is not so effectively eliminated except under exceptional conditions, but for accurate adjustment the three circuits must be adjusted until the rejector has as little effect as possible on the required signal. A slight decrease in strength may be expected when all three circuits are exactly in tune, but the rejector will be most effective under these conditions.

EFFECT OF INTERACTION OF COILS IN I.T.M.

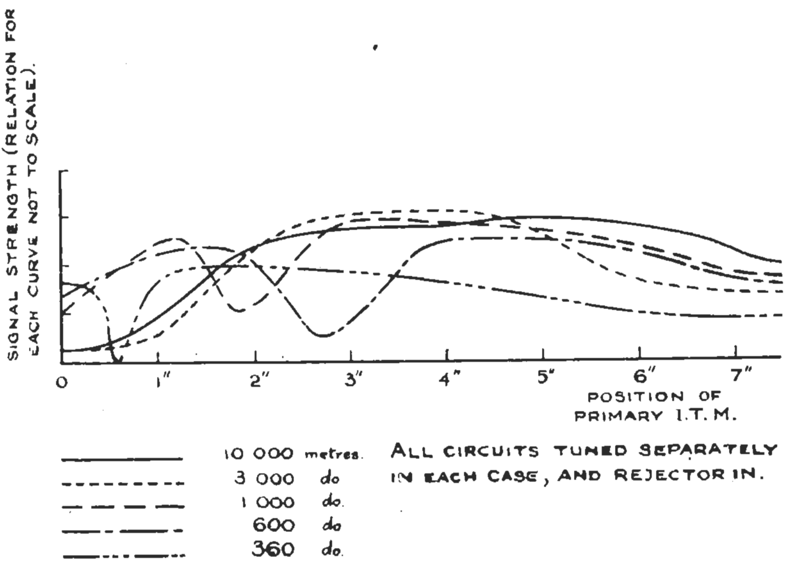


Fig. 6.

The interaction of the two coils of the I.T.M. is rather complicated. Inside about $3\frac{1}{2}$ inches the field varies at different positions, according to the wavelength and Fig. 6 will serve to show how signals may be lost entirely owing to coupling, although all circuits are correctly tuned and the positions of the coils would lead to the supposition that the coupling was about "medium tightness." Beyond this the shorter waves apparently have another point of minimum signals in the case of a 600-metre wave, this is about 7 inches.

Therefore, it is best to set the primary about 3½ to 5½ inches out, according to the expected strength of signal, and to move it about during the operations to make sure that it is not set on one of these dead points. It must be remembered that movement of the primary inside about 5 inches will necessitate a readjustment of the secondary condenser for reasons already explained. Having obtained maximum signals, it remains to increase the selectivity. Therefore, increase the rejector capacity, and the acceptor inductance (if this is not already a maximum) loosen the coupling (take the primary right out and bring it in again to be sure that dead spaces are not affecting the signal strength), increase the capacity in the secondary and decrease the secondary inductance in proportion, as this will also have the effect of reducing the effective coupling. Of course, the greater the selectivity of the circuit, the greater will be the losses of energy, as the ohmic resistance is being increased by the added inductance and the mutual inductance is also reduced by the loose coupling. Further, with a big rejector condenser, the inefficiency of the mica has an appreciable effect in reducing the available energy.

A point which calls for careful attention is the cleanliness of the contacts of the multi-contact switches.

Any bad contact or dirt at these points will not only reduce the current, but also the selectivity. Aerial Tuner No. 5 is a fruitful source of trouble from this direction.

8. **Tuning by Means of Heterodyne Unit K5.**—(*See* Chapter IV.)

TUNING MODEL OUTFIT "C"
BY MEANS OF HETERODYNE UNIT K5.

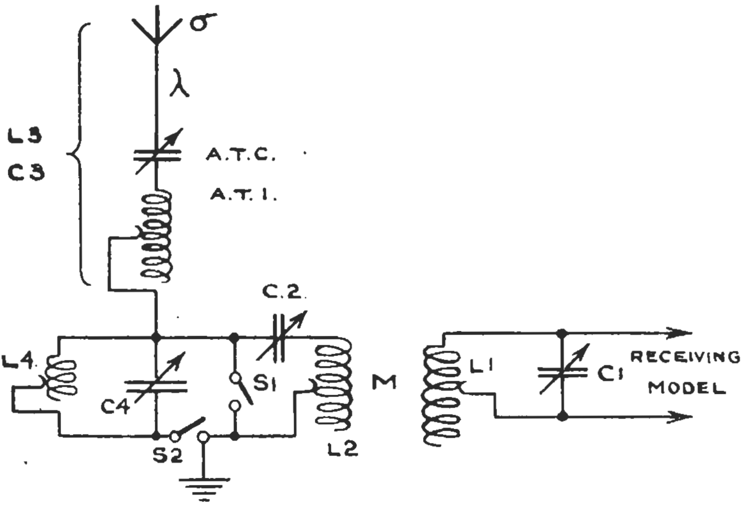


FIG. 7.

Fig. 7 represents diagrammatically the Model " C " circuits.

L1 is the secondary of the I.T.M., C1 the secondary capacity.

L2 is the primary of the I.T.M., and C2 the acceptor capacity.

L3 is the aerial tuning inductance plus the aerial inductance.

C3 is the aerial tuning condenser plus the aerial capacity.

L4, C4 is the rejector circuit. S2 is the Red Switch.

S1 is any switch by means of which the acceptor may be short-circuited when required.

M represents the degree of coupling of the I.T.M.

To tune Model " C " to any given wavelength, switch on the receiver and get K5 oscillating at the required frequency, using the buzzer. Push the primary coil of the I.T.M. as far away from the secondary as possible, and place the coupling coil of the K5 about 4 inches from the end of the secondary coil and in the same plane. Tune L1 C1.

Next tighten the coupling " M," open S2, close S1, couple the K5 coil to Lii and tune L2 C2. Make acceptor as stiff as possible, that is, the acceptor is tuned as a closed oscillator. Then open both the switches S1 and S2, couple K5 to the aerial tuner—placing the coupling coil on the top if convenient—and tune L3 C3.

Finally close Sii and tune L4 C4 and then find the best value for " M." As the correct tuning is approached, to get finest tuning the strength of the oscillations should be reduced, either by holding the coil farther away or by rotating the plane relative to the coil affected. The operations here described must be carried out in the order specified to enable each circuit independently to be tuned to the correct wavelength.

When tuning with heterodyne there are a few points which may be overlooked. The first is the position of the coupling coil when tuning each circuit, for the strength of the heterodyne signal not only depends on the proximity of the coil to the inductance of the circuit under adjustment, but upon the relative angles of the axes of the two coils. Consequently the strength of the signal may be varied at will by rotating the coupling coil, but this may also be rotated accidentally, if held in one hand while the adjustments are being made with the other. Hence change in signal strength may be attributed to the adjustment when in reality it is simply the coil which has been moved. The best results are obtained when tuning the primary by increasing its inductance to a maximum, when a very good tuning point can be found on the No. 7 of the acceptor. To pick up signals after tuning, this circuit may be made less selective if necessary, but for the purpose of getting adjustments it is most convenient to keep it stiff. It is then much easier to get the rejector correction. The position of the coupling coil when tuning the aerial is a matter of importance. If the coil is placed on the top of inductance No. 1, maximum signals are obtained when it is in the middle of the box; if it is put over to one side it is quite possible that practically nothing will be heard at all or, at any rate, only very weak signals. This, of course, gives a simple way of reducing signal strength. The coil, if not in the centre of the box, must not be pushed over towards the rejector, as that circuit is very easily influenced from comparatively large distances. With the coil on the desk, strong signals can be picked up on the rejector which cannot be heard without it.

When using buzzer, Heterodyne K5 with the old tuned anode circuit gives two distinct waves and it is important that when tuning in, the same one be taken in each adjustment. They will be found very close together when tuning the acceptor but the difference of adjustment on the No. 7 of that circuit will be quite sufficient to throw out the tuning with the rejector. The new models have a tuned grid and the double peak does not occur.

9. **To receive very long waves.**—Switch "A" in Fig. 1 is put over to position "2" thus putting the acceptor condenser No. 13 in parallel between the foot of the aerial and earth—increasing the capacity of the whole circuit. Switch "B" is made thus short-circuiting the acceptor fine tuning condenser No. 7 and putting the primary of the I.T.M. in series directly with the aerial inductance. Switch "C" puts condenser No. 13 in parallel with the secondary condenser No. 7 and thus can give a total capacity to the secondary circuit of about 16·4 jars. (At present this capacity is made up of two condensers, No. 8 (0·67) and one No. 13.) These necessitate extra switches. The fact that the No. 13 condensers are mica and the No. 8 condensers are air, leads to slight reduction in efficiency but this is not commensurate with the greater simplicity of the circuit.

The theory of this arrangement is somewhat complicated, but it shows that for the greatest efficiency the transmitting aerial coil should be omitted from the circuit.

10. **Double Reception.**—*Principles Involved.*—In order to avoid confusion as to the circuits referred to in these notes, a specific case is taken. It is assumed that a 1,000-metre wave is being received on the main set of receiving instruments and that a 2,000-metre wave is being received in the second set. Also, the case is discussed from the point of view of signals on the 1,000-metre wave being more important than signals on the 2,000 metres.

The notes can be applied to any two waves which it may be desired to receive. Of these waves, the more important wave will be received on the instruments which in these notes are regarded as receiving on the 1,000-metre wave; the less important of the two waves will then be received on the second set.

Fig. 8 shows diagrammatically the aerial and acceptor circuits of Model "C" receiving instruments with the rejector in, the circuits being assumed to be tuned to 1,000 metres. The figures given represent normal working conditions. The resistances shown are, of course, diagrammatic, and represent the resistances of the various sections of the circuit. Suppose, now, that some oscillating current is set up on the 1,000-metre wave and consider

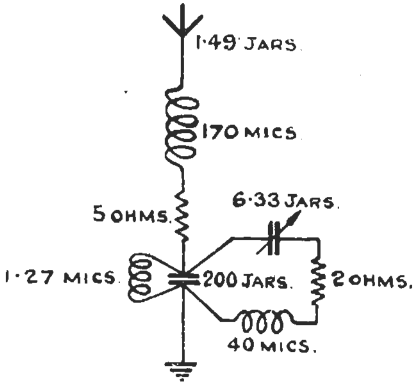


FIG. 8.

the relative voltages between the various parts and earth. A current 1 ampere R.M.S. can be assumed in the aerial for this purpose. To within about 10 per cent. (which is near enough for the purpose of illustration) this will also be the current in the acceptor circuit. Since the acceptor is in resonance the applied voltage, *i.e.*, the voltage across the rejector, simply has to overcome the resistance of the acceptor circuit. That is, the voltage across the rejector will be about 2 volts R.M.S.

The LC value corresponding to a wavelength of 1,000 metres is 253·4. The corresponding frequency is therefore :—

$$\frac{4 \cdot 8 \times 10^6}{\sqrt{253 \cdot 4}} = 3 \cdot 02 \times 10^5.$$

The voltage across the inductance for a current of one ampere is :—

$$2\pi f L = 2\pi \times 3 \cdot 02 \times 10^5 \times \frac{170}{10^6} = 322 \text{ volts},$$

that is to say, the R.M.S. voltage to earth on the aerial side of the inductance is of the order of 160 times the voltage across the acceptor. At a point half-way down the inductance the voltage will be 80 times that across the acceptor and so on.

Consider now how the current on 1,000 metres will be affected if any other path to earth is provided. The amount of current flowing along this new path will depend upon the nature of the path and the voltage across it. Suppose, for example, that the alternative path has a resistance of 100 ohms. If this is put across the rejector, the current will be $\frac{2}{100} = 0 \cdot 02$ ampere, which is small compared to the one ampere assumed. But if this 100 ohms is put across from the top of the inductance to earth, the current will be $\frac{322}{100} = 3 \cdot 22$ amperes; which means that of a total aerial current of about 4 amperes a considerably greater proportion will flow through the new path than through the proper circuit.

The same argument will apply if the new path consists of inductance and capacity. If it is connected to a part of the circuit where the voltage to earth is large, it will rob the acceptor of a considerable proportion of the 1,000-metre wave current.

It therefore follows that if double reception on one aerial is to be used without appreciable interference with the 1,000-metre wave signals, the 2,000-metre wave circuit must be connected to the 1,000-metre wave circuit at a point where the voltage to earth is small.

With the standard Model "C" instruments the only point satisfying this requirement is the aerial side of the rejector. But if such connections were made no signals would be received on 2,000 metres, because the rejector is tuned to 1,000 metres, and is, therefore, practically a short circuit to earth for currents of frequency corresponding to 2,000 metres.

It becomes necessary, therefore, to modify the Model "C" circuit in such a way that a point may be available to which the 2,000-metre wave circuit can be connected. The requirements of this point are that it must be practically earth potential, as far as the currents of 1,000-metre wave frequency are concerned, but it must not be short-circuited to earth for currents of 2,000-metre wave frequency.

These conditions are realised by inserting an additional acceptor either between the aerial inductance and the rejector, or in the earth lead from the rejector. The former is, perhaps, the more convenient, but there is little to choose between the two

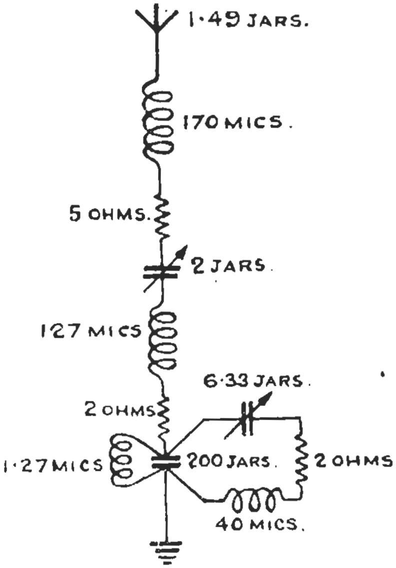


FIG. 9.

arrangements. Diagrammatically, the circuits shown in Fig. 9 now become as shown in Fig. 8. Since the added circuit is an acceptor to 1,000-metre wave, the only added voltage to earth on the aerial side of the two-jar condenser is due to the resistance of the acceptor, and in this case is 2 volts. The more efficient the additional acceptor the smaller this voltage becomes.

The aerial side of the additional acceptor is therefore practically at earth potential so far as the 1,000-metre wave oscillations are concerned.

Now consider the path to earth and its effect on signals on 2,000-metre wave. The frequency of the 2,000-metre wave is about $1 \cdot 5 \times 10^5$ cycles per second. The additional acceptor is thus very much out of resonance for the 2,000-metre wave, and it follows that from the point of view of the leakage of 2,000-metre wave current, the aerial side of the additional acceptor condenser is a suitable point at which to connect up 2,000-metre wave-receiving instruments.

The same results follow if the additional acceptor is in the earth lead from the rejector. The 2,000-metre wave connection is then taken from the aerial or earth side of the rejector. The added acceptor again forms a barrier to 2,000-metre wave current, but not for the 1,000-metre wave current.

The method of inserting an additional acceptor is the one always employed for double reception. The complete circuits are as shown in Figs. 10 and 11, the latter referring to the case in which the additional acceptor is in the earth lead from the rejector instead of on the aerial side of it. As far as the point "A" the aerial is tuned to 1,000-metre wave, then in the 1,000-metre wave circuit there is an additional acceptor, also tuned to 1,000 metres, together with the rejector, acceptor, &c., as usual.

In the 2,000-metre wave circuit there is the added inductance "L." The aerial circuit to "A," together with the combined effect of this inductance and the 1,000-metre wave acceptor, is in tune to 2,000-metre wave. The remainder of the 2,000-metre wave circuit is as usual.

With this arrangement it is possible to receive on the two waves at the same time with nearly the same strength of signals as when either of the two waves is being received alone.

The Reduction of Strength on 1,000-metre Wave Signals.—This is due to the introduction of the additional acceptor, and arises in two ways:—

(*a*) The additional acceptor involves an additional series resistance. This resistance should be kept down as far as possible, and should not exceed, say, one quarter of the aerial resistance. The smaller it is the better, but a point is soon reached in the design of the apparatus where the increased size is not compensated for by the reduction of the resistance.

(*b*) The introduction of the additional acceptor increases the effective ratio of the LC for the whole aerial, because the effective inductance is now the sum of the aerial inductance and the inductance in the additional acceptor and the effective capacity is that of the two condensers in series.

For instance, taking the cases shown in Figs. 10 and 11, the ratio of "L" to "C" is increased in the proportion of 1 to 3, about. When receiving damped trains or oscillations, the ratio of "L" to "C" has a great effect on the amount of energy the aerial can pick up, quite independently of any question of resistance. A large ratio of "L" to "C" means that the oscillations build up slowly, and the damped train of waves is over before the aerial oscillations have had time to build up. On the other hand, a small "L" and a large "C" enables the oscillations to build up quickly, and more energy is absorbed from the wave train.

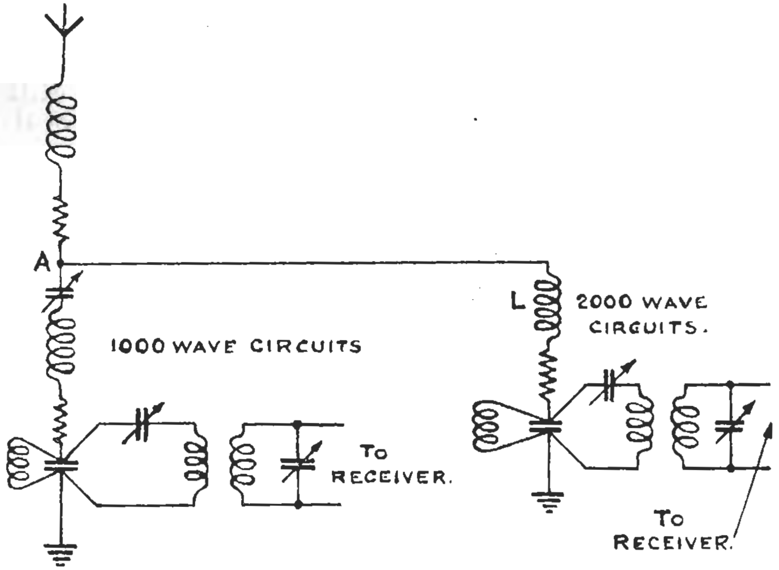
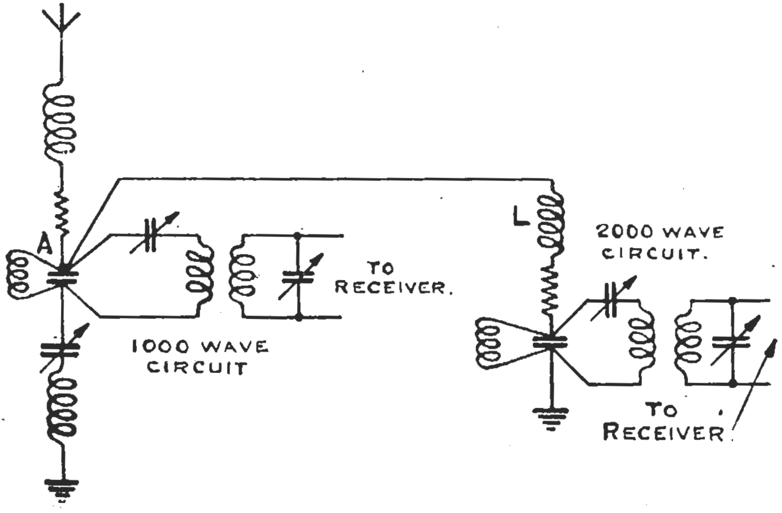


FIG. 10.



From consideration of both the ratio of "L" to "C" and the resistance, which for similar designs is proportional to the "L," it will be seen that the weakening of the 1,000-metre wave signals is less when a large "C" and a small "L" is used in the additional acceptor.

The Reduction in Strength of the 2,000-metre Wave Signals.— This is due to the fact that the 1,000-metre wave circuit provides a path to earth which is not connected to the 2,000-metre wave circuit at a point near earth potential. The action is rather complicated owing to the two circuits being in parallel, but the cause of the loss of strength can be seen by the following approximate calculation. With the same aerial capacity of 1·49 jars, the inductance "L" in the 2,000-metre wave circuit will be from three to four times that in the 1,000-metre wave circuit. Consequently, about three-quarters of the whole 2,000-metre wave voltage is acting across the 1,000-metre wave circuit to earth. This means that there must necessarily be great leakage of the 2,000-metre wave energy.

Taking the numerical case again (shown in Figs. 9 and 10 or 11) and assume that "L" is about 400 mics; suppose a current of 1 ampère to be flowing at the 2,000-metre wave frequency in the 2,000-metre wave tuner. The whole voltage across the inductance will be :—

$$2\pi fL = 2\pi \times 1\cdot5 \times 10^5 \times \frac{400}{10^6} = 395 \text{ volts.}$$

This voltage is acting across the 1,000-metre wave additional acceptor to earth. Neglecting the resistance, the current which will flow down this path is :—

$$\frac{395}{\left(2\pi fL - \frac{1}{2\pi fC}\right)} = \frac{395}{(121 - 485)} = 1\cdot1 \text{ ampères.}$$

These rough figures show that although the additional acceptor is well out of tune to 2,000 metres, there is, nevertheless, a great leakage of 2,000-metre wave current through it. A current of the order of one-half of the total aerial current of 2,000-metre wave frequency leaks through, in fact. If the capacity of the additional acceptor circuit is made smaller, the leakage of 2,000-metre wave current will be less. For instance, if it is reduced to 0·5 jar, the leakage current calculated as above would be :—

$$\frac{395}{\left(2\pi fL - \frac{1}{2\pi fC}\right)} = \frac{395}{(484 - 1444)} = 0\cdot27 \text{ ampère.}$$

With this arrangement only about one-quarter of the total 2,000-metre wave current in the aerial would leak away.

It should be added that these figures are arrived at by approximate methods, and do not accurately represent the actions taking place in the two parallel circuits.

As pointed out in the previous section, reducing the capacity in the additional acceptor leads to serious weakening of the 1,000-

metre wave signals. The conditions for receiving strong signals on both waves are thus directly antagonistic, and a compromise has to be struck. When the 1,000-metre wave signals are loud, some loss of strength can be afforded, and a small acceptor capacity is permissible, giving the loudest signals on 2,000-metre wave. On the other hand, if 1,000-metre wave signals are weak, a large additional acceptor capacity is essential and the consequent weakening of 2,000-metre wave signals is inevitable.

The best value for the acceptor capacity depends upon the aerial capacity and on the nature of the signals being received. It cannot be laid down definitely, but with ships having aerial capacities of from 1·5 to 2 jars it will be found that possible values of 1, 2, 3, or 4 jars will give convenient range. The 1 jar can be used when the 1,000-metre wave signals are strong, the 4 jars when they are weak. In the latter case the strength of the 2,000-metre wave signals may be expected to fall to one-third or one-quarter of the strength when being received alone. But with 1 jar the strength of 2,000-metre wave signals should be up to about two-thirds of the maximum.

The Effect of the Adjustment on the Tuning of the Circuits.—Variations in the adjustment of the 2,000-metre wave circuit will have practically no effect on the 1,000-metre wave circuit unless brought practically into tune with it—a condition which should never arise in practice.

The adjustments of the 1,000-metre wave circuit may, however, have a great effect on the 2,000-metre wave tuning. The conditions of resonance of the two circuits to 2,000-metre wave are rather complicated. They depend very much on the value of the capacity in the additional acceptor in the 1,000-metre wave circuit, but comparatively little on the inductance of this acceptor. Thus, so long as this capacity is kept constant, the 2,000-metre wave tuning will not appreciably be affected by any adjustments of the additional acceptor. For this reason it is preferable to use a condenser having a few definite values which are not frequently changed, and to tune the additional acceptor on the inductances, using a variometer for fine tuning.

For a reason similar to the above, taking out the red plug from the 1,000-metre wave rejector will upset the 1,000-metre wave tuning because it changes the effective capacity to earth from the point at which the 1,000-metre wave circuit is joined on to the aerial.

This trouble will be worst when the largest values of the additional acceptor condenser are in use, because the effective change of capacity by putting the ordinary acceptor condenser in series is then the greatest.

The difficulty can be overcome, as far as the 2,000-metre wave circuits are concerned, by putting an inductance of about 20 mics across the aerial side of the 1,000-metre wave rejector to earth. When the red switch is made, this inductance is simply in parallel with the 1,000-metre wave rejector inductance.

When the 1,000-metre wave red switch is open, the 20 mics inductance simply short-circuits the ordinary 1,000-metre wave acceptor so far as the 2,000-metre wave is concerned, and thus prevents it from altering the 1,000-metre wave tuning appreciably.

This inductance shunt has the disadvantage that when the 1,000-metre wave red switch is open, the 1,000-metre wave aerial circuit and ordinary acceptor circuit are no longer in series, but are conductively coupled across the 20 mics inductance. This may give rise to a comparatively loose coupling and the non-selective condition of the circuits will be lost to some extent.

Method of Receiving the Long Wave with Minimum Reduction of Strength.—If this is essential, the long wave must be received on the set of instruments which has been supposed to be receiving on the shorter 1,000-metre wave in the previous sections, *i.e.*, the set having the additional series acceptor.

The aerial circuit and the additional acceptor, together with the rejector, ordinary acceptor, etc., must be tuned to the long wave.

The connection to the short wave instruments is taken off from the aerial side of the additional acceptor as before. These circuits are brought into resonance with the short wave by means of an aerial condenser, the rejector, ordinary acceptor, etc., being also tuned to the short wave in the usual manner.

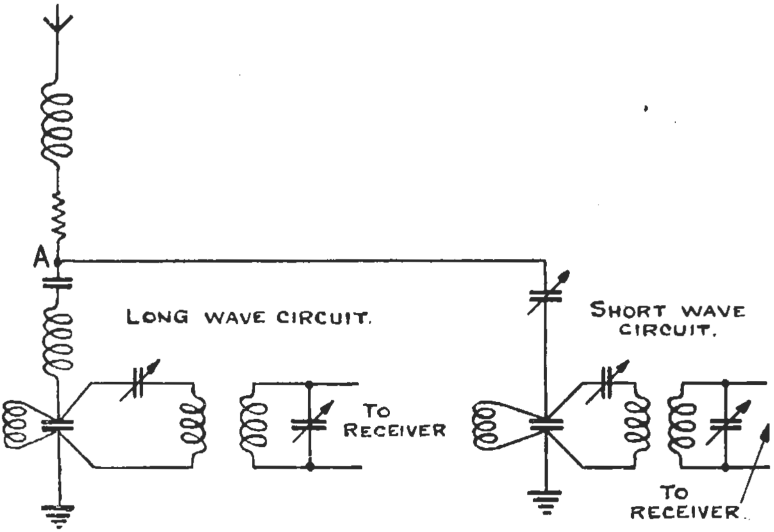


Fig. 12.

The diagram of connections is given in Figs. 12 and 13, the latter referring to the case in which the additional acceptor is on the earth side of the rejector.

It will be observed that with this arrangement the long wave signals are not very much weakened, because the alternative path to earth is taken off at a point which is practically earth potential. Also the additional acceptor tuned to the long wave is very much out of tune to the short wave, with the result that only a proportion of the short wave energy is wasted down this path.

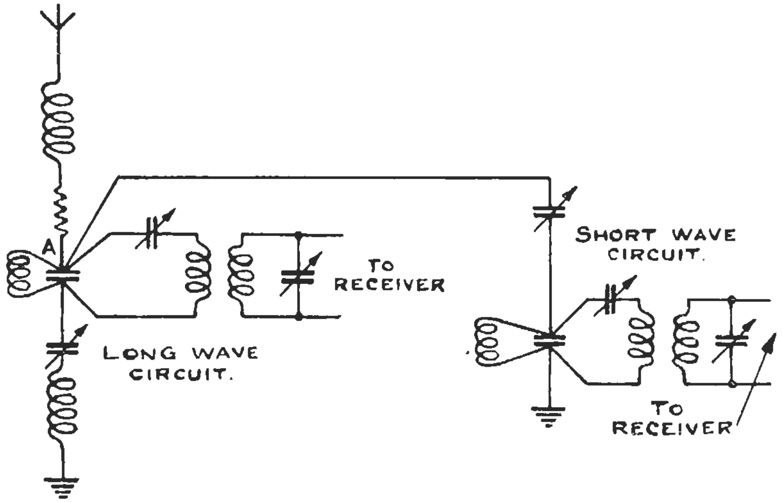


FIG. 13.

The short-wave tuning will not affect the long-wave adjustments. The long-wave tuning will, however, affect the short-wave adjustments in the same way as the case of 1,000-metre and 2,000-metre waves previously discussed. In this case the inductance of the additional acceptor has a greater effect on the short-wave tuning than the capacity, and it would be an advantage to use the capacity for fine tuning.

The weakening of the signals will be due to the same causes as before, and the same compromise will have to be struck, depending upon the conditions.

11. **Box, Double Reception, Patt. 4750.**—This combines in itself—

(*a*) A micrometer spark gap.

(*b*) An aerial tuning condenser with an aerial discharge coil to earth.

(*c*) A series acceptor.

(*d*) A rejector shunt.

The connections are shown in Fig. 14, together with the necessary switches, terminals, etc.

(*a*) *The Micrometer Spark Gap.*—The sparking " points " are flat studs of a non-oxidisable metal, about one-eighth of an inch in diameter, arranged so that the distance between them can be adjusted easily to one or two-hundredths of an inch, the studs then being locked in that position.

(*b*) *The Aerial Tuning Condenser.*—The aerial tuning condenser consists of three mica condensers arranged with switches, so that values of 10, 1·5, and 0·75 jars can be used. The aerial discharge coil has an inductance of about 6,000 mics.

The object of the aerial tuning condenser is to make it possible to tune the aerial circuit accurately under all conditions. Nor-

BOX D.R. No. 1. PATT. 4750.
DIAGRAM OF CONNECTIONS.

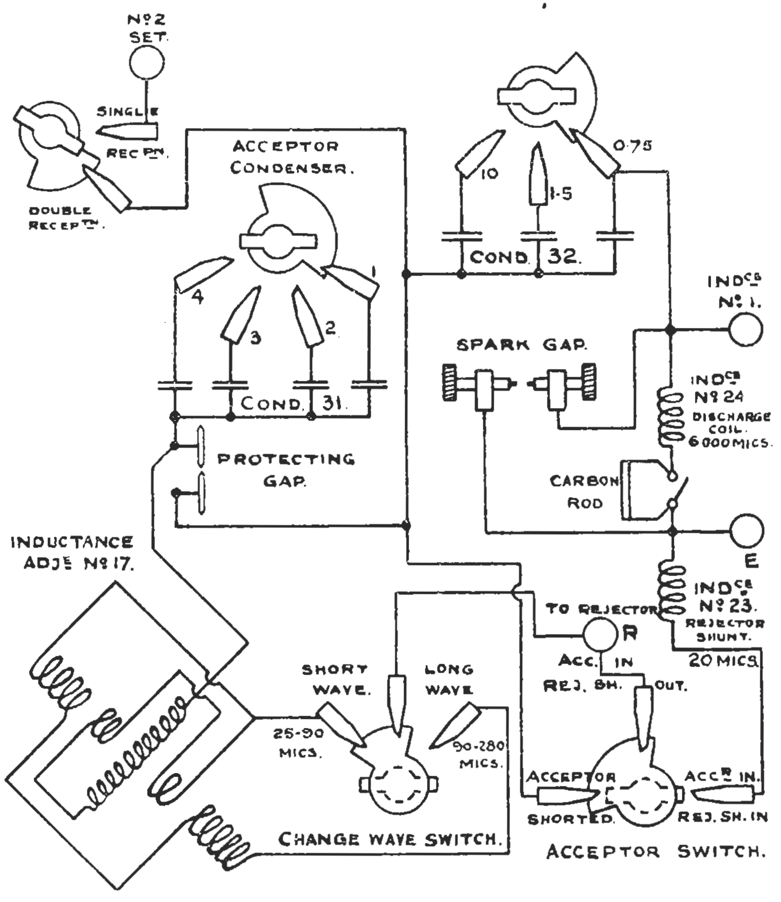


FIG. 14.

mally, 10 jars are used and when sending and receiving on the same wave the aerial is brought into tune on the 300-mic or the 20-mic section of the aerial tuner.

A 1·5 jar aerial has effective capacities of 1·3, 0·75 and 0·5 jars for the positions.

The small values of this condenser are to allow of an aerial circuit of small effective capacity and large inductance being used when desired.

This end is obtained by using the 0·75 jar section and tuning up on the aerial tuner.

The function of the discharge coil is slowly to get rid of any static charge which may collect in the aerial. If no such coil is provided, the charge will accumulate and spark over the safety gap, and so cause loud noises in the telephones when receiving.

DIAGRAM OF APPROXIMATE WIRING IN LARGE CABINET USING BOX D.R. AND TWO MODEL "C" SETS.

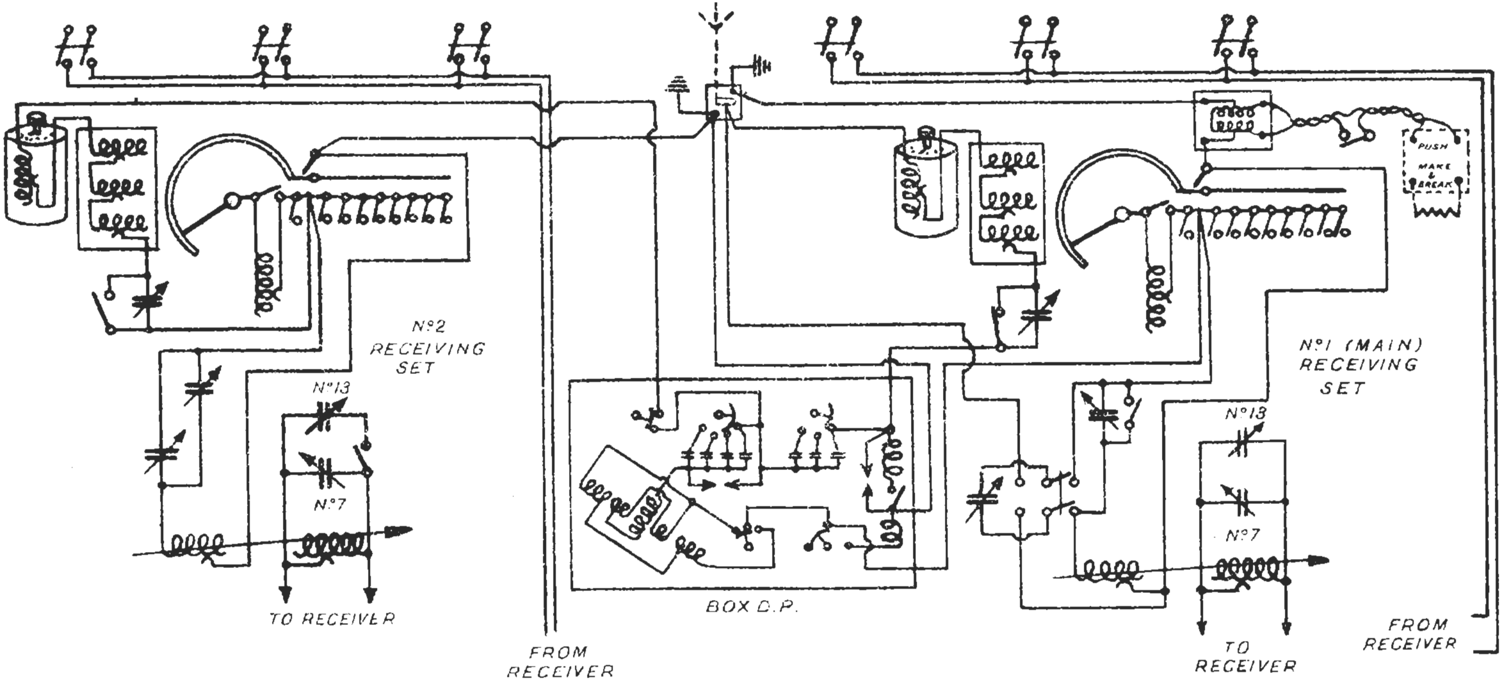


FIG. 15.

When receiving on 600 metres and using either 1·5 or 0·75 jars in the aerial condenser, it may be found desirable to disconnect the discharge coil, as it has a natural resonance on approximately this wavelength. A small switch is provided in the right-hand corner of the box for disconnecting the discharge coil if required.

If the second cabinet is receiving on waves of 4,000 LC upwards, it may also be found advisable to disconnect the discharge coil, in order to avoid the leakage of the long-wave energy through it.

(*c*) *The Series Acceptor.*—This consists of a two-range variometer and a combination of mica condensers, with switches for connecting them in parallel. The variometer gives a variation of inductance from about 25 to 90 mics on the low range and from 90 to 280 mics on the high range. The condensers are arranged to give effective capacities of 1, 2, 3, or 4 jars.

The scale of the acceptor is graduated directly in LC values. The graduations on the acceptor apply when a capacity of 1 jar is in use. When 2, 3, or 4 jars are in use, the values given on the scale are multiplied by 2, 3, or 4, as the case may be.

(*d*) *The Rejector Shunt.*—This consists of a small inductance of about 20 mics, which may be put in parallel with the rejector, if desired, by means of a switch. Its object is to prevent serious changes of the long-wave tuning when the rejector switch is opened.

Terminals.—Terminals are provided for connecting up the lead from the aerial tuner, the rejector, and the earth return. A fourth terminal is also provided, which is connected in the box to the earth side of the aerial tuning condenser.

This terminal is marked "No. 2 Set," and is fitted so that the long-wave receiving instruments can be connected on to this point when they are in the same cabinet as the short-wave instruments, or when a third lead is available between the two cabinets.

Connection of Box D.R. to Receiving Sets.—Fig. 15 shows the wiring of two Model "C" sets with box D.R. in one cabinet.

Where two Model "C" sets are fitted for double reception, it will probably be found that the buzzer in the earth lead of either set will influence both the sets; if this is found to be the case, the main set should only be fitted with a buzzer tester, so that the use of a buzzer tester in the earth lead of the secondary set will not lead to interference of the reception of more important signals in the main set. For this reason, in Fig. 15, showing the wiring of two model "C" sets and box D.R., the second buzzer tester is omitted. Experience in individual ships will show whether the second buzzer tester can be fitted with safety or not.

When the long-wave instruments are in a separate cabinet and no third lead between the cabinets is available, then the long-wave connection may be made where convenient outside the short-wave cabinet. It must be remembered, however, that when this is done, double reception can be carried out only when the short-wave set is sending and receiving on the same wave.

II. Model "E."

12. **Description of the Circuit.**—This receiving model is fitted in third offices of ships and has a range of from 50 to 250 metres. It is used in conjunction with Model "ME" and Board Pattern 5201.

The arrangement simply consists of two tuned circuits magnetically coupled, as shown in Fig. 16.

MODEL "E" CIRCUIT.

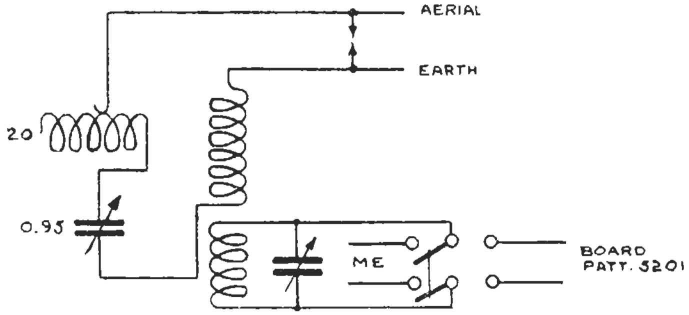


FIG. 16.

The original design of this model included a third intermediate tuned circuit coupled to the other two in order to give much greater selectivity. This circuit was, however, eliminated as experience showed that the advantage of this selectivity was outweighed by the disadvantage of the great difficulty of adjustment of the receiving gear, the extremely accurate tuning demanded from the transmitter, and also inefficiency, causing loss of signal strength. The two-circuit arrangement gives a degree of selectivity quite sufficient for all practical purposes.

III. Tuners "A."

13. **Tuner A4.**—Tuner A4 (range 50 to 200 metres) has been designed in order to overcome the difficulties in manipulation of Model "E" and also to obtain greater selectivity than is possible with the latter instrument.

A comparison with Model "E" shows that A4 is more compact and slightly more selective. Signal strengths obtained with the two models are practically the same and manipulation of A4 is much easier than with Model "E," since signals can first be picked up on the aerial circuit only and the selectivity increased afterwards.

This is accomplished by the "stand-by" and "tune" switch. In the former position of this switch the grid of the first valve of the receiver is connected directly to the aerial circuit at the point between the aerial-tuning condenser and inductance, while, in the latter position, the secondary circuit is brought into action with attendant increase in selectivity.

A point of importance lies in the "valve equivalent" condenser. When in the "stand-by" position, the capacity of the first valve is placed across the aerial-tuning inductance. When in the "tune" position, however, this capacity is no longer across these points but across the secondary circuit. In order, therefore, that the conditions in the aerial circuit shall remain constant when the signal has been picked up in the unselective position and the switch is put over to "tune," a small variable condenser (0·03 jar) is brought in across the aerial-tuning inductance to compensate for the absence of the valve capacity.

TUNER A4.

(Diagrammatic).

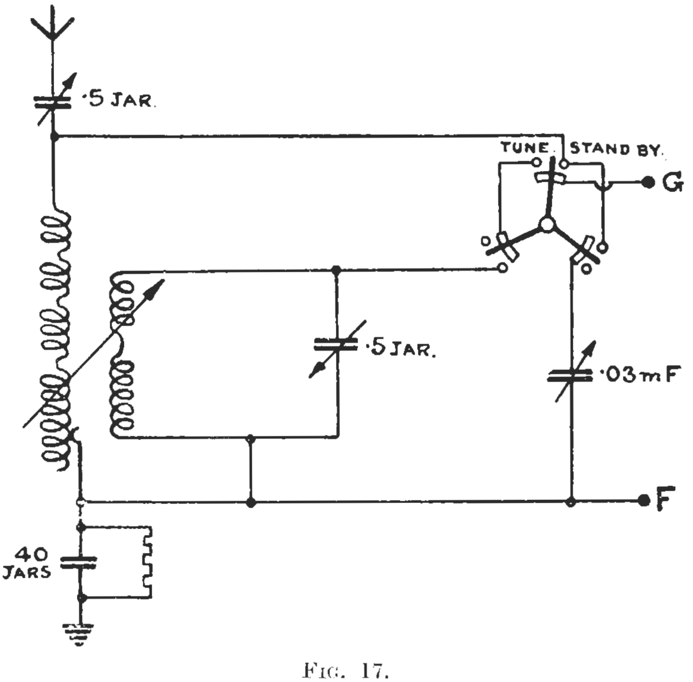


Fig. 17.

As seen from Figs. 17 and 18 the circuit consists of an aerial-tuning condenser (0·5 jar) and an aerial-tuning inductance tapped in four points giving values of 13·6, 17, 42·5 and 110 mics.

The secondary circuit comprises a two-value secondary inductance magnetically coupled to the A.T.I., the coupling being variable axially by means of rack and pinion, and tuned by means of a variable (0·5 jar) condenser. The values of the inductance are 6 and 52·5 mics. The lower end of the A.T.I. and the mid point of the secondary circuit are common with the filament terminal and, to avoid the battery being connected directly to earth, a 40-jar condenser shunted by a very high non-inductive resistance is placed between this point and earth. The condenser is of large value so as not to affect the aerial tuning. Both the terminals of this condenser are accessible from the front of the instrument.

TUNER A4.

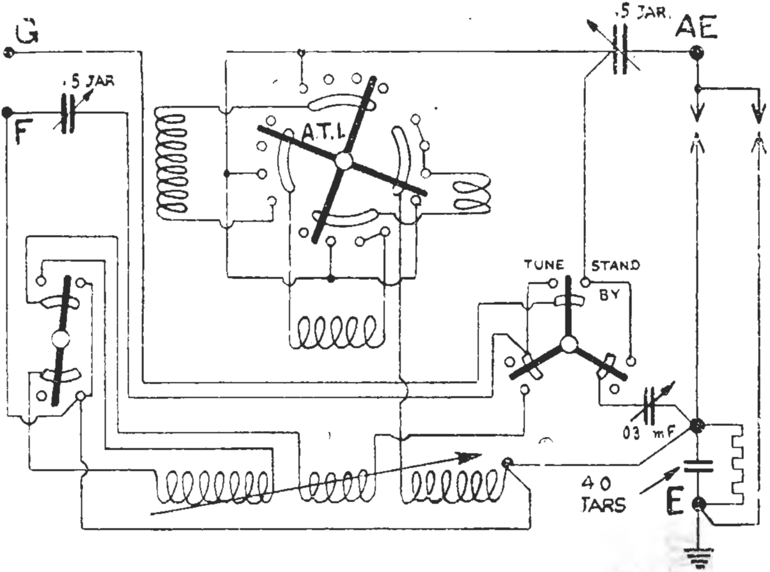


FIG. 18.

The valve equivalent condenser has already been explained.

14. **Tuners A5 and A6.**—These tuners are two circuit tuners similar in design to A4, but have ranges of 200–600 and 600–24,000 metres respectively.