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594

PHILIPS DC to AC "SQUARE TYPE" CONVERTER UNIT

PHILIPS' "Square type" DC/AC vibratory converter permits an AC receiver, with a special type of mains transformer, to be energised from DC mains. It operates broadly on the same principle as the battery type vibratory converter, but is applicable to the comparatively high voltage of DC mains, instead of to a 4 V or 6 V battery.

Used in conjunction with a special connecting plug and socket, the receiver is automatically adjusted for operation on AC mains simply by the removal of the plug. Voltage adjustment is accomplished by rotating a six-position bakelite disc attached to the receiver, and, once adjusted, it is correct for AC or DC operation.

The makers' code number for the converter unit is 28.891.460; and the unit is used in the following receivers :

Philips 745U, 790U, 791U, 792U, 794U, 795U, 797U.

Mullard MUS3, MUS4, MUS5.

CIRCUIT DESCRIPTION

As this unit requires a specially wound mains transformer into which to feed its output, it is necessary, in considering the unit, also to include the mains transformer and the mains lead, which are part of the receiver and not part of the converter unit.

Also, since the combination of unit and receiver is applicable to AC or DC operation, both of these states must be considered.

DC OPERATION

As the primary purpose of the unit is in association with DC mains operation, however, this case will be described first. The circuit diagram of the unit in this condition is given in Fig. 1, which is a complete diagram in the simplest form, omitting the complications of the interconnecting plug and socket, which will be described later.

In Fig. 1, the unit is assumed to be at rest; that is, the mains switch on the receiver is open. Upon closing the switch and applying, say, 240 V DC to the mains lead, current flows via socket **10,** which is one of the connections between the receiver and unit, a fuse **F1,** a choke **L5,** into the actual vibrator compartment (enclosed by a dotted rule in the diagram) at socket **D,** through the energising coil **L1,** out at socket **A,** through the series resistances **R3, R2, R1,** switch **S1** being open, out of the unit again at socket **3,** and so to the mains transformer primary at the voltage adjustment tappings marked **3.** It then passes through one section of the transformer primary and leaves it via a second group of tappings marked **1,** enters the relay circuit at terminal **E** and passes via contact **a, R4** (which is connected between **G** and **H**), and terminal **H,** fuse **F2,** socket **7,** and so back to the other side of the mains.

The current through the vibrator coil **L1** causes the armature to be attracted to the core, closing contact **e,** so that **L1, R3, R2, R1** are by-passed, the current flowing instead through contact **e,** socket **B** and choke **L2** to the transformer primary. Since no current is now flowing through **L1,** however, the armature is released; it swings back and closes contact **d,** so that current flows via contact **d,** socket **C,** choke **L3** and the group of tappings marked **2** to the remote end of the second section of the mains transformer primary, leaving it via tapping group **4** and then following along the same path as before back to the mains.

Meanwhile, the core of **L1** has become energised again, so that the cycle repeats itself, and continues to do so until the mains supply is interrupted.

For 110 V, 125 V and 145 V mains, **S1** closes to short-circuit **R1, R2.**

The two sections of the mains transformer primary are connected in opposition, and as the current enters it alternately from either end, flowing inwards in opposite directions to the centre, the core experiences an effect somewhat similar to AC but with a tendency towards jerky pulses instead of the smooth sine wave of good AC mains. Another difference from the normal AC operation, of course, is that the current always flows in one direction through one half of the primary, which for that short period behaves as a whole primary, and in the opposite direction for the next half cycle through the other half, one half being dormant while the other is active.

The pulses, although not so smooth as AC mains, are by no means square peaked or rough. The action of the filter circuits **C3, C4, L2, L3, C1, C2,** in conjunction with the inductance and capacity of the transformer, smooth out the roughness and squareness to such a degree that the output waveform at the transformer secondary windings is sufficiently like a sine wave for practical purposes.

In order to obtain this result, however, it is necessary that the transformer should behave as a tuned circuit resonating with the vibrator reed movement. In fact, all

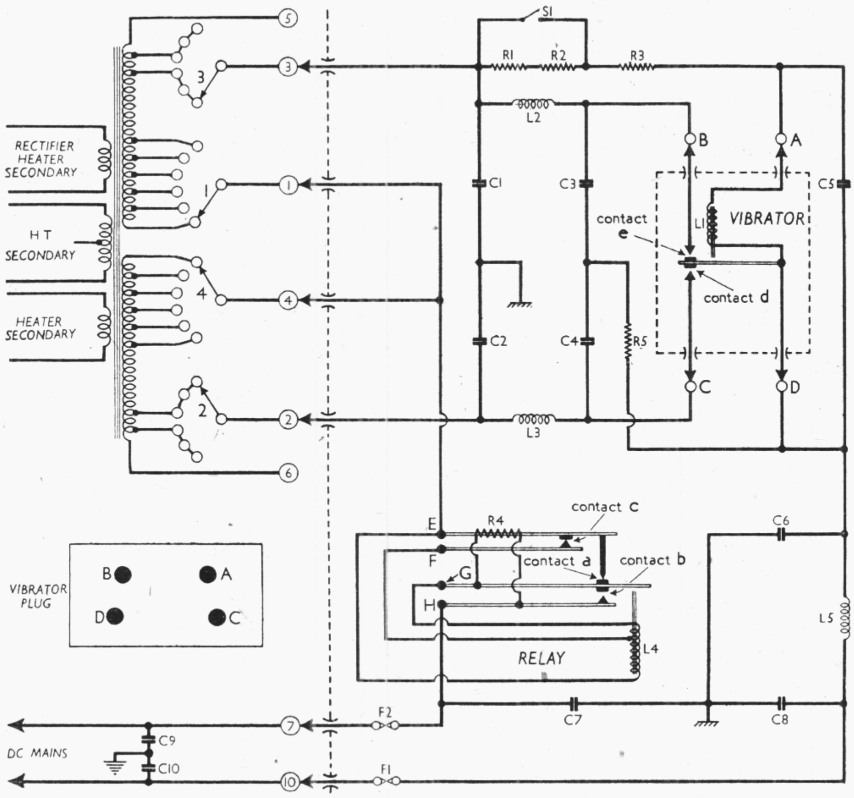
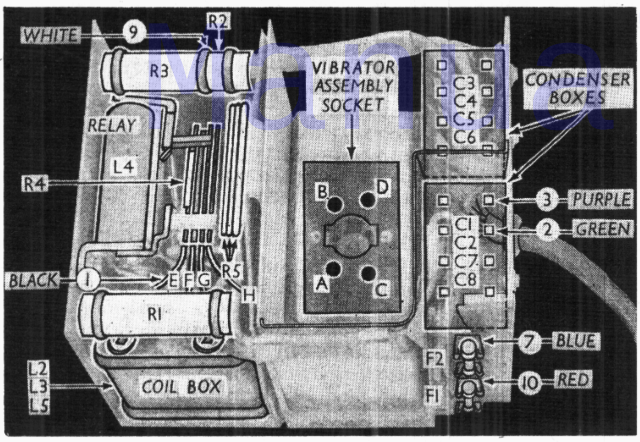


Fig. 1. Complete circuit diagram of the unit and significant parts of the receiver when the plug is inserted for DC operation. Components on the right of the dotted vertical line are contained in the unit; those on the left are in the receiver. Connecting points between the two are indicated by numbers in circles corresponding to the socket numbers, but the complications of the switching are omitted here. They are shown in Fig. 3 overleaf. The relay and vibrator are shown at rest.



The appearance of the converter unit, with cover removed. The terminals of the relay are indicated by letters E to H. Diagrams showing the connections to the coil and condensers boxes are in Fig. 7 overleaf. The connecting points of the plug cable are indicated by arrows, pin numbers in circles and lead colours.

components associated with a vibratory converter have very critical values, and replacements must have the correct values; otherwise the efficiency of the unit falls off rapidly.

It should be observed, when considering the diagram in Fig. 1, that the transformer and the mains lead with **C9** and **C10** form part of the receiver. The junctions between the receiver and the unit are at the circles numbered **1, 2, 3, 7** and **10,** which represent the sockets on the receiver in which the converter plug is inserted for DC operation.

AC OPERATION

To convert the receiver to AC operation, all that is necessary is to withdraw the converter plug from its socket on the receiver. Conditions are then as shown in Fig. 2, where it will be seen that the two sections of the transformer primary are connected in parallel. Although the connecting sockets are shown as before, no plug is used. It is necessary to show the sockets, however, because upon withdrawing the plug for AC working, certain switching actions are performed by the sockets, which are formed of leaf-springs which then overlap and touch one another when the plug is out. Fig. 2, therefore, is entirely contained in the receiver; no part of the vibrator comes into it.

THE RELAY

For some time after switching on the receiver and converter for DC operation, resistance **R4** in the relay unit remains in series with the DC supply. The purpose of this is that otherwise too large a current may flow when switching on. Meanwhile, the vibrator armature is oscillating and the valves in the receiver are warming up.

During this period, **R4** is also warming up, transmitting heat to the contact strip attached to terminal **E** of the relay, and as this is a bi-metal strip, it bends. Its movement is in such a direction as to cause contacts **a** and **c** to open. Up to this time, the relay energising coil **L4** has been short-circuited by contact **a,** but when **a** opens, the core of **L4** becomes magnetised, and attracts the armature, which is the contact strip attached to terminal **G.** This action closes contact **b.**

Taking the direction of the current to be the same as it was in the description of DC operation, entering the converter via fuse **F1** and leaving by fuse **F2,** it now enters the relay at terminal **E** and passes via the energising coil **L4,** terminal **G,** contact **b** and leaves the relay circuit at terminal **H** on its way to fuse **F2.**

After a further interval, **R4** cools down, and the bi-metal strip around which it is wound cools down also, so that the strip resumes its normal position. Contact **c** thus closes again, short-circuiting part of the coil **L4,** leaving a sufficient number of turns in circuit only to hold the armature to the core, but thus keeping contact **b** closed.

Although the bi-metal strip has relaxed, contact **a** cannot close, because the armature, to which one side of it is attached, remains drawn towards **L4** core.

The action of the relay is complex, but its object is to include a considerable amount of resistance in series with the mains supply at the time of switching on, and to remove as much of it as possible once proper working conditions have been reached. Upon switching off the mains supply to the unit, the whole system relaxes and returns to the position it occupied at the commencement of the cycle; it is in this position that it is drawn in the diagram in Fig. 1.

INTERCONNECTING PLUG AND SOCKET

The change over from DC to AC operation in a receiver incorporating this type of converter unit is effected by withdrawing the connecting plug, attached by a cable to the unit, from the socket fitted at the rear of the receiver; conversely, to change from AC to DC operation, all that is necessary is to insert the plug.

The action of inserting or withdrawing the plug automatically operates a switching system contained in the socket. No switches of the normal type are involved, the switch action being the result of the springy contact tags in the socket touching one another when the plug is out and being separated when the plug is inserted. In one case, also, two of the tags in the socket are short-circuited upon insertion of the plug.

In Fig. 3 are reproduced two diagrams showing, on the left, a simplified circuit of the converter unit as in Fig. 1; and on the right, the complete circuit diagram of the receiver, from the socket to the mains transformer. On the right of the converter circuit are shown the output leads terminated by arrow-heads

(*Continued overleaf*)

COMPONENTS AND VALUES

	RESISTANCES	Values (ohms)
R1	Mains voltage adjustment resistances	5,000
R2		1,000
R3	——	4,000
R4	Relay surge limiter	1,200
R5	Vibrator buffer resistance	50*

* Approximate value. Made up of three 160 O resistances connected in parallel.

	CONDENSERS	Values μF
C1	Filter condensers	0·1
C2		0·1
C3	Vibrator buffer condensers	0·1
C4		0·1
C5	Vibrator coil shunt	0·2
C6	Input filter condensers	0·1
C7		0·25
C8		0·5
C9*		—
C10*		—

* Fitted in the receiver, not in the converter.

	OTHER COMPONENTS	Approx. Values (ohms)
L1	Vibrator energising coil	2.700
L2	Vibrator filter coils	3.5
L3		3.5
L4	Relay magnet winding	70*
L5	Input filter coil	3·5
F1, F2	Mains input fuses, 1A	—

* Tapped at 0.5 O from G.

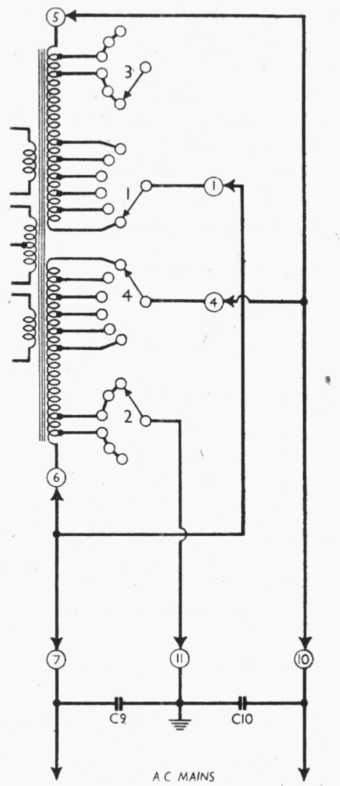


Fig. 2. Circuit diagram of mains input to receiver as in Fig. 1 but with converter plug out for AC mains operation. The entire circuit is contained in the receiver. The socket numbers are shown, but the arrows merely indicate connections between opposite contacts.

which represent the connecting plug. They are seven in number, and they are numbered and colour-coded to agree with the sketch of the underside view of the plug in Fig. 4.

On the left of the receiver transformer circuit are shown the tags (called sockets for easy distinction from other tags, such as the soldering tags on the relay). The enclosure represents the socket assembly as a whole, and embraces all the components of the socket assembly, including the number of each socket and switches formed by the action of the springy leaves. Broken lines to switches **S2**, **S3**, **S4**, **S5**, **S6** and **S7** indicate that they close for AC working; that is, when the plug is out. The switch **S8**, shown connected by solid lines, closes for DC working when the plug is in.

The manner in which these switching operations occur can be seen from an examination of the sketch in Fig. 5, where the socket assembly is drawn as seen from "inside" the receiver. The numbers given to the individual sockets correspond with those in the circuit diagram and, so far as they are applicable, with those in Fig. 4.

It will be seen in Fig. 3 that pins 1 and 4 on the plug are joined together, and in Fig. 4 that pin 8 is unconnected. It is pin 8 that closes **S8**, as will be seen from Fig. 5, where in socket 8 position there are two spring contacts, numbered 8 and 11. They are mounted one behind the other, and pin 8 contacts them both when the plug is inserted.

Socket 11 is connected directly to the chassis of the receiver. On DC, therefore, it is connected to socket 8, and the tap at the junction of condensers **C9**, **C10** goes to chassis, and the condensers act as mains RF by-pass filters in the normal manner. On AC, 8 is connected via **S6** to socket 2, and the condenser tap then goes to the transformer winding at voltage adjustment group 2.

A study of Fig. 3 will show how, by

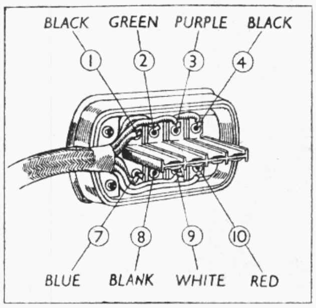


Fig. 4. Sketch of underside of converter plug, with paxolin cover removed, showing pin connections, numbers and lead colours. Pin 8 is blank.

the socket switching, Fig. 1 for DC becomes converted to Fig. 2 for AC mains.

In a receiver, the converter unit is housed in a metal container to which it is screwed, and the container is connected by a lead to the receiver chassis. In our diagrams, several condensers are shown returned to chassis by the usual chassis sign, which indicates that one side of the condenser is connected to the case of the converter unit. In the case of the tap from **C9**, **C10**, however, an earth sign is used. This indicates that the tap goes to the receiver chassis. These two condensers are, of course, contained in the receiver. The lead connecting the metal container, and, therefore, the converter unit case, to the receiver chassis, is not shown in our diagrams.

MAINS VOLTAGE ADJUSTMENT

In the diagrams in Figs. 1 and 2, the voltage adjustment tappings on the mains transformer are shown as semi-circuiar groups of contacts with a switch arm. In addition, **S1** is shown as an ordinary switch, short-circuiting **R1**, **R2** on 110 V, 125 V and 145 V mains.

In Fig. 3 the mains transformer tappings and switch **S1** are shown in a manner more closely resembling their arrangement in practice, where they are disposed in five hexagonal groups. In all three diagrams they are shown adjusted for the highest voltage range—245 V.

A very ingenious system permits the simultaneous adjustment of all five groups by an angular movement of the single voltage adjustment plate. The outside surface of the plate is marked in six positions for voltage ranges as follows: 110 V, 125 V, 145 V, 200 V, 220 V and 245 V. Inside the plate are six spring metal bridging pieces, arranged on a circle disposed eccentrically to the circu-

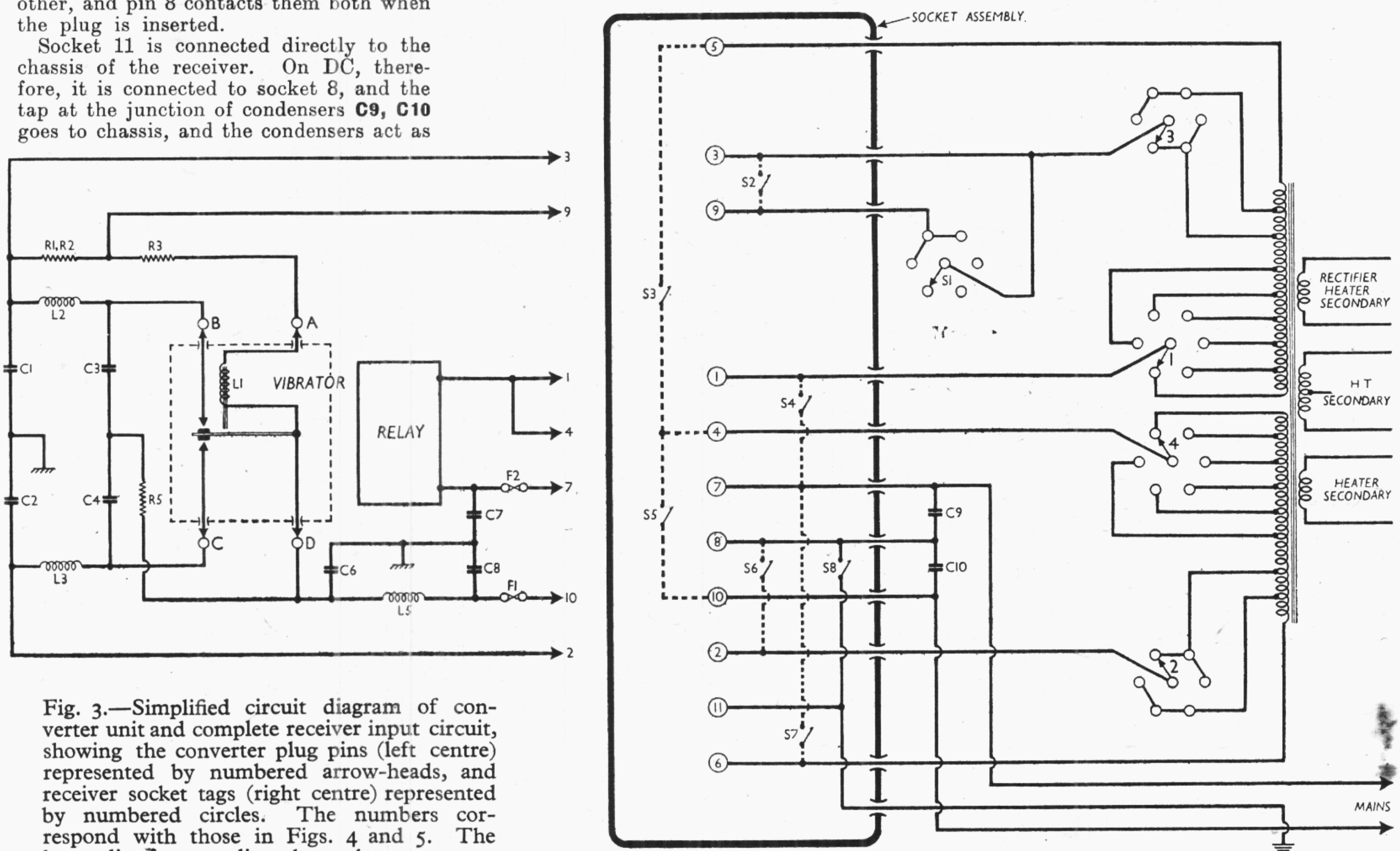


Fig. 3.—Simplified circuit diagram of converter unit and complete receiver input circuit, showing the converter plug pins (left centre) represented by numbered arrow-heads, and receiver socket tags (right centre) represented by numbered circles. The numbers correspond with those in Figs. 4 and 5. The heavy line surrounding the socket tags represents the confines of the socket itself, and the switches **S2–S8** within it are contained in the socket. The switches connected by dotted lines close for AC (plug out), while **S8** closes for DC (plug in). All the mains voltage adjustment groups are shown set at the highest range, 245 V. For lower ranges, the arrows in groups 1, 3 and S1 move in an anti-clockwise direction, and in groups 2 and 4 clockwise.

lar plate itself. All six bridges lie on parallel lines, and they are indicated in our diagrams by the switch arms.

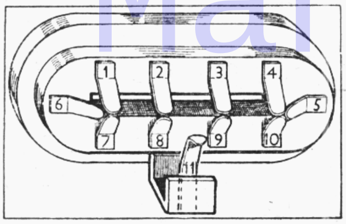


Fig. 5. Converter socket, seen from inside receiver. Socket tags close and touch one another, excepting No. 11.

The five voltage adjustment groups, which are numbered **1, 2, 3, 4,** and **S1** in our diagrams, are arranged with a sixth (similar) blank group, the whole being mounted on a square paxolin disc in a circle of groups.

The arrangement is shown in Fig. 6, where the paxolin disc is viewed directly from the rear of the receiver, and the adjustment plate has been lifted off and turned over to show its inside. Normally, the plate cannot be lifted clear, as it is held in position by a screw which, when unscrewed, releases the plate sufficiently to permit its being turned, but does not permit its entire removal. Further, the inside of the plate is not normally visible even when the plate is removed, but is covered by a circular disc of paxolin, punched to correspond with the pins in the square disc.

The action is as follows : If we assume the plate to be adjusted for 245 V, as in our diagrams, a bridge piece in each group will join the centre pin of each group to its 245 V outer pin. If it is now desired to change to the next voltage tapping downwards, 220 V, the movement that the switch arm will be required to make in each group will be one-sixth of a complete circle; this is 60 degrees.

On the adjustment plate, each voltage marking is also 60 degrees from its neighbours; and each group of pins on the disc is 60 degrees from its neighbour. To make our adjustment, therefore, we lift the plate and turn it through 60 degrees. The bridge piece from each group will, therefore, leave its original group and travel to the next; but it will also have turned through 60 degrees, so that when it arrives at its new group it will not only replace the bridge that has vacated that group, but will take up a new position 60 degrees round that group. In effect, it will act as though the original bridge had been left with its original group, but had been turned round one position to the next stud in the group.

This happens to all six groups (including the blank group) simultaneously. At the same time, since the bridges are on an eccentric circle, they work their way progressively round the high range half of each group over one half of the rotation of the plate, and over the lower half during the remaining half of its rotation.

In the diagram in Fig. 3, the switch arms, which all occupy the 245 V position, move from 245 V to lower voltages successively as follows : Groups **1** and **3**, and switch **S1** group, in an anti-clockwise direction; groups **2** and **4,** in a clockwise direction.

Once the adjustment has been set for a particular mains voltage range, it is correct for AC or DC mains in that range. The only differences that occur between AC and DC operation are that on DC operation, **R1, R2** require to be short-circuited on the upper three settings, and on AC, groups **2, 3** and **S1** are virtually out of circuit, but this is taken care of automatically.

DISMANTLING THE UNIT

Removing Unit.—Remove the two screws holding the two lugs beneath the unit to the container in the receiver, and withdraw the plug if it is in its socket.

Removing Cover.—Remove the three small screws at the bottom corners at the ends of the unit, slacken the two screws holding the two sides at the bottom of the unit, and slacken the two remaining screws, one at each end, holding the top of the cover.

The cover is a tight fit, but it may now be eased off, exposing the interior of the unit.

When replacing, the shorter side of the cover goes on the same side of the unit

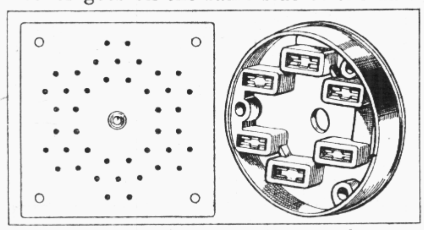


Fig. 6. Voltage adjustment pin disc (left) as seen from rear of receiver, with adjustment plate removed. The underside of the plate (right) with its own cover removed, shows the bridge pieces.

as are the fuses, so that the fuses remain accessible when the cover is in position.

Take care that the felt padding does not become rucked as the cover is slid into position.

Removing Vibrator.—This is located in the centre compartment of the unit, and is mounted on a sponge-rubber base.

Remove the larger screening cover by raising one end of it, at the open end of the compartment, and gripping the two corners at that end.

Insert the fingers beneath a second screening box thus revealed, again at the open end of the compartment, grasp the top of the box, and lift it out. This is the vibrator assembly, which has a non-reversible four-pin base.

To obtain access to the vibrator it is now necessary to remove its second cover, which is held in position by four spots of solder, two on each side near the bottom corners. Inside the assembly, the vibrator unit itself will be found slung on four coil springs in a cradle.

When replacing the screen on the vibrator, the waxed paper lining should go *inside* the flanges of the base.

Removing Plug Cover.—To obtain access to the connecting tags in the plug, remove the two screws on the underside of the plug near the cable entry. The paxolin cover can then be prised off.

GENERAL NOTES

Switches.—With the exception of those shown in our diagrams as contacts **a, b, c, d** and **e** in the relay and vibrator, there are actually no switches in the converter unit itself. **S1** is one of the voltage adjustment groups, and the remaining switches **S2-S8** are formed by the leaves of the socket. **S1-S8,** therefore, are fitted in the receiver. Their action is explained respectively under "Voltage Adjustment" and "Interconnecting Socket."

Coils.—**L1** and **L4** are respectively the vibrator and relay energising coils. **L2, L3** and **L5** are filter chokes, and are contained in a screened box beneath the relay.

Condensers.—All the condensers in the converter unit are contained in two screened boxes, shown in our illustration of the unit behind the fuses. **C9** and **C10** are not included in the unit, but are fitted in the receiver.

Condenser and Coil Boxes.—There are three of these, which are referred to in the two preceding paragraphs. The connections to components enclosed in them, and their positions in the unit, are indicated in the sketch in Fig. 7, where the unit is viewed roughly in the same position as in the photograph overleaf.

Relay.—The action of the relay is described under "Circuit Description" and "Relay," and can be seen in the diagram and photograph, where the connecting terminals are lettered.

In the diagram in Fig. 1, the magnet core is shown attracting directly one of the contact strips of the relay, whereas, in practice, as will be seen from the photograph, the armature is actually L-shaped, and transmits its movement at right-angles to the magnet core via a pertinax bridge which moves the contact strip.

The pertinax bridge is held in position only by tension, and the makers state that, if the bridge slips from its position, a fuse will blow after switching rapidly on and off several times. The bridge should then be replaced carefully, so that the cut-away corners rest on the armature.

Fuses.—**F1** and **F2** are the mains circuit fuses, rated at 1 A each. They are of the standard $\frac{3}{4}$ inch type. Replacements should be correctly rated, as otherwise the mains transformer primary may be damaged.

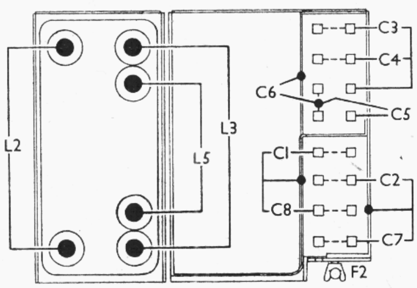


Fig. 7. Plan view of converter unit, in approximately same position as in photograph overleaf, showing internal connections of coil and condenser boxes.

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