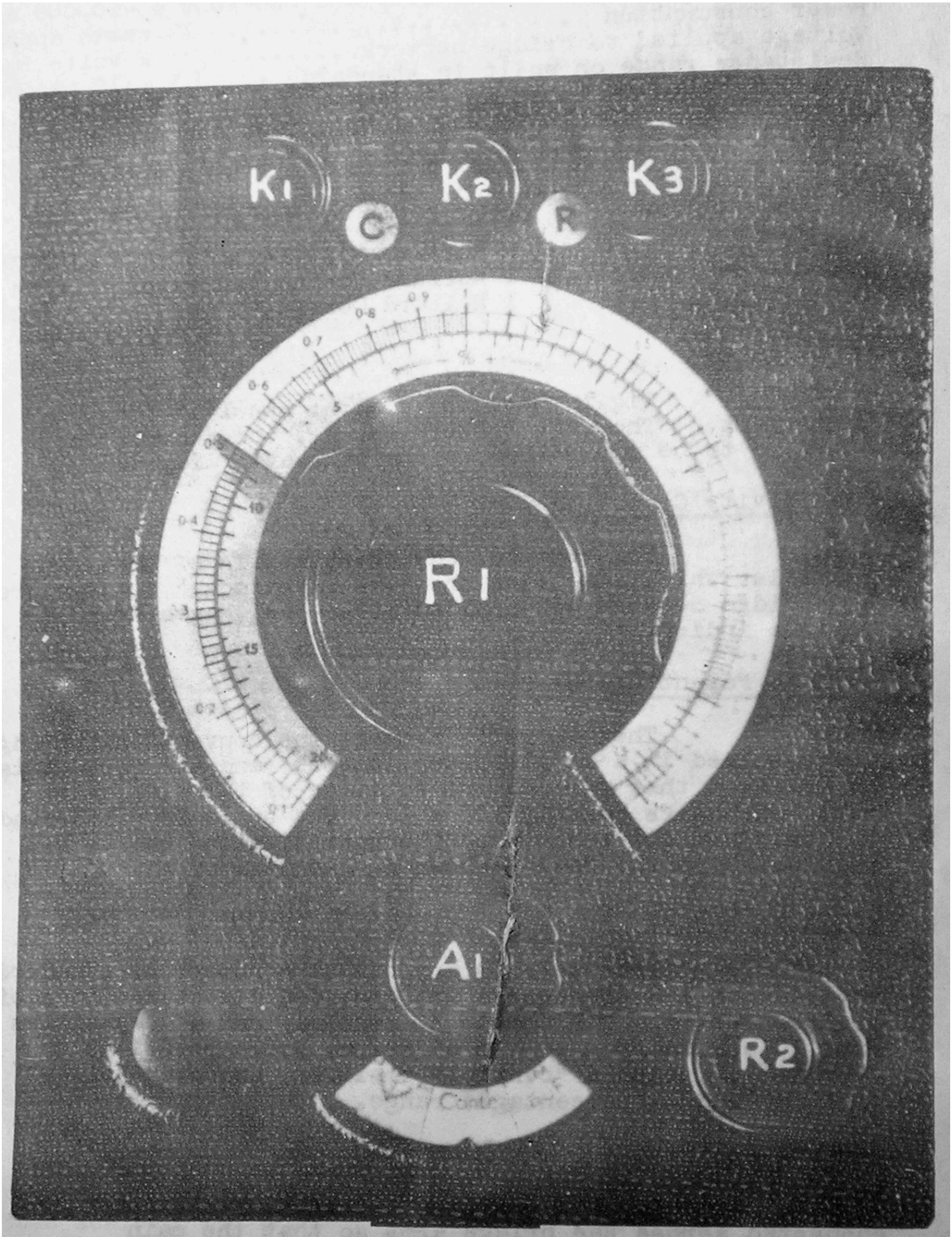


FIG. 1.

MEASURING BRIDGE TYPE GM.4140.

Mains input	100-150v and 200-250v 40-10,000 c/s.
Power consumption	11 watts approx.
Voltage applied to bridge network	2 volts rms.
Resistance range on built in standards ...	0.1 - 10 megohms.
Capacity range on built in standards	10 μμF - 10 μF.
Accuracy on all built in standards except one megohm	± 2%.
" " 1 megohm range	± 5%.

Valves

Amplifier	1 Mullard H.F. Pentode	EF36
Balance Indicator	1 Mullard Tuning Indicator	EM4
Power Supply	1 Mullard Double-Diode	EB34

CONTROLS

Fig.1 shows the control panel of the instrument. The code letters R_1, A_1, etc. enable the controls to be identified in the schematic diagram.

Sensitivity Control R_2

This control adjusts the gain of the amplifier which amplifies the "out-of-balance" voltage from the bridge network and applies it to the "Magic Eye" balance indicator.

Balance Potentiometer R_1

The two ratio arms of the conventional bridge are combined in a single potentiometer, and the circuit is so arranged that for maximum rotation of the dial, the ratio change is exactly 100 : 1. The scale is calibrated to read from 0.1 to 10, and the scale reading has to be multiplied by the factor shown on the dial of the

Range Switch A_1

This selects any one of a number of standard resistances and condensers and provides direct readings of resistances from 0.1 ohm to 10 megohms, and of capacities from 10 μμF to 10 μF. In addition, extra positions provided comprise a "control" position, an "open bridge" position and a "percentage" range.

Control Position

In this position two equal resistances are connected across the bridge arms so that the main potentiometer balances in the centre "unity" position. This position is used to check the correct operation of the bridge and to enable the instrument to be set up again after it has been dismantled to replace a valve, etc.

On connecting the bridge to the 50 cycle mains supply, the range switch is turned to the control position and the sensitivity control R_2 is turned to maximum (fully clockwise). In the unbalanced condition, the whole area of the "Magic Eye" balance indicator will fluoresce brightly as shown in fig.2a. On rotating the balance potentiometer, a position will be found where the area of fluorescence contracts to a minimum as shown in fig.2b. If the pointer of R_1 is now exactly over the centre division (marked "1") the bridge is functioning correctly. If it balances at some other point, the grub screw fixing the knob R_1 should be slackened off and the knob rotated until the bridge balances in the correct position, when the grub screw should be tightened up again.

Measurement of resistance.

Four standard resistances are provided, viz. 1 ohm, 100 ohms, 10,000 ohms and 1 megohm. The unknown resistance is connected between the terminals K_2 and K_3, the appropriate standard is selected by the range switch, and the main potentiometer is rotated until a balance is obtained. The value of the unknown resistance is then given by the scale reading of the balance potentiometer multiplied by the factor shown on the range switch.

Measurement of capacity.

Three standard condensers are provided, viz. 100 μμF, 10,000 μμF and 1 μF. The unknown capacity is connected between the terminals K_1 and K_2.

When measuring capacities of the order of 100 μμF or less, certain precautions should be observed. It is essential that earth terminal of the bridge should be connected to a good electrical earth. Due to the extremely high impedances of such small capacities at 50 cycles, it is necessary to keep the external lead to such condensers as short as possible and to keep the whole apparatus clear of stray A.C. fields (an earthed metal screen around the whole apparatus is most helpful.)

When measuring small capacities of large area, the "earthy" side of the condenser should be connected to the left hand terminal, as the centre terminal goes direct to the grid of the amplifier valve.

The stray capacity across each half of the bridge has been adjusted to exactly 10 μμF, so that this capacity must be subtracted from the value read off from the scale.

OPEN BRIDGE POSITION.

Measurement of resistance.

The resistance range may be extended by the use

of external standards. The standard resistance is connected between the terminals K_1 and K_2, and the value of the unknown resistance is the product of the scale reading and the value of the standard resistance.

Measurement of capacity.

To extend the capacity range, the unknown capacity is connected between the terminals K_1 and K_2 and the standard between K_2 and K_3.

Power Factor of Condenser.

A condenser with a bad power factor is equivalent to a perfect condenser of capacity Cx in series with a pure resistance Rx.

In order to evaluate Cx and Rx it is necessary to include a variable resistance Rs in series with the standard condenser Cs. First of all, with Rs equal to zero, the bridge is balanced as nearly as possible, the amplifier sensitivity control being turned down if necessary. Rs is then increased until a sharper balance is obtained and the two adjustments are varied successively until a sharp balance is obtained at maximum sensitivity. If the scale reading is now N_1 then

$$\text{Capacity} \qquad Cx = N \times Cs$$

$$\text{and Loss Resistance} \qquad Rx = Rs/N$$

From this the power factor can be evaluated, this being given by the expression

$$\text{Power Factor} = \omega \, CxRx$$

where ω is the angular frequency of the voltage supplying the bridge network (2π x frequency in cycles/sec.)

Measurement of Inductance.

By using an external standard, inductances may be measured over a wide range. The standard is connected between the terminals K_1 and K_2, and the unknown between K_2 and K_3. In order to compensate for the D.C. resistance of the coils it is necessary to include a variable resistance in series with the coil having the lower D.C. resistance.

Percentage Tolerance Measurements.

By multiplying the scale reading by 10, the unknown impedance measured on the open bridge position is expressed as a percentage of the standard. In the "%" position of the range switch, a shunting resistance "opens" the middle portion of the

scale, and the inner scale is calibrated directly in percentage difference from the standard, the range covered being -20% to +25%.

Use as Balance Indicator.

In the open bridge position the instrument may be used as a Balance Indicator with an external impedance bridge. The input is applied between the centre terminal and earth terminal, and over the range 40 c/s - 10,000 c/s an input of less than 10 mV rms. is sufficient to close the more sensitive half of the "Magic Eye".

Use at Different Frequencies.

The bridge and amplifier-detector unit may be used on any frequency from 40-10,000 c/s and if a supply giving 11 watts at 6.3 or 100 - 150 V or 200 - 250 V. is available, the whole instrument may be plugged into this supply. Alternatively, the main power supply may be 50 c/s and the bridge network may be fed from a higher frequency.

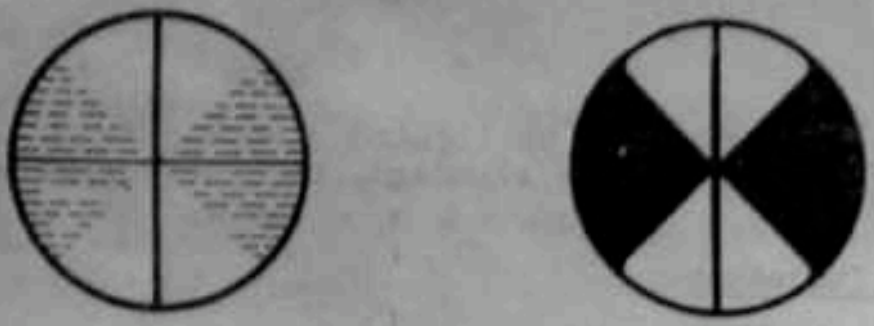
To disconnect the bridge network from the 50 cycle supply, the bottom of the instrument should be removed, (this is held by four screws), when the screws A and B of fig.3 can be removed. On the same panel may be seen the link which is used to adapt the instrument for mains voltages of either 100 - 150 V. or 200 - 250 V. All instruments are set for 200 - 250 V. when leaving the factory.

USE WITH MULLARD GM.4260 1,000 CYCLE OSCILLATOR.

The GM.4260 provides a voltage of approximately 1,000 c/s for supplying the bridge network, and is particularly suitable when small capacities are being measured, or when the bridge is being used with the GM.4251 conductivity cell for measurement of the electrical conductivity of liquids. After disconnecting the internal 50 c/s supply as described in the previous paragraph, the equipment is connected as shown in fig.4.

The control knob on the GM.4260 is used to control the strength of oscillation and hence the purity of the waveform. To obtain the purest waveform, the apparatus should be set up as shown with the bridge potentiometer at one end of the scale and the sensitivity control about half way advanced. Then starting from minimum, the GM.4260 control is rotated in a clockwise direction until the dark area of the "Magic Eye" begins to fluoresce. The GM.4260 also contains a 50 cycle voltage for feeding the bridge network, in order to be able to change quickly from 50 c/s to 1,000 c/s without opening up the measuring bridge.

BALANCE INDICATOR



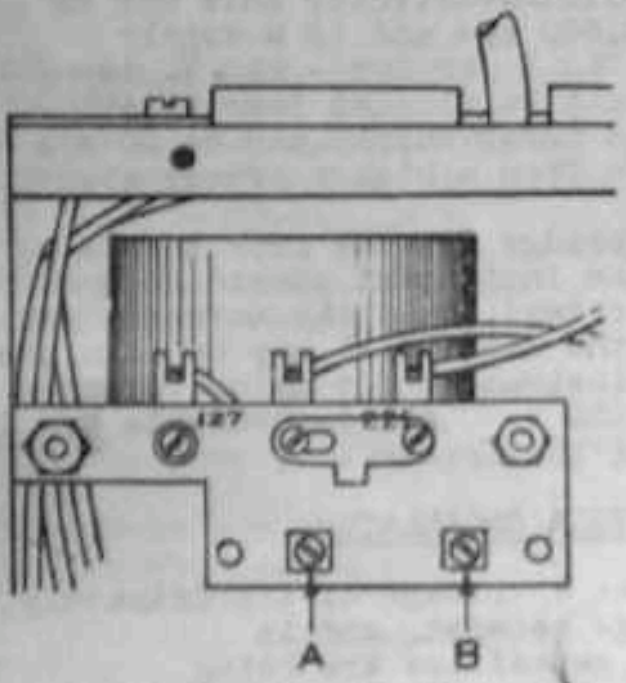
BRIDGE OUT OF BALANCE

A

BRIDGE IN BALANCE

B

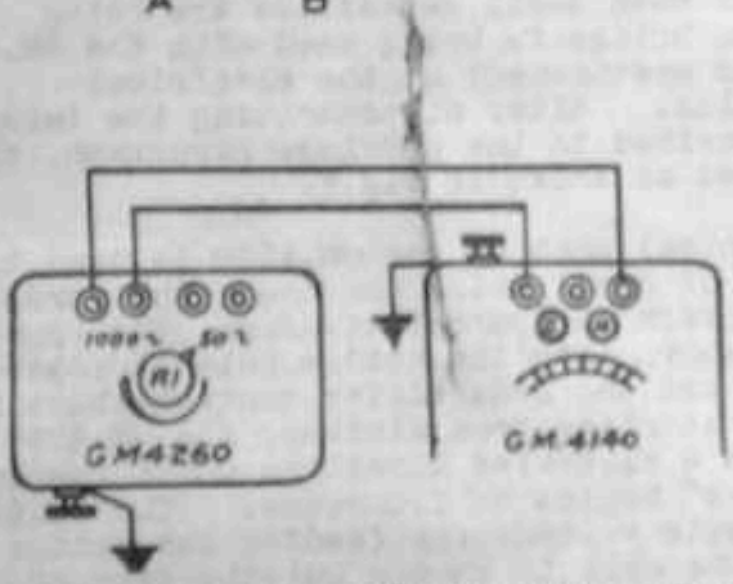
FIG. 2



View of connections to mains transformer. As shown the instrument is set for 200-250 V. For operation on 100-150 V. the link should go across the left-hand screws.

Screws A and B should be removed to disconnect the 50 cycle supply from the bridge network.

FIG. 3



Connections for use with GM.4260 oscillator.

FIG. 4

MAINTENANCE.

To dismantle the bridge for valve replacement, etc., first remove the bottom plate as described earlier. Next remove all knobs and the countersunk screw under the main control knob. Then remove the earth terminal and the three screws around the base of the instrument, after which the chassis can be withdrawn from the case. The EF36 and the EB34 may be replaced without any further trouble, but to replace the EM4 "Magic Eye" it is necessary to raise the metal screen which is held by a screw holding the valve socket. The bridge is reassembled in the reverse way and then adjusted in the "control" position as previously described.

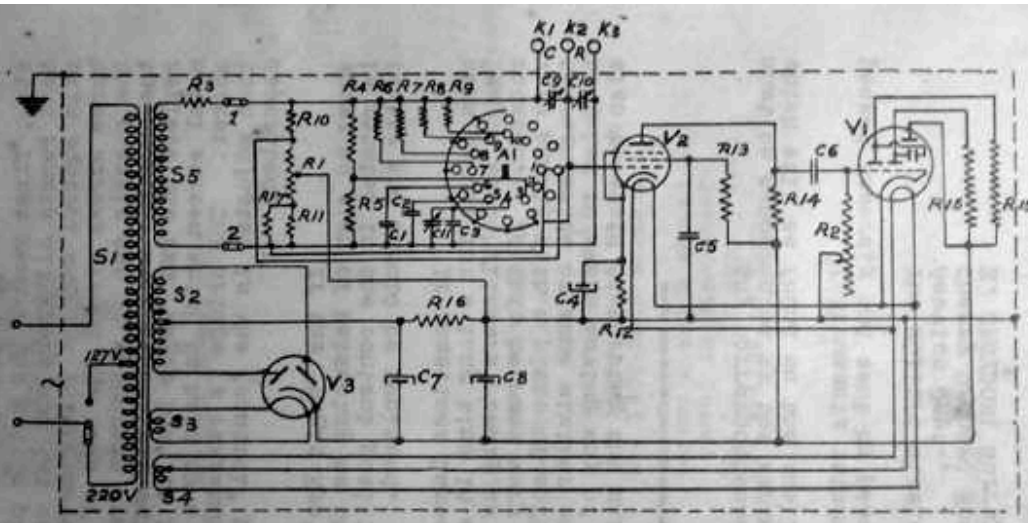
If the "Magic Eye" indicator lights up, but shows no sign of balancing as the main control potentiometer is rotated in the control position, the EM4 is most probably faulty and should be replaced.

It sometimes happens that after the bridge has been in use for a long time in a corrosive atmosphere, the "Magic Eye" "flickers" badly as the control potentiometer is rotated. If this becomes very bad, the track may be wiped very gently with a piece of soft rag soaked in carbon tetrachloride or some similar solvent. Great care should be taken to avoid moving any of the turns on the element and also to avoid disturbing the main wiring in any way.

Any correspondence regarding this instrument must be accompanied by the serial number of the instrument, which will be found on the small type plate at the back.

Instruments returned for service should be packed securely and sent by passenger train to:-

The Mullard Wireless Service Co. Ltd.,
Service Dept.,
Cherry Orchard Road,
E. CROYDON, Surrey.



SCHEMATIC DIAGRAM AND LIST OF COMPONENT PARTS

R1	Potentiometer	Wire-wound	1000 ohms	C1	Condenser	tubular paper	1 µF
R2	"	Carbon	1 Mohm	C2	"	"	10000 pF
R3	Resistance	Wire-wound	5 ohms	C3	"	mica	85 pF
R4	"	" "	100 ohms	C4	"	dry electrolytic	25 µF
R5	"	" "	100 ohms	C5	"	tubular paper	0.47 µF
R6	"	" "	1 ohm	C6	"	" "	10000 pF
R7	"	" "	100 ohms	C7	"	wet electrolytic	8 µF
R8	"	" "	10000 ohms	C8	"	" "	8 µF
R9	"	Carbon 1 watt	1 Mohm	C9	"	trimmer	6 pF
R10	"	Wire-wound	85 ohms	C10	"	"	6 pF
R11	"	" "	85 ohms	C12	"	"	5 pF
R12	"	Carbon ½ watt	16000 ohms				
R13	"	" 1 watt	1.25 Mohm				
R14	"	" ½ watt	0.8 Mohm				
R15	"	" 1 watt	1 Mohm				
R15a	"	" 1 watt	1 Mohm	V1	Tuning indicator		EM4
R16	"	" 1 watt	11000 ohms	V2	H.F. pentode		EF36
R17	"	Wire-wound	23 ohms	V3	Full-wave rectifier		EB34