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GROUP 117 : RADIO AND RADAR TEST EQUIPMENT
SUB-GROUP L : COMPONENT TESTERS

# REFORMING UNITS ELECTROLYTIC CAPACITOR No. 1 EQUIPMENT

## GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

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Ministry of Defence

FOR USE IN THE
ROYAL AIR FORCE

(Prepared by the Ministry of Technology)
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# LEADING PARTICULARS

## REFORMING UNIT, ELECTROLYTIC CAPACITOR, No. 1 EQUIPMENT

| | |
|---|---|
| *Stores Ref.* | 10S/6625-99-949-0042 |
| *Purpose of equipment* | *For reforming electrolytic capacitors one at a* time |
| *Capacitance settings* | *LV*, 2, 4, 8, 16, 32, 60, 100 (*and over*) *microfarad. The* LV *setting is used for all capacitors having a working voltage less than* 150*V, regardless of the capacitance involved.* |
| *Working voltage settings* | 6, 12, 25, 50, 100, 150, 275, 350, 375, 450 (*and over*). |
| *Indications* | *A red lamp lights to indicate mains supply* ON. *On all reforming ranges the leakage current through the capacitor is indicated by a meter; in addition, on reforming voltage ranges of* 150*V and above, a green lamp flashes to indicate that reforming is proceeding. The same lamp flashes on all ranges while the capacitor is discharging, extinction of the lamp indicating either that the reforming current has fallen below* 0·5*mA or that the capacitor is discharged, according to the position of the* REFORM *switch.* |
| *Power supply* | 100 *to* 125*V or* 200 *to* 250*V a.c. at* 50 *c/s.* |
| *Approx. overall dimensions* | $8\frac{3}{4}$ *in. by* 12 *in. by* $9\frac{3}{8}$ *in.* |
| *Weight* | 20 *lb. approx.* |

# Chapter 1

# GENERAL INFORMATION

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### Introduction

**1.** Reforming unit, electrolytic capacitor, No 1 equipment is a panclimatic instrument suitable for testing and reforming the majority of the electrolytic capacitors in use with the Services. It can accommodate only one capacitor at a time. The controls permit the selection of reforming voltages suitable for capacitors with working voltages of 6, 12, 25, 50, 100, 150, 275, 350, 375 and 450V. For capacitors having a higher rated voltage the 450V setting is used.

### Brief structural description

**2.** The instrument is housed in a sturdy case of cast aluminium (fig. 1). Seals are introduced between this case and the front panel, and also at the meter, control-spindle and all other openings in the panel, to prevent the ingress of dust and moisture. Two desiccator units are fitted in the bottom of the case to absorb any residual moisture from the case interior.

**3.** A raised flange fitted around the front panel assists in protecting the controls and meter from accidental damage when the equipment is in use. A lid, secured by four captive screws, is fitted over the flange and panel when the equipment is not in use.

**4.** Fitted within the lid is a "test plate' which provides stowage for the mains connector and the capacitor leads it also serves as a holder for the capacitors being serviced. This test plate consists of a flat metal panel having four cleats around which the leads may be coiled. It also has four spring clips, each of a different size, to accommodate the various types of capacitors having terminals at both ends, and three circular openings, of differing diameters, suitable for supporting the normal range of capacitors having terminals at one end only.

**5.** The capacitors are connected to the unit by a twin-wire lead terminated at one end by a plug to fit the output socket on the front panel of the instrument, and at the other end by crocodile clips for attaching to the terminals of the capacitor being serviced. Insulating sleeves are fitted over the clips, the sleeve colour indicating the polarity of the wires. The lead is normally secured to the test plate at a point approximately six inches from the crocodile clips, but may be unclipped to facilitate the testing of capacitors insitu.

**6.** The test plate is secured to flanges within the lid by four pivoted screws fitted with knurled nuts which engage with slots in the plate. To stow

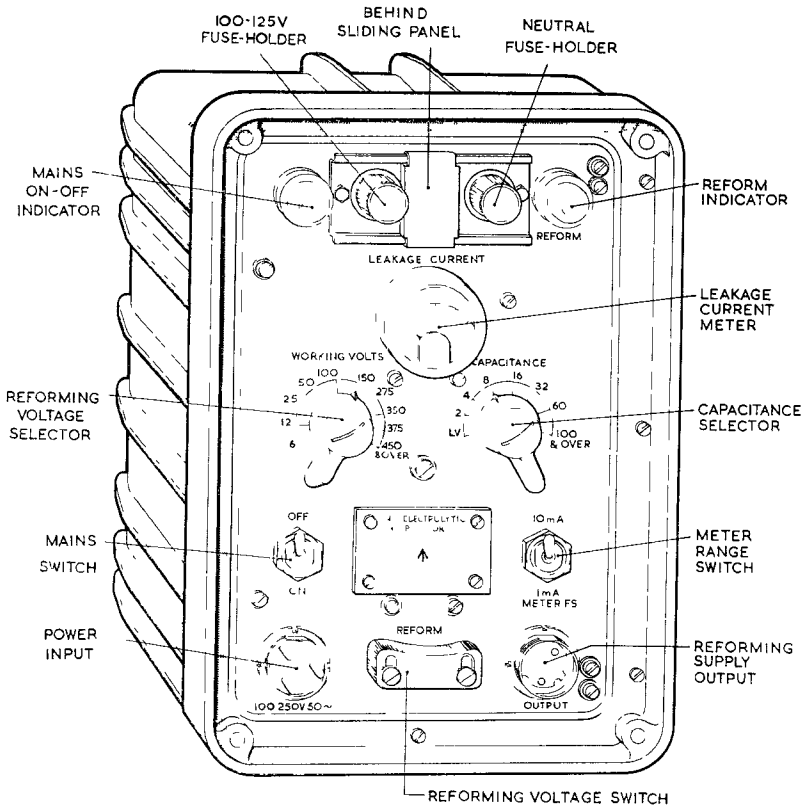



**Fig. 1. Reforming units, electrolytic capacitor No. 1 equipment**

the equipment after use the capacitor lead and the mains connector are first disconnected from the front panel and wound round the cleats of the test plate. The four knurled nuts are then slackened and swung back clear of the test-plate slots, the plate is turned over within the lid so that the leads and clips face away from the front panel, and the plate is again secured by the four captive nuts. The lid is then fastened over the front panel. The front panel controls and their functions are listed in para. 16 and illustrations of the internal structure of the instrument are given in Chap. 2 of this publication.

**Brief technical description**

**7.** Electrolytic capacitors consist of positive and negative electrodes in a suitable conducting liquid or paste. In the types normally encountered, the electrodes consist of aluminium foil separated by paper or other suitable material impregnated with a viscous electrolyte. In such a capacitor the dielectric consists of a thin insulating film formed directly on the positive electrode, and it is usually deterioration of this film which causes excessive leakage current through the capacitor.

**8.** As noted earlier, the function of the reforming unit is to provide means for measuring this leakage current, particularly in capacitors which have been stored for some time, and for reforming the dielectric film as necessary to restore the capacitor to a serviceable condition. This reforming is performed by applying a suitable d.c. voltage of correct polarity to the capacitor for a period of time depending on the condition of the capacitor.

**9.** In the equipment under consideration the reforming voltage is obtained from a mains transformer having a tapped secondary, the correct tapping being selected by a switch (WORKING VOLTS) on the front panel. The selected a.c. voltage is rectified by a bridge-type metal rectifier, and the resulting d.c. voltage, after smoothing, passes through a milliammeter which indicates the reforming (leakage) current, and then through suitable voltage and current-limiting resistors to a two-pole spring-loaded REFORM switch. This switch, when pressed, connects the reforming supply to an OUTPUT plug and thence through flexible leads to the capacitor being serviced. The limiting resistors are selected by the remaining wafers of the WORKING VOLTS switch and by a CAPACITANCE selector switch.

**10.** The LEAKAGE CURRENT meter has two ranges. It normally operates at 10mA f.s.d. but, by depressing a METER F/S switch, it can be changed over to 1mA f.s.d. An automatic cut-out protects the meter movement from excessive overloads.

**11.** The leakage in an electrolytic capacitor is influenced by the applied voltage, the temperature, and by the amount and conditions of use When voltage is applied to a capacitor after a period of idleness the leakage current is initially excessively high, but rapidly falls to a more normal value as the dielectric film is reformed.

**12.** In this reforming unit the reforming voltage on the lower voltage ranges is applied to the

capacitor directly. On the higher ranges (150V or more), however, there is a possibility that if the supply were connected to the capacitor directly, the heavy leakage current during the early stages of reforming would damage the specimen by over-heating.

**Interrupter circuit**

**13.** To obviate this possibility, on the higher voltage ranges the reforming voltage is interrupted and applied as a series of pulses instead of continuously. As a result of this, although a fairly large leakage current may flow, the mean current, and consequently the heating and deleterious effect on the capacitor, will be minimized. While the interrupter circuit is operating, a green lamp at the top of the front panel will flash and the interrupter relay will be audible.

**14.** The leakage current will decrease as the specimen reforms, and as the fully-reformed state is approached (except where the capacitance and/or the working voltage rating is high), the interrupter is automatically removed from the circuit.

**15.** For certain large capacitors, particularly those of high working voltage, the permissible leakage current (Chap. 3, Table 2) may be of such a high value that the interrupter circuit will remain in action even when the capacitor is fully reformed. For all ranges of reforming voltage and capacitance the leakage current is continuously indicated by the LEAKAGE CURRENT meter on the front panel it is the reading indicated by this meter which is used to determine the serviceability of the specimen.

**WARNING . . .**

**When reforming a capacitor the WORKING VOLTS switch must never be set to a voltage greater than the rated working voltage of the specimen.**

**Controls and associated items**

**16.** Mounted on the front panel are the following:—

| | |
|---|---|
| ON-OFF switch | This is a two-pole toggle switch and controls the mains supply. |
| 100-250V 50 c/s plug | Plug for mains input supply. |
| OUTPUT socket | Reforming voltage output socket; for connection of the capacitor leads. |
| Three fuse sockets with a sliding cover | Only two fuses are used, the cover being over the unused fuse-holder. One fuse is always in the right-hand holder, but the other is in the left-hand holder for 100 to 125V supplies, or in the centre holder for 200 to 250V supplies. |
| Meter | The meter has two ranges, 0 to 10mA and 0 to 1mA. It indicates the current passing through the capacitor being reformed. |
| Red indicating lamp | Lights to indicate mains supply ON. |
| Green indicating lamp (TEST) | Flashes during the reforming of capacitors on voltages of 150 and above. Flashes during discharge of all capacitors. |
| WORKING VOLTS selector | This 10-position switch selects the reforming voltage, 6, 12, 25, 50, 100, 150, 275, 350, 375, or 450V may be selected. For greater voltages the 450V position is used. |
| CAPACITANCE selector | This eight-position switch is adjusted to suit the specimen capacitor. Positions for 2, 4, 8, 16, 32, 60 and 100 microfarad capacitors are provided. For larger capacitors the 100 microfarad position is used. An additional setting, LV (low voltage) is used for all capacitors having a working voltage of less than 150V. |
| METER F/S switch | Meter-range switch. |
| REFORM switch | This is a two-pole spring-loaded switch operated by pressure on a sliding finger-piece of black material. When it is pressed, the reforming supply is made available at the OUTPUT socket. It must be held in the depressed position for the entire duration of the reforming process. |

Chapter 2
(Completely, revised)

# DETAILED STRUCTURAL AND CIRCUIT DESCRIPTION

## CONTENTS



## ILLUSTRATIONS



## DETAILED STRUCTURAL DESCRIPTION

1. The reforming unit is a fully panclimatic instrument. The circuit components are mounted either on a heavy-gauge aluminium front panel or on a small flanged chassis, which is secured behind, and parallel to the panel.

2. The Chassis and components at the back of the panel are enclosed by a sturdy ribbed case of cast aluminium. The controls, meter and other components on the front of the panel are protected from accidental damage while the instrument is in use by a rised flange or 'fence' of cast aluminium, and when not in use, by a lid assembly of spot-welded sheet metal.

3. The panel is secured to the case by eight 2 BA screws with washers and self-locking nuts, and the lid is secured to the panel by four captive screws. A rubber ring in a groove in the case edge seals the joint between the case and the panel, and further seals are provided at all openings in the front panel, e.g. where the meter, fuseholders, controls and similar items pass through the panel. Two desiccator units are fitted in the bottom of the case to absorb residual moisture from the case interior. There is no seal between the lid and the case.

4. Figure 1 shows the complete unit ready for use, the lid assembly being shown in the foreground. As described in Chap 1, the lid assembly comprises the lid itself and a "test-plate" which provides stowage for the mains

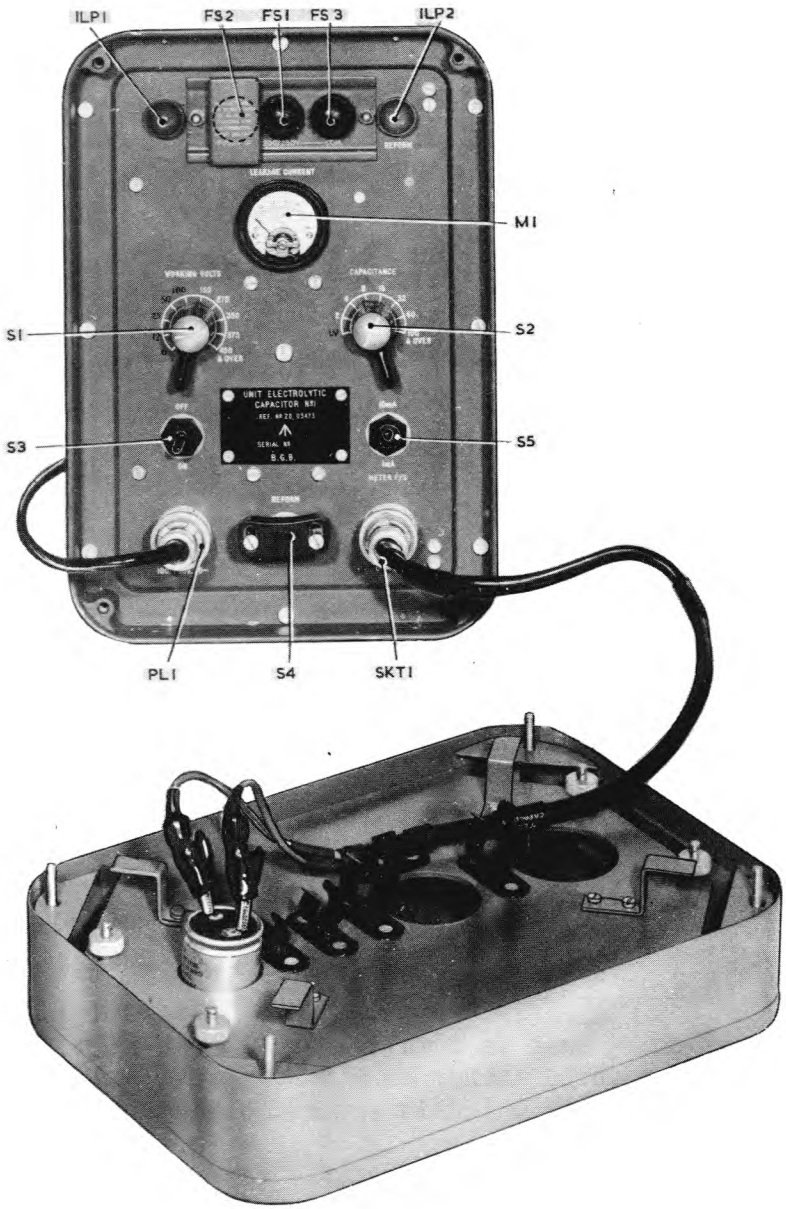



Fig.1. Reforming unit, front view with lid removed

connector and the test leads; it also serves as holder for the capacitor under test. In the illustration a specimen of the "single-ended" type of capacitor is shown installed. Before fitting the lid on the reforming unit, the test plate must be turned over (so that the smooth side of the plate will be towards the front panel) and secured in this position by the knurled nuts.

5. Figure 2 shows the panel and chassis assembly removed from the case. Heavy guard rails are fitted to the back of the chassis, and a microswitch S6, (in the mains input circuit) is fitted near the lower end of the left-hand rail in such a position that installing the case will make, and removing the case will break the mains supply circuit.

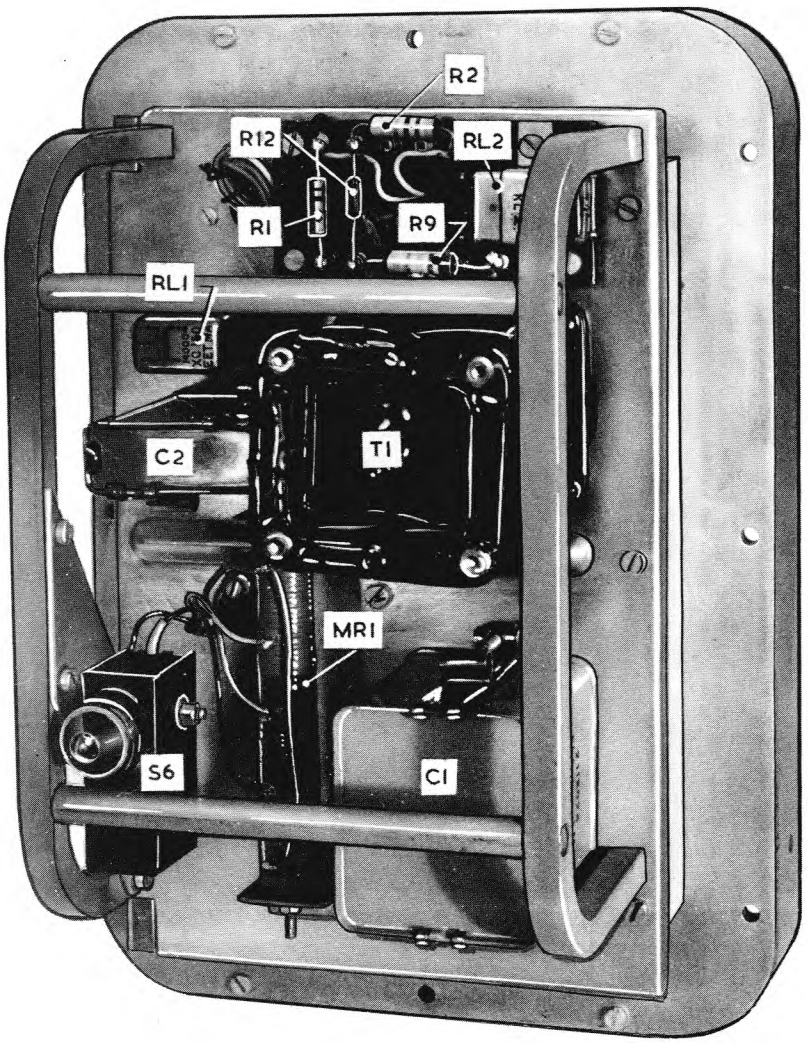



Fig.2. Reforming unit, rear view, with case removed

6. The rectifier MR1 and smoothing capacitor C1 for the reforming supply are visible at the lower end of the chassis, and the meter cut-out relay RL2 near the top. The mains transformer T1, the interrupter relay RL1 and a capacitor C2, which forms part of a spark filter and delay network for the interrupter relay, are towards the centre of the chassis. The resistors associated with these portions of the circuit are located at the top of the chassis; R1 being part of the relay filter, R2 and R12/R12A being in the meter cut-out circuit, and R9 being part of the reforming supply smoothing filter.

7. The left-hand edge of the chassis (fig.2) is pivoted to two pillars on the front panel, the right-hand edge is secured by three screws to an aluminium strip on the panel and, for additional rigidity, the centre of the chassis is secured to a pillar on the panel by one screw. When these four screws are removed, the complete chassis may be swung back to give access to the components and wiring located between the chassis and panel, as shown in fig.3. The meter and the various switches are easily identified in the illustration.

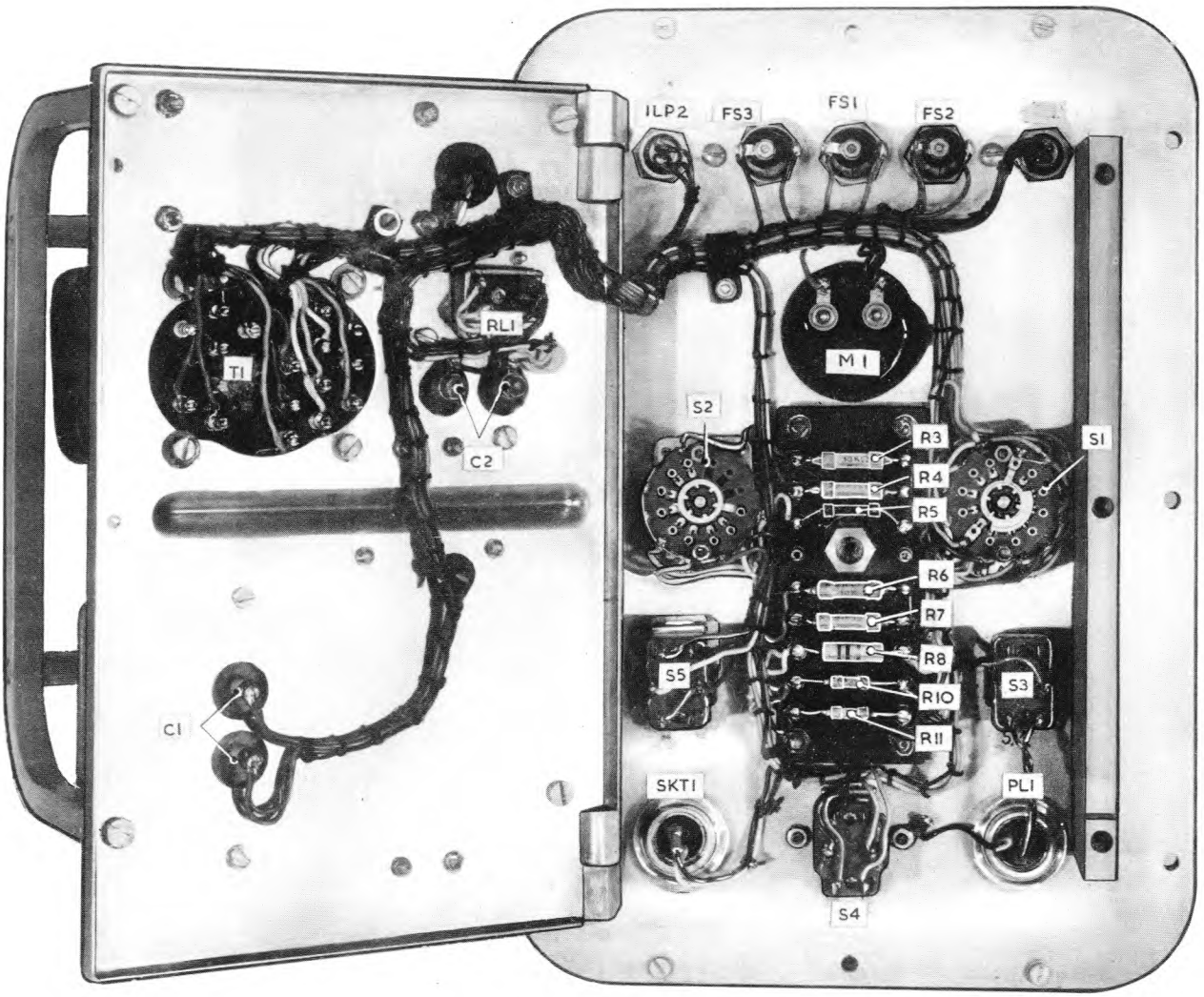



Fig.3. Reforming unit, rear view with case and chassis removed

The two resistors R10 and R11 at the bottom of the centre tagboard are the meter multiplier and the meter shunt resistor respectively. The remainder of the resistors and those selected for use in the capacitor reforming or discharge circuits by means of the WORKING VOLTS and CAPACITANCE switches (S1 and S2, respectively).

## DETAILED CIRCUIT DESCRIPTION

8. The unit (fig.5) includes a power pack, range switches, an interrupter circuit, and indicating circuits. The power pack provides the required reforming supplies, and the range switches control the reforming voltage, and adjust the circuitry to suit the type of capacitor being serviced. The interrupter circuit reduces the possibility of the capacitor being damaged through excessive current flow. The indicating circuits provide lamp indications on some reforming and all discharge ranges, and meter indications of the current on all reforming ranges.

Power pack

9. The mains supply is fed to the transformer through poles A and B of a three-pole plug PL1, a two-pole mains ON OFF switch S3, fuses FS1 (or FS2) and FS3, and a safety micro-switch S6. The latter switch is biased to return to the OFF position whenever the instrument is removed from the case.

10. The equipment is suitable for operation on single phase 50 Hz supplies at either 115V or 230V (nominal), or within ±5 per cent, of these voltages. Adjustment for input voltage is made by inserting a fuse in holder FS1, for the 230V range, or in holder FS2, for the 115V range; this connects the supply to the appropriate tapping on the mains transformer primary. A sliding cover protects the fuseholder not in use, Fuse FS3, in the neutral line, is always in circuit. Additional tappings on the mains transformer permit adjustments during manufacture to suit small component variations.

11. There are two secondary windings on the mains transformer, one winding providing a 6V a.c supply for the two indicating lamps ILP1 and ILP2, and the other one having ten tappings giving a.c. outputs of 10.4, 15, 24.5, 42, 79, 113, 207, 260, 278 and 341V 50Hz which, when rectified constitute the capacitor reforming supply.

12. The secondary winding tapping which corresponds to the required reforming voltage is selected by wafer A of a WORKING VOLTS selector switch S1, and the resulting a.c. output is rectified by a bridge-type metal rectifier MR1. This d.c. supply is smoothed by a filter consisting of a 4 microfarad capacitor C1 and a 220k resistor R9. To reduce the possibility of accidental shock, the entire reforming-voltage system is insulated from the chassis. When the mains supply is switched on, ILP1 (red) will light. The other lamp ILP2 (green) lights only when the interrupter circuit (Chap.1, Para 13) is operating.

Indicating and control circuits

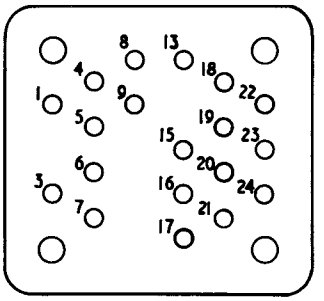
13. The principal controls on the unit are the three-pole ten-way WORKING VOLTS selector switch S1, the two-pole eight-way CAPACITANCE selector switch S2 and a spring loaded non-locking two pole REFORM switch S4. The circuit varies according to the setting of the above switches, but the two-range meter M1 and its associated safety circuit is always in circuit when a capacitor is being reformed. The interrupter relay is always in circuit when capacitors with working voltages greater than 150V are being reformed, and is also in use on all ranges when capacitors are being discharged.

Meter circuit

14. During the reforming of a capacitor (REFORM switch S4 depressed) the meter M1 and its series resistor R10 are connected between the negative side of the reforming supply and pole B of the output socket SKT1 to provides a constant indication of the reforming or leakage current passing through the capacitor. Normally the meter and its series resistor R10 are shunted by a 130-ohm resistor R11, in which condition the full-scale deflection corresponds to a current of 10mA. When the meter indication is less than 1mA, more accurate indications may be obtained by depressing a METER F/S range switch, S5. Contact S5B then disconnects the shunt R11, with the result that full-

scale deflection represents 1mA.

15. To reduce the possibility of the meter being damaged by accidental overload, such as might occur through breakdown of the capacitor being serviced, and overload relay RL2 is introduced. This relay is controlled by the voltage drop across one or other of the two resistors R12 and R2 which are in series with the reforming supply, the relay winding being connected by contact S5A of the METER F/S switch across R12 (4.7Ω) for the 10mA meter range, or across R2 (47 ohms) for the 1mA range. When the current through the resistors becomes excessive, the relay is energized and its contacts RL2/1 close to provide a direct path across the meter terminals. The use of the two alternative resistors in the relay-energizing circuit ensures that the overload relay will operate when a given current passes through the meter movement, regardless of the total current flowing in the reforming circuit.



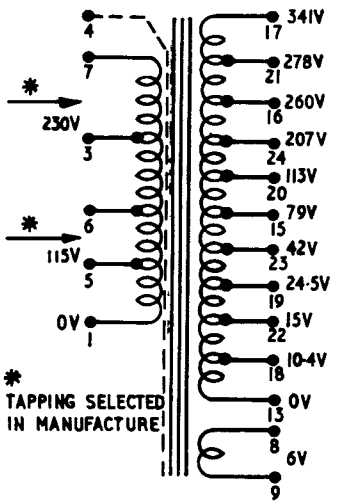




Fig.4. Mains transformer terminal and voltage diagram

Interrupter relay

16. The interrupter relay RL1 is in circuit on all ranges when the REFORM switch S4 is at its normal or 'discharge' position, and is also in circuit on WORKING VOLTS settings of 150V or more. From figure 5 it will be seen that the winding of RL1 and the 'break' side of contacts RL1/1 are connected in series in the negative reforming supply line, while the 'make' side of RL1/1 is connected across a circuit which includes the 6V winding of T1 and a green REFORM indicating lamp ILP2. When capacitors with a working voltage or less than 150V are being serviced, the relay winding is automatically short-circuited when the REFORM switch is depressed and, consequently, the relay is inoperative. If the REFORM switch is depressed on any other WORKING VOLTS setting, the capacitor reforming (leakage) current will flow continuously through the relay windings and contacts so long as the current is less than approximately 0.6mA. If the current exceeds this value, however, relay RL1 will be energized and contacts RL1/1 will break the reforming circuit and make the indicating lamp circuit, causing ILP2 to light. Since RL1 is now de-energized, the contacts will return to their original position, re-connecting the reforming supply and extinguishing ILP2. This sequence will continue, the reforming voltage being applied to the capacitor in pulses (with

the green lamp flashing) until the leakage current through the relay has fallen below the 0.6mA level when the lamp will be extinguished and a steady current will flow. A filter comprising a 1K resistor (R1) and a 1 microfarad capacitor (C2) is connected across the break contacts of the relay to increase the break time and also to protect the relay contact from excessive sparking.

Note ...

The power unit is not designed to supply short-circuit currents greater than 15 mA for long periods. The introduction of RL1 ensures an average current of 10 mA through the interrupter circuit.

17. When the REFORM switch is released, the reforming supply is disconnected from the capacitor and the two capacity terminals are connected together through the relay winding and the break contacts of RL1/1. The lamp ILP2 is still connected to the break contacts of RL1/1, consequently the relay will operate and the lamp will flash until the discharge current has fallen below 0.6mA so providing an indication of the progress of the discharging process. This indication is available on all ranges of the unit.

Note ...

The maximum voltage likely to exist across the capacitor at the 0.6mA stage of discharge is normally less than 10V.

Range selection and reform controls

18. As noted, the reforming unit is adjusted by means of the WORKING VOLTS switch S1 and the CAPACITANCE switch S2 to suit the capacitor being serviced. Wafer A of S1 determines the reforming voltage available from the power pack, and the remaining wafers B and C of this switch, in conjunction with wafers A and B of S2, determine the amount of resistance in the reforming and discharge circuits, and whether the interrupter relay will be in use or not.

Capacitors of less than 150V working

19. In figure 5, switches S1 and S2 are shown adjusted for capacitors of 6V.W., that is, S1 is set to 6V and S2 is set to LV (the latter setting is used for all capacitors having a working voltage of less than 150V, regardless of the capacitance). If the REFORM switch S4 is now depressed, resistor R8 will be short-circuited by S1C and the winding of relay RL1 will be short-circuited by S2B, S4B and S1B. Consequently, at this control setting the capacitor is connected, in series with the leakage, current meter M1, directly across the selected reforming supply.

20. If the REFORM switch S4 is now release, S4A disconnects the capacitor from the reforming supply and connects it to the indicating lamp circuit. At the same time S4B removes the short-circuit from the winding of RL1, with the consequence that the capacitor discharges through the relay, as described in para. 16, and lamp ILP2 flashes to indicate that discharge is proceeding.

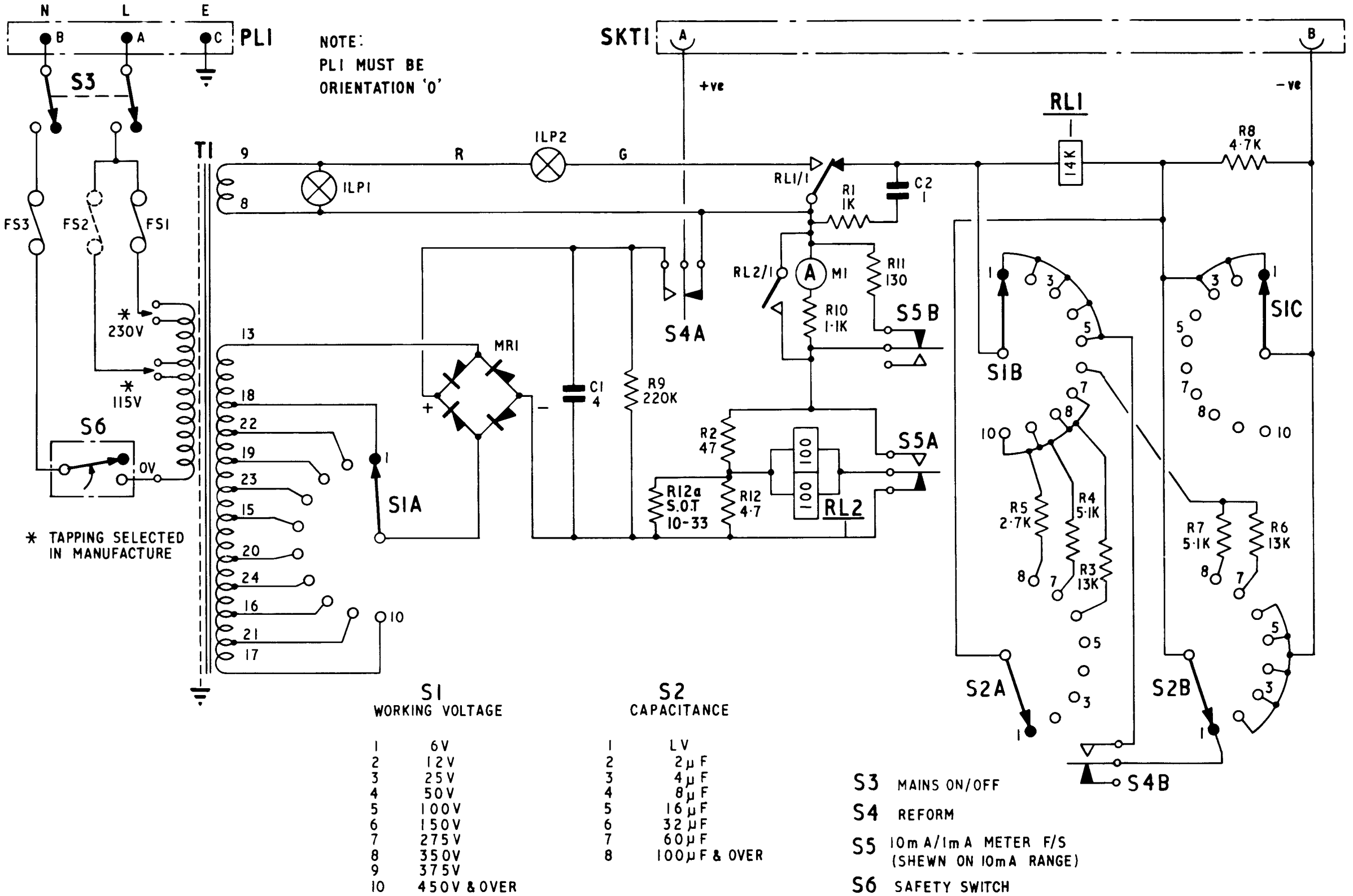
21. With the exception of the changes in reforming voltage brought about by wafer A of S1, the circuit will be as described above for capacitors of 6, 12 or 25V.W. For capacitors of 50 and 100 V.W., the action of S1C introduces

a 4.7k series resistor R8 both in the reforming and in the discharging circuits.

Capacitors of 150V or above

22. When servicing capacitors rated at 150 V.W., and above, the CAPACITANCE control must be turned to the correct capacitance setting. When S2 is at LV (position 1) and S1 is turned to 150V (position 6) the short-circuit (para. 16) across RL1 will be removed, with the consequence that the reforming voltage will be applied to the capacitor in pulses, and the green lamp will flash until the leakage has fallen below 0.6mA. In positions 2 to 6 of the CAPACITANCE switch S2 (2 to 32 microfarads). R8 will be short-circuited, but in position 7 (the 60 microfarad setting) this short-circuit will be removed, leaving R8 in series with the winding of RL1; at the same time a 13k shunt, R6, will be connected across the RL1 winding. On the 100 microfarad and over setting (position 8) the circuit is similar but the relay winding shunt is then 5.1k (R7).

23. On all WORKING VOLTS settings above 150V, R8 is short-circuited for capacitances below 60 microfarad (except for the LV setting) and is in circuit for those above that value. The interrupter relay is in circuit on all capacitance settings, but on the three highest settings (32, 60 and 100 or over microfarad), is shunted respectively by R3, R4 and R5 (13k, 5.1k and 2.7k ohms). This applies both to the reforming and discharge circuits.




**S1**
WORKING VOLTAGE

| | |
|---|---|
| 1 | 6V |
| 2 | 12V |
| 3 | 25V |
| 4 | 50V |
| 5 | 100V |
| 6 | 150V |
| 7 | 275V |
| 8 | 350V |
| 9 | 375V |
| 10 | 450V & OVER |

**S2**
CAPACITANCE

| | |
|---|---|
| 1 | LV |
| 2 | 2μF |
| 3 | 4μF |
| 4 | 8μF |
| 5 | 16μF |
| 6 | 32μF |
| 7 | 60μF |
| 8 | 100μF & OVER |

**S3** MAINS ON/OFF

**S4** REFORM

**S5** 10mA/1mA METER F/S
(SHEWN ON 10mA RANGE)

**S6** SAFETY SWITCH

Fig. 5. REFORMING UNIT, ELECTROLYTIC CAPACITOR, No. 1, EQUIPMENT

# Chapter 3

# OPERATING INSTRUCTIONS

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### Introduction

**1.** The operation of the instrument is basically simple but not fool-proof, and since the test specimen is assessed by the indicated leakage current, it is important that the working voltage of the specimen is not exceeded and that the polarity of the reforming voltage conforms with the polarization of the capacitor (i.e. +ve lead to +ve pole). The panel controls and their respective functions are given in Chap.1.

### Preliminary instructions

**2.** (1) Undo the four captive screws which secure the lid of the reforming unit and remove the lid.

(2) Loosen the four knurled nuts within the lid, disengage them from the test-plate, then invert the plate and again secure it with the nuts.

(3) Make certain that the two fuses at the top of the panel are in the correct position, that is, one fuse in the right-hand holder, and the other in the left-hand holder if the supply is 100 to 125V, or in the centre holder if the supply is 200 to 250V.

(4) Set the mains ON-OFF switch to OFF, then unwind the capacitor lead and the mains connector from the test plate and connect them respectively to the OUTPUT socket, and to the "100/250V, 50 c/s" plug and the mains supply.

### Testing and reforming a capacitor

**3.** (1) Insert the capacitor in a suitable holder in the test plate, then connect the red crocodile clip of the test lead to the positive terminal of the capacitor and the black clip to the negative terminal. If the capacitor is to be tested insitu it will be necessary to unclip the lead from the test plate before connecting it to the capacitor. All other wiring should be disconnected from the capacitor before the test leads are connected.

(2) If the d.c. working voltage of the capacitor is 150V or more, turn the CAPACITANCE selector to the capacitance in microfarads if it is less than 150V, set the CAPACITANCE selector to LV.

(3) Set the WORKING VOLTS switch to the rated voltage of the capacitor.

(4) Set the mains ON/OFF switch to ON the red lamp should light.

(5) Depress the REFORM switch and hold it in that position the reforming voltage is now being applied to the capacitor. Proceed as in operation (6) if the working voltage is less than 150V, or as in operation (7) if the working voltage is 150V or more.

(6) If the d.c working voltage is less than 150V (CAPACITANCE selector at LV) the leakage current will be shown on the meter (normal f.s.d. 10mA; if the reading is less than 1mA press the METER F/S switch for 1mA f.s.d.). Compare this reading with the

figure for maximum permissibl
ent given in Table 1. If the reading is equal to, or slightly less than, that quoted the capacitor is satisfactory. Note, however, that if no leakage whatever is indicated, the capacitor is probably open-circuited and is not usable. This can be verfied by releasing the REFORM switch and noting whether a discharge current is indicated. If no discharge is shown, then the capacitor is open-circuited. If the reading is greater than that quoted, continue to hold the REFORM switch at ON, and observe whether the leakage decreases. If it increases the capacitor should be rejected. If it decreases gradually, continue the reforming process until the reading falls to the specified value, then proceed as in operation (10).

**Note . . .**

*Rapid check of a capacitor.—A steady fall in leakage current indicates that reforming is proceeding satisfactorily. Once this is ascertained the reforming can, if desired, be terminated and the capacitor put into use. It will continue reforming in use. This method, however, does not ensure that the leakage will be within the limits prescribed.*

(7) If the rated d.c. working voltage is 150V or more, and the capacitor is of such a type and condition that the leakage current is less than 0·5 mA, the process will be as described in operation (6) but if the capacitor has a leakage current greater than 0·5mA the interrupter circuit (Chap. 1, para. 13) will operate, applying the reforming voltage in pulses, and the green REFORM lamp will flash in time with the pulses.

(8) Note the leakage as indicated by the LEAKAGE CURRENT meter. As before, an increase in the leakage indicates that the capacitor is unsatisfactory and should be rejected,

ı the leakage indicates that reforming is progressing.

(9) Where the capacitor has a permissible leakage current less than 0·5mA the interrupter will cut out at that figure. In capacitors with higher permissible leakage it will operate during the entire reforming time. In either instance, continue the reforming process until reforming is complete and the meter indication has fallen to the appropriate value as shown in Table 2.

(10) When reforming is complete (or the specimen rejected) release the REFORM switch. This automatically applies a discharge resistor across the capacitor. As the discharge takes places through the interrupter relay, the green lamp will flash until the discharge current falls below 0·5mA. The capacitor should not be disconnected until a few seconds after the lamp has stopped flashing. When the capacitor is discharged, disconnect and remove it.

**WARNING . . .**

**The capacitor under test should not be removed from the instrument until it is fully discharged (i.e. a few seconds after the green lamp ceases to glow). Serious even fatal shocks can result from a comparatively low voltage capacitor fully charged.**

*If there is any reason to doubt that a capacitor is fully discharged (for example, if the green lamp does not flash when the* REFORM *switch is released after a capacitor appears to have reformed correctly) a suitably insulated conductor (preferably incorporating a resistor) should be applied across the capacitor terminals before it is handled.*

**TABLE 1**

**Maximum permissible leakage current for reformed capacitors with working voltage less than 150V**

| Capacitance (microfarads) | Leakage current (mA) 6V.W. | 12V.W. | 25V.W. | 50V.W. | 100V.W. |
|---|---|---|---|---|---|
| 3 | 0·10 | 0·10 | 0·10 | 0·10 | 0·10 |
| 5 | 0·10 | 0·10 | 0·10 | 0·10 | 0·10 |
| 10 | 0·10 | 0·10 | 0·10 | 0·10 | 0·15 |
| 12 | 0·10 | 0·10 | 0·10 | 0·10 | 0·18 |
| 20 | 0·10 | 0·10 | 0·10 | 0·15 | 0·30 |
| 25 | 0·10 | 0·10 | 0·10 | 0·19 | 0·38 |
| 50 | 0·10 | 0·10 | 0·19 | 0·38 | 0·75 |
| 100 | 0·10 | 0·18 | 0·38 | 0·75 | 1·50 |
| 250 | 0·22 | 0·45 | 0·94 | 1·88 | 3·75 |
| 500 | 0·45 | 0·90 | 1·88 | 3·75 | 7·50 |
| 1,000 | 0·90 | 1·80 | 3·75 | 7·50 | 15·00 |
| 1,500 | 1·35 | 2·70 | 5·63 | 11·30 | 22·50 |
| 2,500 | 2·25 | 4·50 | 9·40 | 18·70 | 37·50 |
| 3,000 | 2·70 | 5·40 | 11·30 | 22·50 | 45·00 |
| 5,000 | 4·50 | 9·00 | 18·70 | 37·50 | 75·00 |

## TABLE 2

**Maximum permissible leakage current for reformed capacitors with working voltage 150V or more**

| Capacitance (microfarads) | Leakage current (mA) 150V.W. | 275V.W. | 350V.W. | 375V.W. | 450V.W. |
|---|---|---|---|---|---|
| 2 and less | 0·10 | 0·10 | 0·10 | 0·11 | 0·14 |
| 4 | 0·10 | 0·16 | 0·21 | 0·25 | 0·27 |
| 8 | 0·18 | 0·33 | 0·42 | 0·45 | 0·54 |
| 16 | 0·36 | 0·66 | 0·84 | 0·90 | 1·08 |
| 32 | 0·72 | 1·32 | 1·68 | 1·80 | 2·16 |
| 60 | 1·36 | 2·46 | 3·15 | 3·37 | 4·05 |
| 100 and above | 2·25 | 4·10 | 5·23 | 5·62 | 6·75 |

Chapter 4
(Completely revised)

# SERVICING AND FAULT DIAGNOSIS

CONTENTS



TABLES



## Access to components

1. Access to the interior of the instrument is obtained by removing the eight 2 B.A screws around the edge of the panel and withdrawing the instrument from the case. For access to components between the panel and chassis undo the three screws at the right-hand edge of the chassis (as viewed from the back) and the single screw at the centre of the chassis. The chassis may then be opened back on the hinge at its left-hand edge.

2. If the case is removed for servicing, or if any of the front panel components are renewed, make certain that any seals which have been disturbed in the process are in good condition and correctly installed when the instrument is re-assembled. After re-assembly of the instrument the desiccator units should be checked for condition and, if necessary, reconditioned or renewed.

## Fuses

3. If fuses are to be renewed, the correct replacement is: Ref.Z5920/Z590109. When fitting the new fuses, make certain that they are installed in the fuse-holders appropriate to the available mains voltage.

Indicating lamps

4. If an indicating lamp fails, the replacement lamp is: 6.5V, 0.1A lamp, Ref. X959119.

Calibration checking

5. The information contained in the following para. will enable second line servicing units to calibrate the reforming unit by stating the expected voltage and current under open circuit, short circuit, "flash" circuit inception and cut-out operating conditions.

Open-circuit reforming voltages

6. With the CAPACITANCE selector S2 set to 100 and OVER, depress the REFORM switch S4 and measure the output voltage across the test leads at each position of the WORKING VOLTS selector S1; using a multirange d.c. voltmeter having a sensitivity of 20,000 ohms per volt (e.g Multimeter Type 1). The output voltage should be within the limits indicated in Table 1 when the reforming unit is operated from a 230V, 50 Hz or 115V, 50 Hz mains supply as appropriate.

Note ...

It is permissible to select either of the mains transformer primary connections to assist in meeting these limits, i.e. terminals 3 or 7 for 230V input and terminals 5 or 6 for 115V input. Once chosen however, the reforming unit must then meet these limits and be used only with those connections.

Short-circuit currents

7. For the measurements of Table 2, short-circuit the outer contacts of relay RL1 and operate the reforming unit from 230V, 50 Hz mains supply. Depress the REFORM switch S4 and measure the short-circuit current using a multirange d.c. millammeter (e.g Multimeter Type 1) connected across the test leads. The short-circuit current for each combination of selector switch settings, should not exceed the limits indicated in Table 2. After completing this test, remove the short-circuit from the outer contacts of relay RL1.

TABLE 1

Voltage limits (open-circuit condition)

| WORKING VOLTS selector (S1) | Output voltage limits (V) | WORKING VOLTS selector (S1) | Output voltage limits (V) |
|---|---|---|---|
| 6 | 6-8 | 150 | 140-160 |
| 12 | 12-14 | 275 | 260-300 |
| 25 | 24.2-27.8 | 350 | 330-380 |
| 50 | 48.4-55.6 | 375 | 353-407 |
| 100 | 97.7-112 | 450 | 428-492 |

TABLE 2

Current limits (short-circuit condition)

| WORKING VOLTS | CAPACITANCE | Current limit (mA) |
|---|---|---|
| 6 | LV | 1.2 |
| 12 | LV | 9 |
| 25 | LV | 32 |
| 50 | LV | 6 |
| 100 | LV | 14 |
| 150 | 100 & OVER | 12 |
| 275 | 100 & OVER | 26 |
| 350 | 100 & OVER | 32 |
| 375 | 100 & OVER | 35 |
| 450 | 100 & OVER | 38 |

CAUTION ...

To prevent damage to the capacitor do not operate the REFORM switch S4 longer than is necessary to take a current reading.

"Flashing" circuit inception current

8. For the measurements of Table 3, connect across the test leads a series circuit consisting of a rheostat and a multirange d.c. milliammeter (e.g. Multimeter Type 1). Depress the REFORM SWITCH S4 and by adjusting the series rheostat, determine the current at which the "flashing" circuit starts to operate, ie. REFORM lamp ILP2 flashes. This inception current for each combination of selector switch S1 settings, 150V and above, should be within the limits indicated in Table 3.

Meter accuracy and cut-out operation

9. For this test, retain the rheostat and milliammeter connections of para. 8. Set the WORKING VOLTS selector S1 to 25 and the CAPACITANCE selector S2 to LV.

(1) Depress the REFORM switch S4 and adjust the series rheostat to obtain a reading of exactly 5mA on the reforming unit meter. Check that, for this condition, the external milliammeter reads between the limits 4.5 and 5.5mA.

(2) By means of the series rheostat, increase the current until the overload relay RL2 just operates i.e. reforming unit meter reading falls to zero, for this condition, the external milliammeter should read within the limits 7 and 15 mA.

(3) Depress the METER F/S switch S5 to its 1mA position and adjust the series rheostat to obtain a reading of exactly 0.5mA on the reforming unit meter. Check that, for this condition, the external milliammeter

reads between the limits 0.45 and 0.55mA.

(4) Again increase the current until the overload RL2 just operates, i.e. reforming unit meter reading falls to zero. For this condition, the external milliammeter should read within the limits 1.0 and 1.5mA.

Note ...

With reference to para 9(2), if the indicated current for relay operation does not lie within the limits 7 to 15mA, add an additional resistor R12A in shunt with R12. Values may range between 10 to 33 ohms. Use style RC7-K or RFG1-0.25.

TABLE 3

Inception current limits (flashing circuit)

| WORKING VOLTS selector (S1) | CAPACITANCE selector (S2) | | | |
|---|---|---|---|---|
| | LV, 2, 4, 8 and 16 current limits (mA) | 32 current limits (mA) | 60 current limits (mA) | 100 & OVER current limits (mA) |
| 150 | 0.45-0.85* | 0.45-0.85 | 2-3 times A | 3.5-4.5 times A |
| 275 | 0.45-0.85 | 2-3 times A | 3.5-4.5 times A | 5.5-7.4 times A |
| 350 | 0.45-0.85 | 2-3 times A | 3.5-4.5 times A | 5.5-7.5 times A |
| 375 | 0.45-0.85 | 2-3 times A | 3.5-4.5 times A | 5.5-7.5 times A |
| 450 | 0.45-0.85 | 2-3 times A | 3.5-4.5 times A | 5.5-7.5 times A |

* Let this actual reading be called 'A'

Fault diagnosis

10. In view of the comparatively few components involved, the location of the cause of defective performance should present no particular difficulty. Table 4 lists some symptoms which may occur and suggest possible causes of same.

TABLE 4

Fault diagnosis

| Symptom | Possible causes |
|---|---|
| Red lamp does not light. | No power supply. Fuse failed. Defective lamp ILP1. Switch S6 defective or not operated. |
| Working volts less than 150V. Red lamp lights, but no indication on meter when REFORM switch is pressed. | Defective resistor R2, R12, R10 or R8. Possibly overload, or defective contacts on RL1. An open-circuited capacitor on test will also produce this effect. Check the capacitor leads and the output at SKT1. Repeat test with a capacitor known to be in good condition, or test with a resistor of the order of 20K ohms. |
| Working volts 150V or more. Red lamp lights, but no indication on the meter when REFORM switch is pressed. | If the green lamp does not flash the trouble may be as above. If the green lamp flashes the trouble is probably a defect in the overload circuit, or a defective meter. |
| The interrupter relay operates on REFORM settings below 150V. | Defective S1B, S2B or S4B. |
| No output at SKT1 on all REFORM settings. | Defective T1, S1A, MR1, C1, R13, S4A, RL1. Check DC voltage across C1 at the various settings of S1. Check the outputs from T1. (Chap.2 figure 4). |
| Capacitor appears to reform correctly, but green lamp does not flash on discharge. | Make certain that the capacitor is in fact discharged before handling it. Check ILP2, S4 and, if necessary, RL1. |



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