AC/DC Breakdown Leakage & Ionisation Tester FT6/12 Mk.2

User Guide

MEGGER®

SAFETY WARNINGS

- ★ *The circuit or equipment to be tested must be de-energized and isolated BEFORE connections are made for any tests.*
- ★ *Connect or disconnect the test leads/probes ONLY when (i) the 'TEST' button is released, (ii) the button on the l.v. probe is released, or (iii) the output voltage control is at zero.*
- ★ *The instrument MUST be connected to a separate low impedance earth.*
- ★ *Ensure the operator is in a safe area. Do not work with the instrument in a damp environment or one where the operator can be distracted or pushed while he is performing tests.*
- ★ *Do not touch the circuit or equipment during a test.*
- ★ *Take great care when testing capacitive items.*
- ★ *The test probes, and their connecting leads and plugs, must be in good order; scrupulously clean and having no broken, cracked or otherwise damaged insulation.*
- ★ *Hold the test probes correctly, with fingers behind the guard. Keep other parts of the body safely out of the way of earthed equipment.*
- ★ *Ensure the supply voltage adjuster is set correctly.*
- ★ *Replacement fuses MUST be of the correct type and rating.*

Refer to page 11 for further explanations and other precautions. The warnings and precautions must be read and understood before the instrument is used. They must be observed during use.

NOTE

This instrument must only be used by suitably trained and competent persons.

Symbols used on the instrument are:

⚠ Caution: Refer to accompanying notes.

⚠ Risk of electric shock.

CE Equipment complies with EU Directives

Contents

General Description

The AC/DC Breakdown Leakage & Ionisation Tester FT6/12 Mk.2 is designed for general flash testing and measurement of the breakdown voltage of electrical components and insulating materials.

The instrument may be operated from a nominal 110 V, 220 V or 240 V, 50 Hz/60 Hz mains power supply and has a variable output voltage providing up to 12 kV d.c. and up to 6 kV a.c. r.m.s. The equipment is completely self-contained in a sheet steel cabinet and all the controls are on the front panel with the exception of the input voltage selector, the fuse and the safety earth terminal, all of which are placed at the rear of the case. There are facilities for remote control of the instrument by making connections to a terminal block located within the case.

The controls etc. are grouped to assist the ease of use of the instrument; the groups are as follows:-

Mains Supply

The mains supply on/off switch in the area of the front panel marked 'SUPPLY', is a self-latching push-button which shows red for 'on' and green for 'off'. After the instrument has been connected to the supply, additional warning that it is switched on is given by a red lamp illuminating.

Current Controls and Meter

The left hand section of the front panel, marked 'CURRENT' is devoted to the current controls and meter. The meter has separate scales for showing the 'IN PHASE' current (0 - 100 μA scale) and the 'TOTAL' current (0 - 1 mA scale) being passed through the item under test. The 'IN-PHASE' current is that current which is in phase with the applied voltage and therefore is the part associated with the resistance of the item being tested. The 'TOTAL' current is the vector sum of the in-phase and quadrature components of the current in the item being tested and represents the total being drawn from the instrument. A self-latching push-button indicates, by the flag within it, which current is being displayed on the meter.

A second self-latching push-button indicates which of the 'TRIP' or 'BURN' modes of operation has been selected; these are also indicated by a flag within the button.

When 'TRIP' is selected, breakdown or flash-over will be indicated when the level of current passing through the item under test exceeds the value which has been pre-set. The 'TRIP LEVEL' control is a rotary potentiometer used to set the level of leakage current between 0,1 mA and 1,0 mA peak value. The output voltage is tripped off when this level is exceeded.

When 'BURN' is selected the output voltage is not tripped off when breakdown occurs but rather is maintained enabling the leakage current to continue to flow. This allows arcing through the leakage path to be observed.

In both 'TRIP' and 'BURN' modes an amber indicating lamp, in the bottom left hand corner of the front panel, illuminates when the item under test has failed, i.e. when the trip level current has been exceeded and breakdown has occurred. (This visual warning is accompanied by an audible one from the loudspeaker).

Voltage Controls and Meter

The centre section of the front panel marked 'VOLTAGE' has the voltage controls and meter. The meter continuously monitors the output voltage on one of its four scales; one for each test voltage range available.

Below the meter is a self-latching push-button used for selecting either the low output voltage ranges or the high output voltage ranges. A flag appears within the button to show which has been selected. A second self-latching push-button marked 'DIRECT' or 'MAINTAIN' selects the mode of indication of the meter; again a flag in the button shows which has been selected. When set to 'DIRECT' a reading of the voltage being applied to the item under test is shown on the meter (this voltage is measured across the output terminals). Thus upon breakdown the voltage reading will return to zero. Also, prior to breakdown, the loading caused by any increase of the leakage current will be reflected by the voltmeter giving a reduced reading. When set to 'MAINTAIN' the voltage reading reflects the setting of the '% OUTPUT VOLTAGE' control, ignoring the effect of loading (this voltage is measured in the primary circuit of the transformer). When breakdown occurs this voltage will also return to zero in the 'TRIP' mode. Before breakdown the meter reading follows the output voltage accurately for load resistances greater than 100 MΩ when on d.c. and 6 MΩ when on a.c. The regulation characteristic of the output in this region is within the specified accuracy. The 'MAINTAIN' reading is of most value when used in conjunction with the 'BURN' mode to obtain the breakdown voltage of a test specimen.

The output voltage is controlled from the variable transformer mounted on the front panel. The control knob (labelled '% OUTPUT VOLTAGE') has graduations approximately representing percentages of the maximum output possible for each voltage range. This control enables the output voltage to be continuously varied.

The red 'TEST' push-button is so positioned that it can be operated, in conjunction with the voltage control, by one hand. Operating this 'TEST' button is one of the ways in which output test voltage can be energized.

Ionisation Indication

In the top right of the front panel, in the area marked 'IONISATION', is the loudspeaker through which the operator can hear the on-set of any ionisation which may take place. Adjacent to the loudspeaker is its volume control. When this control is fully anticlockwise the loudspeaker is turned off as far as ionisation is concerned, however, it is still able to give the audible breakdown warning.

The jack socket marked 'OUTPUT' can be used to connect an oscilloscope for greater sensitivity. The volume control adjusts the amplitude of the signal from the 'OUTPUT' socket.

Terminals and Test Probes

The two high voltage output terminal sockets, one for a.c. and one for d.c., are at the extreme right hand side of the front panel. These have been designed with safety of paramount importance and only one of these sockets must be used at any time. They have spring loaded caps which are raised to insert the h.v. test probe lead connector and automatically spring back to cover the socket when the connector is removed.

The low voltage output terminal socket is at the bottom of the front panel and is marked 'LOW PROBE'. It accepts the three pin connector on the l.v. test probe lead.

The instrument is not supplied with test probes unless they have been ordered separately. The high voltage test probe supplied by the manufacturer has a pistol grip action with a "trigger" to control a retractable probe tip for safety. Its flexible lead is terminated by a moulded plug to fit the instrument's h.v. output sockets. The low voltage test probe is similar to the high voltage one but it has a fixed tip. It is fitted with a microswitch, operated by the "trigger" of the probe, which acts as a second 'TEST' button to switch on and off the high voltage applied to the terminals.

The instrument must be connected to earth. There are two earthing points provided: one is via the earth wire in the mains power supply lead, a second is via the green/yellow terminal at the back of the case. The terminal at the back of the case must always be connected to a known good earth; this provides an additional level of safety. The earth terminal on the front panel is a measurement earth point and is connected to the instrument's case and chassis. This terminal would be connected to an earth point on the item under test if necessary.

Earthing is important. The reason for having two good earth connections is to maintain a safety level should one connection fail. If there was only one earth connection and it became open circuit, it is possible for the instrument casing to become "live", at 12 kV d.c. or 6 kV a.c., should the high voltage probe be accidentally short circuited to earth.

Mains Supply Panel

The mains supply is permanently connected through a panel at the back of the instrument. This panel also holds the supply fuse, supply voltage adjuster and safety earth terminal. Ensure that the voltage adjuster is set correctly for the mains supply which will be used.

Remote Control

The instrument contains a terminal block which may be used for making connections to control the output externally, to activate external indicators and to provide other equipment with a source of supply.

Applications

The instrument may be used for flash testing and non-destructive insulation testing of materials, electrical components and equipment. Leakage currents and breakdown voltages are easily measured, also ionisation can be detected.

The source impedance of the output voltage is low enough to permit the rapid testing of high capacitance components, while at the same time automatically limiting the available output current. The maximum output current under any circumstances is 5 mA.

Using the separate connections for remote control means that the instrument can be rack mounted and form part of a test equipment consul.

Leakage

Leakage current through the item under test is continuously measured while the high voltage is applied. For a d.c. test voltage this is shown by selecting 'TOTAL' or 'IN PHASE' current. Similarly, for an a.c. test voltage the total value of the leakage current is shown when 'TOTAL' is selected. However, the in-phase leakage current can be measured when 'IN PHASE' is selected. Therefore, from the knowledge of the total and in-phase leakage currents the quadrature (capacitive) leakage current can be calculated; it is the vector difference between the total and in-phase currents. This is explained in more detail later in the book.

Breakdown

A breakdown (or flashover) is deemed to have taken place when the leakage current trip level has been exceeded. This level can be set between 0,1 mA and 1 mA. Exceeding the trip level causes the output voltage to be cut off; the 'FAIL' neon and a buzzer operate to indicate that breakdown has occurred.

Ionisation/Partial Discharge

Before breakdown or flashover in the item under test, partial discharges or ionisation usually occur. The onset of ionisation will be detected by the instrument and can be heard over the built-in loudspeaker. Facilities are provided for amplification of the sound as it occurs and this enables the early detection of an approaching breakdown to be made.

Note:- Whilst it is safer to use the instrument in the 'TRIP' mode, because the output voltage is removed immediately the trip operates, it may prove more practical to use the 'BURN' mode in which the voltage remains applied. Using the 'TRIP' mode will minimize any damage to the item under test that might be caused by burning at the fault. However, to identify where arcing occurs it will be necessary to use the 'BURN' mode.

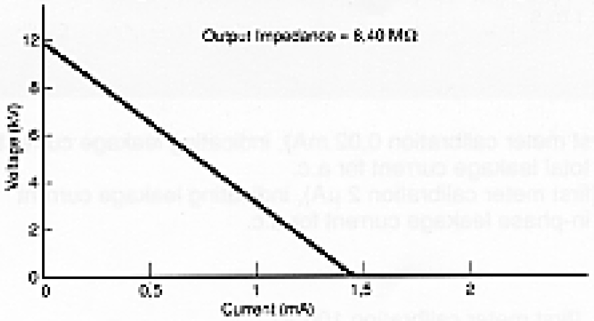
Specification

Test Voltage Ranges	0 - 4 kV d.c. 0 - 12 kV d.c. 0 - 2 kV a.c. r.m.s. 0 - 6 kV a.c. r.m.s.
Current Meter	
Total Current	0 - 1 mA (first meter calibration 0,02 mA), indicating leakage current for d.c. and total leakage current for a.c.
In-Phase Current	0 - 100 µA (first meter calibration 2 µA), indicating leakage current for d.c. and in-phase leakage current for a.c.
Voltage Meter	0 - 4 kV d.c. (first meter calibration 100 V) 0 - 12 kV d.c. (first meter calibration 250 V) 0 - 2 kV a.c. r.m.s. (first meter calibration 100 V) 0 - 6 kV a.c. r.m.s. (first meter calibration 250 V)
Direct Reading	Indicating loaded output voltage
Maintained Reading	Indicating unloaded output voltage
Accuracy	
Voltage d.c. (Direct Reading)	±1,5% of f.s.d. ±1% of reading
Voltage d.c. (Maintained Reading)	±1,5% of f.s.d. ±4,5% of reading (load resistance ≥ 100 MΩ)
Voltage a.c. (Direct Reading)	±1,5% of f.s.d. ±2% of reading
Voltage a.c. (Maintained Reading)	±1,5% of f.s.d. ±5% of reading (load resistance ≥ 6 MΩ)
Current d.c. (Leakage)	±2% of f.s.d. ±1% of reading
Current a.c. (In-Phase or Total Leakage)	±4% of f.s.d. (For waveforms with a form factor of 1,11)
Output Short Circuit Current (output voltage control set at f.s.d. readings)	5 mA a.c. r.m.s. max. 2 mA d.c. max.
Breakdown and Flashover Indication	For continuous breakdown a front panel amber neon illuminates and a buzzer sounds. Breakdown, for time periods from 1 ms on d.c. and 5 ms on a.c., are indicated by the illuminating neon and sounding buzzer when the peak current flowing exceeds a pre-set limit between 0,1 mA and 1 mA. For short duration breakdown, the amber neon will remain illuminated for 3 s approx. For breakdown periods greater than 3 s the neon will remain illuminated for as long as the breakdown exists. Additionally, when full breakdown occurs, the voltmeter reading will fall to zero with the 'DIRECT/MAINTAIN' button set to 'DIRECT', since it is monitoring the output voltage. (With the button in the 'MAINTAIN' position the voltmeter will show the voltage level set immediately prior to breakdown). For an external indication, closing relay contacts rated at 250 V 3 A are provided.
Leakage Indication	For a.c., in-phase leakage current is indicated by the 0 - 100 µA 'IN PHASE' scale of the current meter and total (including capacitive) current by the 0 - 1 mA 'TOTAL' scale of the current meter. For d.c., leakage is indicated on either scale of the meter.
Ionisation Indication	(a) Audible indication from front panel mounted loudspeaker. (b) An oscilloscope connected to a jack socket on the front panel. Output impedance suitable for loads down to 10 kΩ.
Display	Two analogue panel meters show output current and output voltage.

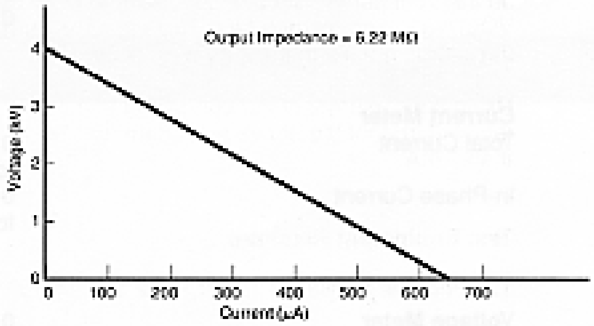
Specification

Typical Output Characteristics

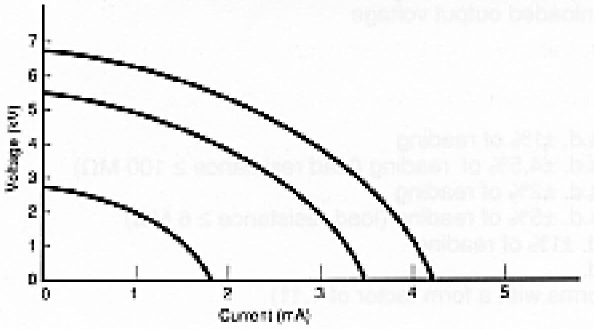
Output Characteristic (12 kV d.c. range)



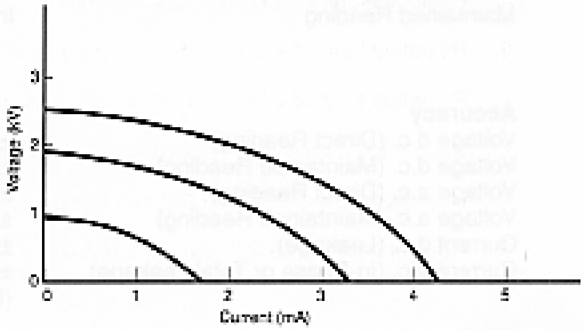
Output Characteristic (4 kV d.c. range)



Output Characteristic (6 kV a.c. range)



Output Characteristic (2 kV a.c. range)



Ripple Content (d.c.)
Less than 5% pk - pk of mean d.c. at output current up to 0,1 mA and load resistance greater than 100 MΩ.

Waveform
The a.c. output waveform will not deviate from the fundamental by more than ±5% at any point on the supply voltage waveform for load impedances greater than 6 MΩ on a.c.

Output Voltage Decay Times
After output voltage cut-off:–
For a.c., typically 20 ms.
For d.c., 10 s unloaded, 5 s for a 100 µA load, 1 s for a 1 mA load.
(Loading capacitance will extend these times.)

Safety
The instrument meets the requirements for safety to IEC 1010-1 (1995) EN61010-1 (1995).

E.M.C.
The instrument meets EN50081-1 and EN50082-1 (1992).

Fuses
For operation from 200 V - 265 V supply, 500 mA (T) HBC 20 mm x 5 mm.
For operation from 100 V - 125 V supply 1 A (T) HBC IEC 127/5 20 mm x 5 mm.

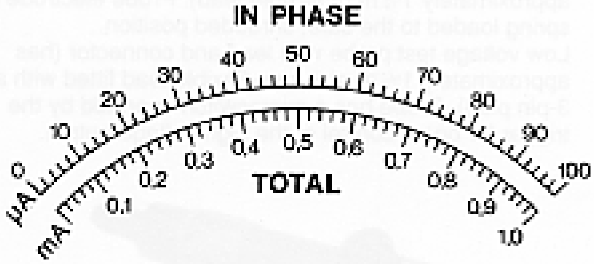
Power Supply
110 V, 220 V and 240 V 50 Hz/60 Hz (nominal values). Instrument set for 240 V, voltage adjuster at the rear of the instrument.
Can be used for ±1-% of the nominal values in accordance with the IEC specification.
Power consumption 80 VA.

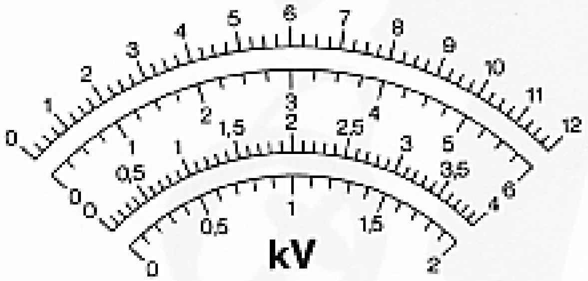
Dimensions
495 mm x 190 mm x 298 mm
(19½ x 7½ x 11¾ in approx.

Cleaning
Wipe the disconnected instrument with a clean cloth damped with soapy water or Isopropyl Alcohol (IPA).

Weight	13,4 kg (29½ lb) approx.

Illustration of Typical Scales





Accessories

Supplied with the instrument	Plug for low voltage output socket	part no. 25424-855
	Plug with 3 m (9¼ ft) of cable for high voltage output sockets	part no. 6131-831
	Jack plug for ionisation output	part no. 25446-008
	Spare 500 mA (T) HBC fuse	part no. 25950-014
	Spare 1 A (T) HBC IEC 127/5 fuse	part no. 25950-004
	Plastic instrument dust cover	part no. 6260-012
	Operating instruction book	part no. 6171-390
Supplied as an optional extra	High voltage test probe with lead and connector (has approximately 1½ m of flexible lead). Probe electrode is spring loaded to the safe, shrouded position.	part no. 6420-061
	Low voltage test probe with lead and connector (has approximately 1½ m of 3-core flexible lead fitted with a 3-pin plug). Probe has a microswitch operated by the trigger for on/off control of the high voltage output.	part no. 6420-062

High Voltage Test Probe

Low Voltage Test Probe

Operation

Warnings and Precautions

1. The safety precautions as described on page 2 of this book must be followed. The further warnings listed below are of equal importance and it is vital that these also are observed.

2. The instrument must be connected to earth. The instrument falls within Safety Class 1. The green/yellow earth terminal at the rear is connected, internally, directly to all accessible conductive parts and to the earth terminal of the input power supply. This green/yellow terminal must be connected to a known good earth.

3. When using the instrument and particularly when holding the high voltage test probe, ensure that the operator is working in a safe area, preferably in isolation, to reduce the possibility of accidents.

4. Do not work with high voltages on a metal bench or on a damp surface as this increases the risk of electric shock. Preferably use a non-metal chair on a rubber mat and do not let the high voltage cable of the test probe lead come into contact with the operator's clothes or body. If this happens it is possible for a charge to be built up on the operator which can be alarming when it is discharged.

5. When the operator is using only one hand with the high voltage probe, it is advisable to keep the other hand in a safe position, such as in the pocket.

6. On completion of a d.c. test, a voltage will remain briefly at the terminals if a breakdown has not occurred and the trip mechanism on the output voltage has not operated. This will be indicated by the voltmeter when the 'DIRECT/MAINTAIN' switch is in the 'DIRECT' position. This voltage will die away in about 10 s, a period determined by the time constant of a 15 nF capacitor and a 100 MΩ resistor in the instrument circuit. (For a capacitive sample this time is extended).

7. Always make the low voltage connection (to the earth or casing of the item under test) first, then make the high voltage connection and finally operate the 'TEST' button.

8. Care should be exercised when disconnecting capacitive components after making voltage tests. Capacitive items may remain charged for some time, even though the applied voltage has been removed. For d.c. tests, discharge is effected through an internal 100 MΩ resistor; the state of charge being indicated by the voltmeter with 'DIRECT' selected. Only remove the connections to the capacitive item when the voltmeter indicates zero.

   Put a short circuit across the capacitance to prevent the dielectric absorption effect re-establishing a high voltage.

   When an a.c. test has been carried out, external capacitors discharge more quickly through the 50 kΩ internal resistance of the transformer secondary winding if there should be any charge in the capacitance at the moment of cutting off the applied voltage.

9. For additional safety, a protective enclosure i.e. a 'test box' surrounding the item under test may be employed to advantage. Such an enclosure should have a lid for access to the test item and its connections. Safety can be improved further by the use of a microswitch arranged to disconnect the 'TEST' button circuit (and therefore switch the output off) when the enclosure lid is opened.

10. Do not remove the instrument from its case until it has been switched off for at least five minutes, as internal components could be dangerous under fault conditions. First set the 'DIRECT/MAINTAIN' switch to 'DIRECT' and make certain that the voltmeter reading is zero. Do not switch the instrument on while it is removed from its case.

11. If no output voltage is available when the '% OUTPUT VOLTAGE' control is turned clockwise, and it is certain that the input supply fuse has not ruptured, the internal fuse FS2 may be faulty. The instrument must be removed from its case before this fuse can be inspected or changed. Observe the precaution (10) above before opening the instrument case. FS2 is a 250 mA (F), standard 20 mm x 5 mm fuse.

    Before replacing the instrument in its case it is most important to check that neither of the capacitors C14 or C15 is faulty i.e. is forming a short circuit. Use a suitable meter connected across the component(s) to establish their integrity. The meter should indicate 120 kΩ; this being the value of the shunting discharge resistance.

12. Periodically check that test probes are in good electrical and mechanical order. This should include the probes themselves, the cables, plugs and their sockets. It should also include the 'test box' if used. Any defective items must be replaced.

13. The instrument circuit contains static sensitive devices. If the casing is removed care must be exercised in handling the printed circuit boards. This should be done in accordance with BS 5783 and DEF STAN 59-98, specifications for the handling of static sensitive devices.

14. Arcing will radiate RF interference and should be kept to an absolute minimum.

Operation

Supply Voltage Setting

The instrument will operate from nominal supply voltages of 110 V a.c., 220 V a.c. and 240 V a.c. 50 Hz to 60 Hz. Before connecting the instrument to the mains supply verify that the voltage selector setting is correct for the voltage available.

The input transformer tappings cover the nominal voltages ±10% i.e. 100 V to 125 V, 200 V to 240 V and 220 V to 265 V operation. During manufacture the instrument is set for a 240 V supply. If necessary alter the setting of the voltage adjuster on the mains supply panel on the rear of the instrument. Use a screwdriver to set the correct nominal voltage opposite the arrow head on the adjuster.

A 500 mA fuse is fitted in the fuse holder, also situated on the mains supply panel, which is suitable for supply voltages of 200 V to 265 V. For operation from supply voltages of 100 V to 125 V the fuse should be changed to a 1 A rated one of the same type (see the Specification); spare fuses are provided.

The power supply cable must be terminated with a suitable 3-pin plug. The connections are as follows:-

Brown wire to phase.(line)
Blue wire to neutral
Green/yellow wire to earth (this connection **must** be made).

WARNING:- The green/yellow earth terminal at the rear of the instrument must be connected to a separate low impedance earth.

Methods of Using the Tester

The output voltage is applied via one of the high voltage sockets marked 'DC⎓' or 'AC~', and the low voltage 3-pin socket marked 'LOW PROBE', whose main pin is effectively connected to earth. The green/yellow terminal on the front panel is also for use as the low voltage connection.

The instrument is supplied with a 3-pin plug to fit the low voltage output socket marked 'LOW PROBE' and a single pin plug (with lead attached) to fit the 'DC⎓' and 'AC~' high voltage output sockets. These are supplied so that the operator may make connections to the item to be tested in his own way, such as use with a test box.

Alternatively the manufacturer can supply test probe leads, suitably terminated, for both the low voltage socket 'LOW PROBE' and the high voltage sockets 'DC⎓' and 'AC~'. (These are illustrated in the Accessories section of this book).

There are three main ways of using the tester to apply the output voltage to the item under test:-
(a) to enclose the item in a test box or jig and make permanent connections from the output voltage terminals.
(b) to make direct application of the voltage using the alternative test probe leads.
(c) to make connections in a similar manner to (a) and control the output voltage remotely.

Using a Test Box

Place the item under test in a test box or jig and connect the earth return to the large pin of the plug which fits the 'LOW PROBE' socket. Connect this plug into the instrument. Connect the high voltage lead to the test item and plug it into the 'DC ⎓' and 'AC~' socket. The 'TEST' button is pressed and held to apply the output voltage to the item under test and the '% OUTPUT VOLTAGE' control is used to adjust the voltage.

It may be found more convenient to use the green/yellow terminal for the measurement l.v. connection and to earth the item under test. A microswitch in the lid of the test box may be used to produce the on/off control of the output voltage.This method provides additional safety. The microswitch's normally open contacts are connected to the 'L' and 'N' pins (the smaller two) in the plug which fits the 'LOW PROBE' socket. The arrangement is such that the microswitch will cut off the output voltage when the lid of the test box is opened i.e. it acts in the same way as the 'TEST' button on the instrument.

Using the Test Probes

The h.v. test probe lead and the l.v. test probe lead are connected to the appropriate sockets on the instrument. The probe tips are applied to the item under test and it is important that the l.v. connection is made first; the h.v. probe has a retractable tip and requires a trigger action to make it protrude. The low voltage probe has a microswitch built into it so that, by squeezing the trigger, the output voltage is switched on. The microswitch acts in the same way as the 'TEST' button on the instrument. It is necessary to set the '% OUTPUT VOLTAGE' control first and then apply the probes. It is most important to make sure that the probe tips are connected before the l.v. probe trigger is squeezed and to release the trigger before the probe tips are disconnected. This is a safer way of using the probes and any sparking caused by making and breaking a high voltage is avoided.

(Alternatively the l.v. connection may be made to the green/yellow terminal, with a test lead. Ensure that the connections are made securely, then use the 'TEST' button and adjust the '% OUTPUT VOLTAGE' control.)

Using Remote Control

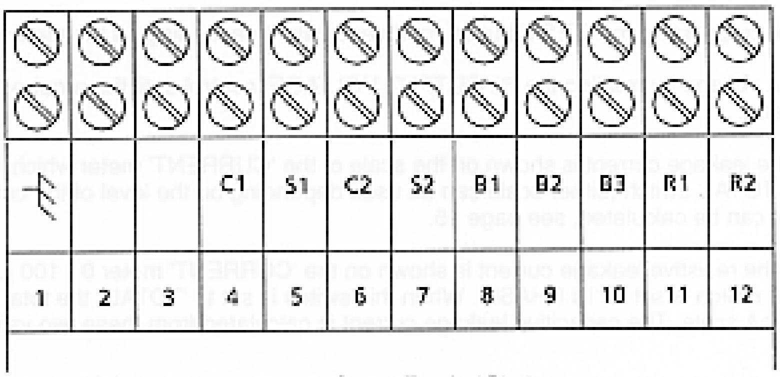
A terminal strip is provided inside the instrument so that connections may be made for controlling the instrument from a remote point.

The h.v. output socket is connected to the item under test using the single pin plug and lead. The l.v. connection is made, via a test lead, to the front panel green/yellow terminal in a secure manner.

The terminal block for making connections is accessible from the rear of the instrument by removing the cover plate adjacent to the mains supply panel (there are three crosshead securing screws to release).

WARNING:- This must only be done by a suitably trained and competent person who will be able to make the connections in a proper manner, so that the safety of the instrument is not impaired. A secure and sound earth connection is vital for safety, nothing must be done to impair the earthing system of the instrument. Make connections to the terminal block only, the other wiring must not be touched. The instrument must be disconnected from the supply before removing the cover panel.

Depending on the nature of the remote control required make connections according to the diagram and instructions below. When this has been completed pass the wiring through the grommet in the cover plate and secure the plate in place with the three screws.



Remote Control Terminal Block

Terminal	Label	Connection
1	Earth	Measurement l.v. connection.
2		Not used.
3		Not used.
4	C1	Input (phase) for control of the h.v. output voltage.
5	S1	Output (phase), separate variable voltage source.
6	C2	Input (neutral) for control of the h.v. output voltage.
7	S2	Output (neutral), separate variable voltage source.
8	B1	External indicator for breakdown (normally open contact).
9	B2	External indicator for breakdown (fixed contact).
10	B3	External indicator for breakdown (normally closed contact).
11	R1	Remote on/off switch (relay coil connection).
12	R2	Remote on/off switch (+ 18 V).

By connecting a variable transformer (with manual or motor control and sited at a distance from the instrument) to the 'C1' and 'C2' terminals the voltage applied to the item under test can be controlled from a remote, and possibly safer, location. This variable transformer effectively replaces the '% OUTPUT VOLTAGE' control on the instrument. 'C1' is the phase connection and 'C2' the neutral connection.

Note:- When using terminals 'C1' and 'C2' the links 'C1' - 'S1' and 'C2' - 'S2' must be removed. When not using these terminals the links must be in place.

A separate variable voltage source of 0 - 240 V a.c. is available from the instrument via terminals 'S1' and 'S2'. This voltage source can be used to drive a motor controlled remote variable transformer or the timing relay for such a device. The actual voltage available from the source 'S1' and 'S2' depends on the setting of the '% OUTPUT VOLTAGE' control.

A remote on/off control can be connected to the terminals 'R1' and 'R2'. This becomes an extension of the 'TEST' button on the front panel of the instrument and also can become an on/off control of the source voltage from 'S1' and 'S2' (thereby providing a remote control of a motor drive or timing circuit). The output voltage from these terminals is approx. 18 V.

Methods of Testing

The instrument is connected to the item under test in one of the modes described in the previous section. It is also connected to the mains power supply and, with that supply switched on, the following methods of test can be carried out:-

Leakage Measurement

1. Set the 'TRIP/BURN' switch to the 'BURN' position and the '% OUTPUT VOLTAGE' control to zero. Set the 'DIRECT/MAINTAIN' switch to 'DIRECT' so that the level of the applied voltage can be seen in conjunction with the leakage current.
2. Select the '2 kV~/4 kV⎓' or '6 kV~/12 kV ⎓' output voltage range as required.
3. Energize the circuit by pressing the 'TEST' button, or its equivalent depending on the method of test being used.
4. Increase the output voltage by rotating the '% OUTPUT VOLTAGE' control until the required level is shown on the 'VOLTAGE' meter.
5. For a d.c. output the leakage current is shown on the scale of the 'CURRENT' meter which has been selected by the 'IN PHASE/TOTAL' switch (either scale can be used depending on the level of the current flowing). The leakage resistance can be calculated, see page 15.

   For an a.c. output the resistive leakage current is shown on the 'CURRENT' meter 0 - 100 µA scale when the 'IN PHASE/TOTAL' switch is set to 'IN PHASE'. When this switch is set to 'TOTAL', the total leakage current is given on the 0 - 1 mA scale. The capacitive leakage current is calculated from these two values (see page 15).

Breakdown Test

1. Set the 'TRIP LEVEL' control to the current level above which a breakdown is deemed to have occurred. Set the 'TRIP/BURN' switch to 'BURN'.
   Note:- The 'TRIP LEVEL' control is calibrated in peak current values. For a.c. the scales on the 'CURRENT' meter are calibrated in r.m.s. values; giving a ratio of 0,707:1 between the two for a sinusoidal current waveform.
2. Select the output voltage range required and set the '% OUTPUT VOLTAGE' control to zero.
3. Energize the circuit by pressing the 'TEST' button, or its equivalent depending on the method of test being used.
4. Increase the output voltage by rotating the '% OUTPUT VOLTAGE' control slowly until the output voltage is tripped off, the 'FAIL' lamp illuminates and the buzzer sounds.
5. The breakdown voltage will be indicated by the 'VOLTAGE' meter if the 'DIRECT/MAINTAIN' switch is set to 'MAINTAIN' without the '% OUTPUT VOLTAGE' control being moved.

Determination of the Breakdown Point

If the current level at which breakdown is deemed to have occurred is not known then follow generally the procedure above but set the 'TRIP LEVEL' control to its maximum value and set the 'DIRECT/MAINTAIN' button to 'DIRECT'. Increase the output voltage until the point where it just collapses or fails to increase further, as indicated by the 'VOLTAGE' meter. (A true breakdown occurs where the current starts to increase rapidly, i.e. 'avalanche'. However the current limiting produced by the instrument prevents an excessive current flowing]. Set the 'DIRECT/MAINTAIN' button to 'MAINTAIN'; the breakdown voltage is now shown on the 'VOLTAGE' meter. If the output current reaches 1 mA the 'FAIL' lamp illuminates and the buzzer sounds.

Note:- This is a more accurate method than the first one.

The 'TRIP LEVEL' current may be set to a level to comply with a safety specification.

Ionisation or Partial Discharge Tests

Ionisation can be detected through the loudspeaker marked 'IONISATION' prior to leakage measurement or breakdown tests.

Note:- At the fully anticlockwise position of the 'VOLUME' control the sound of the ionisation is switched off, however the buzzer still sounds through the loudspeaker to warn of breakdown.

1. Set the 'VOLUME' control to a reasonable level and set the '% OUTPUT VOLTAGE' control to zero.

2. Energize the circuit by pressing the 'TEST' button, or its equivalent depending on the method of test being used.

3. Increase the output voltage by rotating the '% OUTPUT VOLTAGE' control until ionisation becomes audible through the loudspeaker. (The 'VOLUME' control can be adjusted as necessary).

Note:- If the test leads are too long it may be found that background noise becomes excessive, particularly with a.c. voltages. The length of the high voltage output lead in particular should be kept to a minimum to allow maximum sensitivity for this type of test.

Some ionisation exists outside the audible range. For ultrasonic ionisation the use of an oscilloscope provides the most satisfactory method of detection. An oscilloscope may be connected to the 'OUTPUT' jack socket on the front panel, (a jack plug is provided for this purpose).

Note:- The instruments internal rectifiers cause ringing which may be seen on the oscilloscope trace. While the instrument circuit has been designed to keep this at a minimum, it will be increased by the use of output test leads of excessive length.

Flash Testing

This facility is mainly used for testing batches of items to ascertain whether they will withstand a given voltage.

1. Set the 'TRIP/BURN' switch to 'TRIP' and the 'DIRECT/MAINTAIN' switch to 'DIRECT'.

2. With the '% OUTPUT VOLTAGE' control set at zero, temporarily disconnect the high voltage test lead by removing the plug from the 'DC...' or 'AC~' socket.

3. Press the 'TEST' button on the instrument's front panel and adjust the '% OUTPUT VOLTAGE' control until the required test voltage is shown on the 'VOLTAGE' meter.

4. Release the 'TEST' button and reconnect the high voltage lead.

5. Set the 'TRIP LEVEL' control to the permissible level of leakage current.

6. Re-connect the high voltage test lead and ensure that connection is made to the sample under test. Energize the circuit again by pressing the 'TEST' button, or its equivalent depending on the method of test being used. If breakdown occurs it will be indicated by the 'FAIL' lamp illuminating and the buzzer sounding.

Note:- Pressing the test button disables the trip circuit for 100 ms to avoid 'in-rush' currents therefore it is important that the test leads are connected first.

Identification of the Leakage or Breakdown Path

The facility exists on the instrument whereby the output voltage does not trip off when breakdown occurs but remains and causes the leakage current to continue to flow. This enables the leakage or breakdown path in the item under test to be seen if arcing occurs.

1. Set the 'TRIP/BURN' switch to 'BURN' and the '% OUTPUT VOLTAGE' control to zero.

2. Energize the circuit by pressing the 'TEST' button, or its equivalent depending on the method of test being used.

3. The leakage current will be maintained while the 'TEST' button is pressed but will be limited to a maximum of 5 mA.

General Note on Testing

In British Standards and other specifications a requirement similar to the following may be made -- 'Increase the output voltage at a given rate to a given level and maintain it so for one minute'. The instrument has been designed with such a requirement in mind.

This particular type of test can be carried out by using the remote and external control facility, explained earlier, with the aid of a motor driven variable transformer or electronic control circuit and a timer. Alternatively, the requirement may be achieved manually by rotating the '% OUTPUT VOLTAGE' control at the given rate and to the required level and maintaining it there for the specified time, all the while keeping the 'TEST' button pressed.

Calculation of Leakage Resistance and Capacitive Leakage Current

Calculation of leakage resistance is made by dividing the applied test voltage by the in-phase leakage current (either

Operation

current range may be used for a d.c. test).

$$R = \frac{V}{I_R}$$

where V is the applied voltage in kV, I_R is the in-phase leakage current in mA and R is the leakage resistance in MΩ.

The capacitive leakage current can be calculated from:-

$$I_c = \sqrt{(I_T^2 - I_R^2)}$$

where I_c is the capacitive current in µA, I_T is the total current in µA and I_R is the resistive current in µA.

Circuit Description

Refer in general to the Circuit Diagrams on page 25.

Control Circuit

From the mains supply input socket the line (phase) and neutral are switched by push-button switch SW3. The line is connected via fuse FS2 to the supply voltage selector; the neutral is connected directly to the selector. The supply voltage selector uses the tappings on the variable transformer T2 so that an output of 0 to 220 V can be achieved as a minimum. The line output of T2 (i.e. the wiper of the variable transformer) is connected to S1 on terminal block TB5 and the neutral output is connected to S2 on terminal block TB7. These two connections now become an adjustable voltage source and are normally connected to the control input C1 on TB4 and C2 on TB6 respectively, to drive the high voltage circuit.

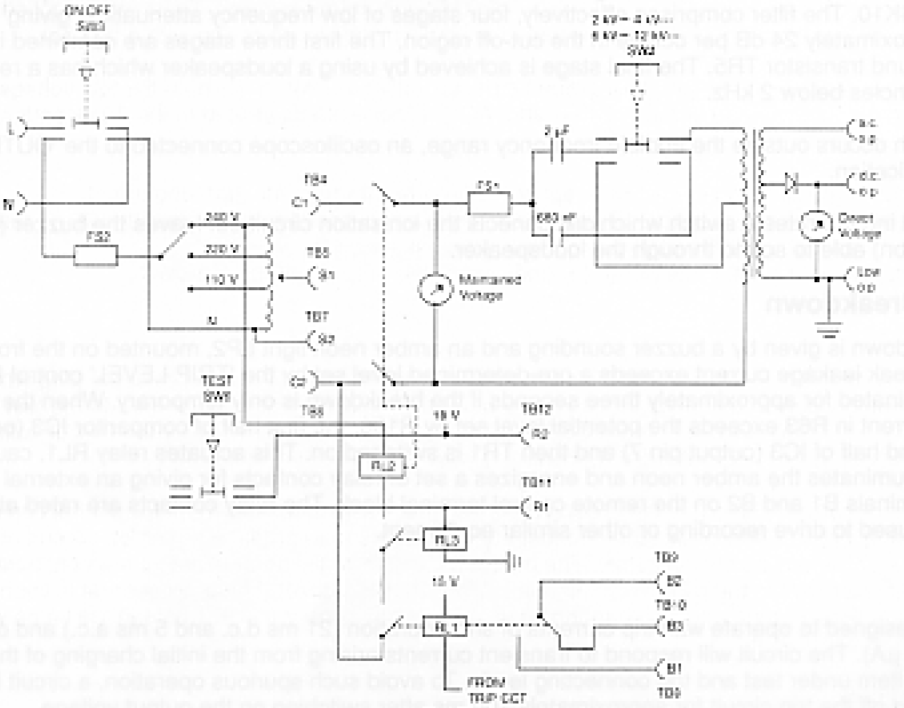
For external control the links between S1 and C1 and between S2 and C2 may be disconnected so that an external control from a 0 to 220 V supply may be connected to C1 (line) and C2 (neutral).

When relay RL2 is energized the supply voltage via C1 and C2 is first measured by the 'maintain' voltmeter circuit which, if selected, indicates the unloaded output voltage. The supply voltage then passes through fuse FS1 to the current limiting capacitors; 2μF for the 6 kV a.c. output (C15) or 680 nF for the 2 kV a.c. output (C14). (The appropriate capacitor is selected by the output voltage range selector push-button.) Thus the controlled supply is fed to the high voltage output transformer T3. The capacitors C14 and C15 determine the a.c. output short circuit current.

For relay RL2 to be energized, two conditions must be met. First, RL3 must be energized by (i) pressing the 'TEST' button, (ii) pressing the button on the low probe or (iii) connecting R1 on TB11 to R2 on TB12. Second, the trip circuit must not have operated relay RL1. The breaking contacts of RL1, i.e. B2 on TB11 and B3 on TB10, and the closing contacts of RL1, i.e. B2 on TB9 and B1 on TB8 are to indicate a trip condition.

The trip circuit is disabled for approximately 100 ms after RL2 is energized so that the test circuits can stabilize and in-rush currents are not measured. Hence automatic testing must be in excess of 100 ms for a valid trip indication.

A simplified diagram for the control circuit is shown below.



Simplified control circuit

Output Voltage

The a.c. output is obtained from a high voltage transformer T3 and manually controlled by variable transformer T2. The capacitor C14 or C15 and the primary of transformer T3, together with its reflected load, form a quadrature circuit which ensures that the source impedance of the output voltage is comparatively low for a.c. loads up to 1 mA at 6 kV. When greater loads occur, the reflected load through the transformer T3 reduces the primary voltage, and hence the output voltage, by a quadrature action with C14 or C15; they set the short circuit current. (See the typical a.c. output characteristics given in the Specification). Transformer T3 is used in conjunction with the voltage doubler circuit formed by C1, C2, D1 and D2 on the h.v. p.c.b. to give the d.c. output voltage at a separate socket.

In both a.c. and d.c. tests the voltmeter M1 continuously monitors the voltage applied to the item under test when the 'DIRECT/MAINTAIN' switch is set to 'DIRECT'. When this switch is set to 'MAINTAIN' the voltmeter M1 gives a maintained reading of the voltage at the breakdown point because the measurement is being made in the primary circuit of transformer T3. The voltmeter also forms the discharge path across C2 for the d.c. output.

The 'TEST' push-button switch SW6 controls a relay in series with the supply to the transformer T3. It is physically mounted near the '% OUTPUT VOLTAGE' control (variable transformer T2) so that it can be pressed with the same hand used to adjust the voltage and yet be quickly released for safety. The output voltage is applied to the item under test via one of the high voltage sockets connected as described in "Methods of Using the Tester".

On a.c. the output sine wave is clipped by the current surges in the d.c. output voltage doubler rectifiers D1 and D2 affecting the current flowing through capacitor C14 or C15 in the primary circuit of transformer T3. The extent of this clipping is approximately 5% of the peak value. Since the voltage measuring circuit is basically a peak detector, an error is introduced when relating this back to a pure sine wave. If this were to be related to the unclipped sine wave, then the full 5% error would be introduced at the peak of the waveform. Alternatively, it could be related to a sine wave of peak value equal to the flattened top of the clipped waveform. This would then introduce errors in the opposite direction in parts of the waveform surrounding the peak. The chosen solution to this accuracy problem is to compromise between these two extremes, so that the value displayed is in error by only 2½% at any part of the waveform.

The mains power supply is unstable and therefore the incoming voltage level is a random one. The mean r.m.s. value is fairly constant, but the peak levels of voltage can vary from one cycle to another by as much as ±5%; although ±2% is more usual. When testing, these higher peaks of voltage will cause breakdown to take place at a level lower than might be expected because breakdown will occur first on the peak of the voltage waveform. To overcome this error the voltmeter is peak detecting but its reading is related back to the equivalent r.m.s. voltage. Unless a stabilised supply is used, this reading will often differ slightly from a reading taken on a true r.m.s. or mean reading meter.

Ionisation

Ionisation in an item under test develops a signal voltage across resistors R63 and R65. This is applied via a high pass filter to the audio amplifier IC2 which energizes the loudspeaker WD1 or an external oscilloscope connecter at the output socket SK10. The filter comprises effectively, four stages of low frequency attenuation, giving an attenuation of approximately 24 dB per octave in the cut-off region. The first three stages are combined into one circuit network around transistor TR5. The final stage is achieved by using a loudspeaker which has a reduced response to frequencies below 2 kHz.

For ionisation which occurs outside the audible frequency range, an oscilloscope connected to the 'OUTPUT' socket will give a clear indication.

The volume control incorporates a switch which disconnects the ionisation circuit but leaves the buzzer (for breakdown indication) able to sound through the loudspeaker.

Indication of Breakdown

Indication of breakdown is given by a buzzer sounding and an amber neon light LP2, mounted on the front panel, illuminating if the peak leakage current exceeds a pre-determined level set by the 'TRIP LEVEL' control R106. The neon remains illuminated for approximately three seconds if the breakdown is only temporary. When the potential set by the peak current in R63 exceeds the potential level set by R106, the first half of comparitor IC3 (output pin 1) activates the second half of IC3 (output pin 7) and then TR1 is switched on. This actuates relay RL1, causes the buzzer to sound, illuminates the amber neon and energizes a set of relay contacts for giving an external indication of breakdown via terminals B1 and B2 on the remote control terminal block. The relay contacts are rated at 250 V and 3 A, and could be used to drive recording or other similar equipment.

Trip Circuit

The trip circuit is designed to operate with trip currents of short duration (21 ms d.c. and 5 ms a.c.) and down to low current levels (100 µA). The circuit will respond to transient currents arising from the initial charging of the external capacitance of the item under test and the connecting leads. To avoid such spurious operation, a circuit is incorporated to hold off the trip circuit for approximately 100 ms after switching on the output voltage.

To take best advantage of this feature the instrument should be connected to the item under test before the output voltage is switched on.

It is possible to switch the trip function off and allow the current to continue to flow while the output voltage is applied. The current is always limited to 5 mA.

Service and Maintenance

Calibration of the Instrument

WARNING:- Very high voltages are present within the instrument when it is switched on. These voltages become exposed to the touch when the instrument is removed from its case during calibration. Therefore this work must only be carried out by a suitably trained and competent person who is aware of the hazards involved.

Before making any connections the instrument must be switched off. Make the connections securely. To calibrate the instrument its power supply must be via a stable power supply unit to provide an output of 240 V ± 1%, see the section on Test Equipment Required. It is not possible to accurately calibrate the instrument directly from a mains supply because this can give rise to errors in the region of 5%.

Before calibration, use a Portable Appliance Tester PAT2 (tests 1 to 4) to check the safety of the instrument, especially the earth bonding of the rear green/yellow terminal.

Calibration of the Voltmeter

Connect a high voltage divider (1000:1 ratio and input impedance 100 MΩ) between the 'DC⎓' socket for d.c. setting or the 'AC~' socket for a.c. testing, and the green/yellow earth terminal on the front of the instrument. Connect the output of the divider to a digital voltmeter of high input impedance. The instrument should be supplied from a variable voltage source. Switch the instrument on.

Safety over-voltage test:-
Set the instrument to 'DIRECT' and the 12 kV d.c. output range. Set the '% OUTPUT VOLTAGE' control so that the measured output is 15 kV d.c. It will be necessary to increase the supply voltage to about 270 V a.c. to achieve this. Check that no ionisation or breakdown occurs. Reset the supply voltage to 240 V a.c.

Setting the voltmeter's differential amplifier:-
Set the instrument to 'MAINTAIN', set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter indicates f.s.d. Reverse the phase and neutral mains supply connections to the instrument and adjust R55 so the 'VOLTAGE' meter again indicates f.s.d. Reconnect the mains supply in the correct manner.

Setting 'DIRECT' 12 kV d.c.:-
Set the instrument to 'DIRECT' and the 12 kV d.c. output range. Set the '% OUTPUT VOLTAGE' control so that the measured output is 12 kV d.c. Adjust R50 until the 'VOLTAGE' meter indicates f.s.d. Check that with measured output voltages of 3 kV, 6 kV and 9 kV the 'VOLTAGE' meter indication is within ±1,5% of f.s.d.

Setting 'MAINTAIN' 12 kV d.c. :-
Set the '% OUTPUT VOLTAGE' control so that the measured output is 10,5 kV. Disconnect the divider and check that the 'VOLTAGE' meter reading rises to about 11,5 kV. Adjust the '% OUTPUT VOLTAGE' control until this operation makes the 'VOLTAGE' meter pointer swing equally around the '11' mark of the 12 kV scale.

Switch the instrument to 'MAINTAIN' and set R67 so that the 'VOLTAGE' meter reading is 11 kV. Set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads f.s.d., the measured output should be 4% low ±1,5%. Check that the measured reading at 6 kV is 4% low ±1,5%.

Setting 'DIRECT' 4 kV d.c.:-
Set the instrument to 'DIRECT' and the 4 kV d.c. output range. Set the '% OUTPUT VOLTAGE' control so that the measured output is 4 kV d.c. Adjust R41 until the 'VOLTAGE' meter indicates f.s.d. Check that with measured output voltages of 1 kV, 2 kV, and 3 kV the 'VOLTAGE' meter indication is within ±1,5% of f.s.d.

Setting 'MAINTAIN' 4 kV d.c. :-
Set the '% OUTPUT VOLTAGE' control so that the measured output is 10,5 on the 12 kV scale. Disconnect the divider and check that the 'VOLTAGE' meter reading rises to about 11,5 on the 12 kV scale. Adjust the '% OUTPUT VOLTAGE' control until this operation makes the 'VOLTAGE' meter pointer swing equally around the '11' mark of the 12 kV scale.

Switch the instrument to 'MAINTAIN' and set R43 so that the 'VOLTAGE' meter reading is 11 on the 12 kV scale. Set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads f.s.d., the measured output should be 2,5% low ± 1% ± 1,5% of f.s.d. Check that the measured reading at 2 kV is 2,5% low ± 1% ± 1,5% of f.s.d..

Testing 'DIRECT' 6 kV a.c.:-
Set the instrument to 'DIRECT' and the 6 kV a.c. output range. Set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads f.s.d. The measured output should be 6 kV a.c. ±3%. (Any error can be shared with setting 'DIRECT' 12 kV d.c. above).

Testing 'MAINTAIN' 6 kV a.c.:-
Switch the instrument to 'MAINTAIN' and set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads 6 kV a.c. The measured output should be 2% high i.e. 6,12 kV a.c. ± 3,8% since it is an unloaded output. (Any error can be shared with setting 'MAINTAIN' 12 kV d.c. above).

Service and Maintenance

Testing 'DIRECT' 2 kV a.c.:-
Set the instrument to 'DIRECT' and the 2 kV a.c. output range. Set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads f.s.d. The measured output should be 2 kV a.c. ± 3%. (Any error can be shared with setting 'DIRECT' 4 kV d.c. above).

Testing 'MAINTAIN' 2 kV a.c.:-
Switch the instrument to 'MAINTAIN' and set the '% OUTPUT VOLTAGE' control so that the 'VOLTAGE' meter reads 2 kV a.c. The measured output should be 2% high i.e. 2,04 kV a.c. ± 3,8% since it is an unloaded output. (Any error can be shared with setting 'MAINTAIN' 4 kV d.c. above).

Calibration of the Ammeter

Setting pick-up nulling:-
Remove the connections from the output terminals. Set the instrument to 'TOTAL' and the 6 kV a.c. output range. Connect an oscilloscope to the positive end of C29 and set the '% OUTPUT VOLTAGE' control to 6 kV a.c. Adjust R81 and R82 to minimize the peak to peak amplitude of the waveform. The reading on the 'CURRENT' meter should be zero.

(R81 and R82 form a back-off circuit for leakage current from the high voltage transformer. R81 adjusts the current flow and R82 adjusts the phase angle).

Setting 'TOTAL' current d.c.:-
Set the instrument to 'TOTAL' and the 12 kV d.c. output range. Connect a 3,6 MΩ (12 kV) resistor in series with a digital ammeter across the output terminals: connect the resistor to the 'DC⎓' output socket and the ammeter to the green/yellow measurement earth terminal on the front of the instrument. Set the '% OUTPUT VOLTAGE' control so that the measured output current is 1 mA and adjust R73 so that the 'CURRENT' meter 1 mA ± 3,5%. (Any error in testing or setting the 'TOTAL' current on a.c. and the 'IN PHASE' current on a.c. and d.c. can be shared by this setting).

Testing 'TOTAL' current a.c.:-
Replace the 3,6 MΩ resistor with a 4,7 MΩ (6 kV) resistor. Set the '% OUTPUT VOLTAGE' control so that the 'CURRENT' meter indicates f.s.d. Check the measured output current is 1 mA a.c. ± 3,5%.

Testing 'IN PHASE' current a.c.:-
Replace the 4,7 MΩ resistor with a 47 MΩ (6 kV) resistor. Set the instrument to 'IN PHASE'. Set the '% OUTPUT VOLTAGE' control so that the 'CURRENT' meter indicates f.s.d. Check that the measured output is 100 µA a.c. ±2,5%. (Re-check this after setting PSD phase; the next step).

Setting PSD phase:-
Connect a 560 pF (6 kV) capacitor in parallel with the 47 MΩ (6 kV) resistor. Adjust R53 so that the 'CURRENT' meter indicates f.s.d. Remove the capacitor.

Testing 'IN PHASE' current d.c.:-
Replace the 47 MΩ resistor with a 100 MΩ (15 kV) resistor. Set the '% OUTPUT VOLTAGE' control so that the 'CURRENT' meter indicates f.s.d. Check that the measured output is 100 µA d.c. ± 2,5%.

Calibration of the Trip Circuit

Connect a 4,7 MΩ (6 kV) resistor in series with a digital ammeter across the output terminals: connect the resistor to the 'AC~' output socket and the ammeter to the green/yellow measurement earth terminal on the front of the instrument.

Set the 'TRIP LEVEL' control to the 1 mA position. Set R25 fully anticlockwise and set the '% OUTPUT CONTROL' so that the measured reading is 0,707 mA r.m.s. (1 mA peak). Adjust R25 until the trip operates. Re-adjust the '% OUTPUT CONTROL' so that the measured reading is 0,6 mA r.m.s. The trip should re-set in about 3 s. Check that the trip occurs again at 0,707 mA ±4%.

Set the 'TRIP LEVEL' control to the 1 mA position. Adjust the '% OUTPUT CONTROL' so that the measured reading is 70,7 µA r.m.s. (1 mA peak) ±22%. (±2% of f.s.d. ±2% of reading). Check that the trip operates.

With the instrument set to 'TRIP' and the 'TRIP LEVEL' set to 1 mA Increase the '% OUTPUT VOLTAGE' control until trip occurs. The 'VOLTAGE' meter reading should fall to zero. Release the 'TEST' button, turn the '% OUTPUT VOLTAGE' control down by 75%, press the 'TEST' button again and observe that the 'VOLTAGE' meter reading rises again.

Short Circuit Current Safety Test

Connect an a.c. current meter between the 'AC~' output terminal and the green/yellow measurement earth terminal on the front panel. Set the instrument to the 6 kV a.c. range, press the 'TEST' button and increase the '% OUTPUT VOLTAGE' control for a f.s.d. reading. The current meter should read less than 5 mA. Repeat this procedure with the instrument set to the 2 kV a.c. range.

Using a d.c. current meter connected to the 'DC⎓' output terminal and the green/ yellow measurement earth terminal, repeat the above procedure for trhe 12 kV d.c. and 4 kV d.c. ranges. The current meter should be less than 2 mA.

Test Equipment Required

1. Portable Appliance Tester PAT2 and an oscilloscope.
2. Stabilised power supply, with output 240 V ± 1%, stable to < 0,1% and total harmonic distortion < 0,25%.
3. 1000:1 attenuator and voltmeter, input impedance 100 MΩ, total accuracy ± 0,25% a.c. or d.c.
4. Resistive load of 3,6 MΩ (12 kV rating) in series with a current meter able to measure 1 mA d.c. ± 0,25%.
5. Resistive load of 4,7 MΩ (6 kV rating) in series with a current meter able to measure 1 mA a.c. ± 0,25%.
6. Resistive load of 47 MΩ (6 kV rating) in series with a current meter able to measure 100 µA a.c. ± 0,25%.
7. Capacitive load of 560 pF (6 kV rating), to be connected in parallel with the resistance and meter in (6) above.
8. Resistive load of 100 MΩ (12 kV rating) in series with a current meter able to measure 100 µA d.c. ± 0,25%.
9. Current meter able to measure 5 mA a.c. ± 0,25% and 2 mA d.c. ± 0,25%.

Repair and Warranty

The instrument circuit contains static sensitive devices, and care must be taken in handling the printed circuit board. If the protection of an instrument has been impaired it should not be used, and be sent for repair by suitably trained and qualified personnel. The protection is likely to be impaired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged storage under unfavourable conditions, or has been exposed to severe transport stresses.

New Instruments are Guaranteed for 1 Year from the Date of Purchase by the User.

Note: Any unauthorized prior repair or adjustment will automatically invalidate the Warranty.

Instrument Repair and Spare Parts

For service requirements for ***MEGGER®*** Instruments contact :-

AVO INTERNATIONAL	or	**AVO INTERNATIONAL**
Archcliffe Road		510 Township Line Road
Dover		Blue Bell
Kent, CT17 9EN		PA 19422-2795
England		U.S.A.
Tel: +44 (0) 1304 502243		Tel: +1 (215) 646-9200
Fax: +44 (0) 1304 207342		Fax: +1 (215) 643-7215

or an approved repair company.

Approved Repair Companies

A number of independent instrument repair companies have been approved for repair work on most ***MEGGER®*** instruments, using genuine ***MEGGER®*** spare parts. Consult the Appointed Distributor / Agent regarding spare parts, repair facilities and advice on the best course of action to take.

Returning an Instrument for Repair

If returning an instrument to the manufacturer for repair, it should be sent freight pre-paid to the appropriate address. A copy of the Invoice and of the packing note should be sent simultaneously by airmail to expedite clearance through Customs. A repair estimate showing freight return and other charges will be submitted to the sender, if required, before work on the instrument commences.

Components List

Main P.C.B.

R1	Resistor	10 kΩ ± 1% 0,25 W
R2	Resistor	15 Ω ± 1% 0,25 W
R3	Resistor	4,7 kΩ ± 1% 0,25 W
R4	Resistor	4,7 MΩ ± 5% 0,25 W
R5	Resistor	2,2 MΩ ± 5% 0,25 W
R6	Resistor	11 kΩ ± 1% 0,25 W
R7	Resistor	22 kΩ ± 1% 0,25 W
R8	Resistor	4,7 kΩ ± 1% 0,25 W
R9	Resistor	2,2 MΩ ± 5% 0,25 W
R10	Resistor	47 kΩ ± 1% 0,25 W
R11	Resistor	68,1 kΩ ± 1% 0,25 W
R12	Resistor	7,5 kΩ ± 1% 0,25 W
R13	Resistor	6,81 kΩ ± 1% 0,25 W
R14	Resistor	6,81 kΩ ± 1% 0,25 W
R15	Resistor	2,7 kΩ ± 1% 0,25 W
R16	Resistor	6,81 kΩ ± 1% 0,25 W
R17	Resistor	100 Ω ± 1% 0,25 W
R18	Resistor	3,9 kΩ ± 1% 0,25 W
R19	Resistor	110 kΩ ± 1% 0,25 W
R20	Resistor	56,2 Ω ± 1% 0,25 W
R21	Resistor	510 Ω ± 1% 0,25 W
R22	Resistor	24,3 kΩ ± 1% 0,25 W
R23	Resistor	15 kΩ ± 1% 0,25 W
R24	Resistor	2,7 kΩ ± 1% 0,25 W
R25	Potentiometer	5 kΩ ± 20%
R26	Resistor	1,5 kΩ ± 1% 0,25 W
R27	Resistor	20 kΩ ± 1% 0,25 W
R28	Resistor	47 kΩ ± 1% 0,25 W
R29	Resistor	1,5 MΩ ± 1% 0,25 W
R30	Resistor	not used
R31	Resistor	100 Ω ± 10% 0,5 W
R32	Resistor	3,9 kΩ ± 1% 0,25 W
R33	Resistor	27 kΩ ± 1% 0,25 W
R34	Resistor	365 kΩ ± 1% 0,25 W
R35	Resistor	118 kΩ ± 0,1% 0,25 W
R36	Resistor	220 Ω ± 1% 0,25 W
R37	Resistor	3,32 kΩ ± 0,1% 0,25 W
R38	Resistor	1 MΩ ± 0,5% 0,5 W
R39	Resistor	3,9 kΩ ± 1% 0,25 W
R40	Resistor	12 kΩ ± 1% 0,25 W
R41	Potentiometer	500 Ω ± 20%
R42	Resistor	not used
R43	Potentiometer	1 kΩ ± 20%
R44	Resistor	9,1 kΩ ± 1% 0,25 W
R45	Resistor	12 kΩ ± 1% 0,25 W
R46	Resistor	95,3 kΩ ± 0,1% 0,25 W
R47	Resistor	15 kΩ ± 1% 0,25 W
R48	Resistor	620 Ω ± 1% 0,25 W
R49	Resistor	511 kΩ ± 1% 0,25 W
R50	Potentiometer	5 kΩ ± 20%
R51	Resistor	22 kΩ ± 1% 0,25 W
R52	Resistor	160 kΩ ± 1% 0,25 W
R53	Potentiometer	50 kΩ ± 20%
R54	Resistor	30 kΩ ± 1% 0,25 W
R55	Potentiometer	50 kΩ ± 20%
R56	Resistor	511 kΩ ± 1% 0,25 W
R57	Resistor	30 kΩ ± 1% 0,25 W
R58	Resistor	1 MΩ ± 0,5% 0,5 W
R59	Resistor	475 kΩ ± 1% 0,25 W
R60	Resistor	1 MΩ ± 0,5% 0,5 W
R61	Resistor	1 MΩ ± 0,5% 0,5 W
R62	Resistor	2,4 MΩ ± 1% 0,25 W
R63	Resistor	500 Ω ± 0,1% 0,25 W
R64	Resistor	1 MΩ ± 0,5% 0,5 W
R65	Resistor	500 Ω ± 0,1% 0,25 W
R66	Resistor	10,5 kΩ ± 1% 0,25 W
R67	Potentiometer	1 kΩ ± 20%
R68	Resistor	4,7 MΩ ± 5% 0,25 W
R69	Resistor	528 kΩ ± 0,25% 0,25 W
R70	Resistor	511 kΩ ± 1% 0,25 W
R71	Resistor	257 kΩ ± 0,25% 0,25 W
R72	Resistor	110 kΩ ± 1% 0,25 W
R73	Potentiometer	100 Ω ± 20%
R74	Resistor	475 kΩ ±1% 0,25 W
R75	Resistor	20 kΩ ± 1% 0,25 W
R76	Resistor	3,9 kΩ ± 1% 0,25 W
R77	Resistor	120 kΩ ± 1% 0,25 W
R78	Resistor	120 kΩ ± 1% 0,25 W
R79	Resistor	1 kΩ ± 1% 0,25 W
R80	Resistor	2,2 MΩ ± 5% 0,25 W
R81	Potentiometer	1 MΩ ± 20%
R82	Potentiometer	100 kΩ ± 20%
R83	Resistor	110 kΩ ± 1% 0,25 W
C1	Capacitor	100 nF 25 V
C2	Capacitor	22 µF 35 V
C3	Capacitor	100 nF 25 V
C4	Capacitor	1 nF 100 V
C5	Capacitor	1 nF 100 V
C6	Capacitor	100 nF 25 V
C7	Capacitor	100 nF 25 V
C8	Capacitor	1 nF 100 V
C9	Capacitor	47 nF 63 V
C10	Capacitor	100 nF 25 V
C11	Capacitor	100 nF 25 V
C12	Capacitor	2,2 nF 63 V
C13	Capacitor	1 µF 50 V
C14	Capacitor	680 nF 250 V
C15	Capacitor	2 µF 250 V
C16	Capacitor	100 nF 250 V
C17	Capacitor	100 nF 25 V
C18	Capacitor	22 µF 35 V
C19	Capacitor	4,7 µF 63 V
C20	Capacitor	1 µF 50 V
C21	Capacitor	1 mF 25 V
C22	Capacitor	100 nF 25 V
C23	Capacitor	1 mF 25 V
C24	Capacitor	100 nF 25 V
C25	Capacitor	not used
C26	Capacitor	1 nF 63 V
C27	Capacitor	1 µF 50 V
C28	Capacitor	1 µF 50 V
C29	Capacitor	22 µF 35 V
C30	Capacitor	22 pF 35 V
C31	Capacitor	220 nF 50 V
C32	Capacitor	1 µF 50 V
C33	Capacitor	100 nF 25 V
D1 to D12	Diode	1N4148
D13	Zener diode	BZT03C18
D14	Zener diode	BZT03C18
D15	Diode	1N4148
D16	Zener diode	BZX79C12
D17 to D24	Zener diode	BZV58C200
D25	Zener diode	BZT03C10
D26	Zener diode	BZT03C10
D27	Zener diode	BZT03C18
D28	Zener diode	BZT03C18
D29	Diode	1N4148
IC1	Integrated circuit	4011
IC2	Integrated circuit	741C
IC3	Integrated circuit	LM358
IC4	Integrated circuit	741C
IC5	Integrated circuit	Voltage regulator 79L15
IC6	Integrated circuit	Voltage regulator 78L15
IC7	Integrated circuit	LF355N
IC8	Integrated circuit	07-OP
IC9	Integrated circuit	741C
IC10	Integrated circuit	741C
IC11	Integrated circuit	07-OP

Components List

TR1	Transistor	BC184C
TR2	Transistor	BC183
TR3	Transistor	BC183
TR4	Transistor	BD437
TR5	Transistor	BC183
TR6	Transistor	BC214C
TR7	Transistor	BD438
TR8	Transistor	J112
BR1	Bridge rectifier	1KAB10E
BR2	Bridge rectifier	1KAB10E
V1	Varistor	Z21L471
V2	Varistor	Z21L471
RL1	Relay	2 pole monostable 12 V
RL2	Relay	2 pole changeover 250 V 10 A
RL3	Relay	2 pole monostable 12 V
TX1	Transformer	6 VA 120 V/15 V a.c.
FS1	Fuse	500 mA (quick blow)
SW1	Switch	part no. 25975-061 (2 pole latching 'TOTAL/IN PHASE')
SW2	Switch	part no. 25975-058 (2 pole latching 'TRIP/BURN')
SW3	Switch	part no. 25975-057 (4 pole latching 'ON/OFF')
SW4	Switch	part no. 25975-057 (4 pole latching voltage range select)
SW5	Switch	part no. 25975-061 (2 pole latching 'DIRECT/MAINTAIN')
SW1	Switch	part no. 25975-056 (2 pole non-latching 'TEST')

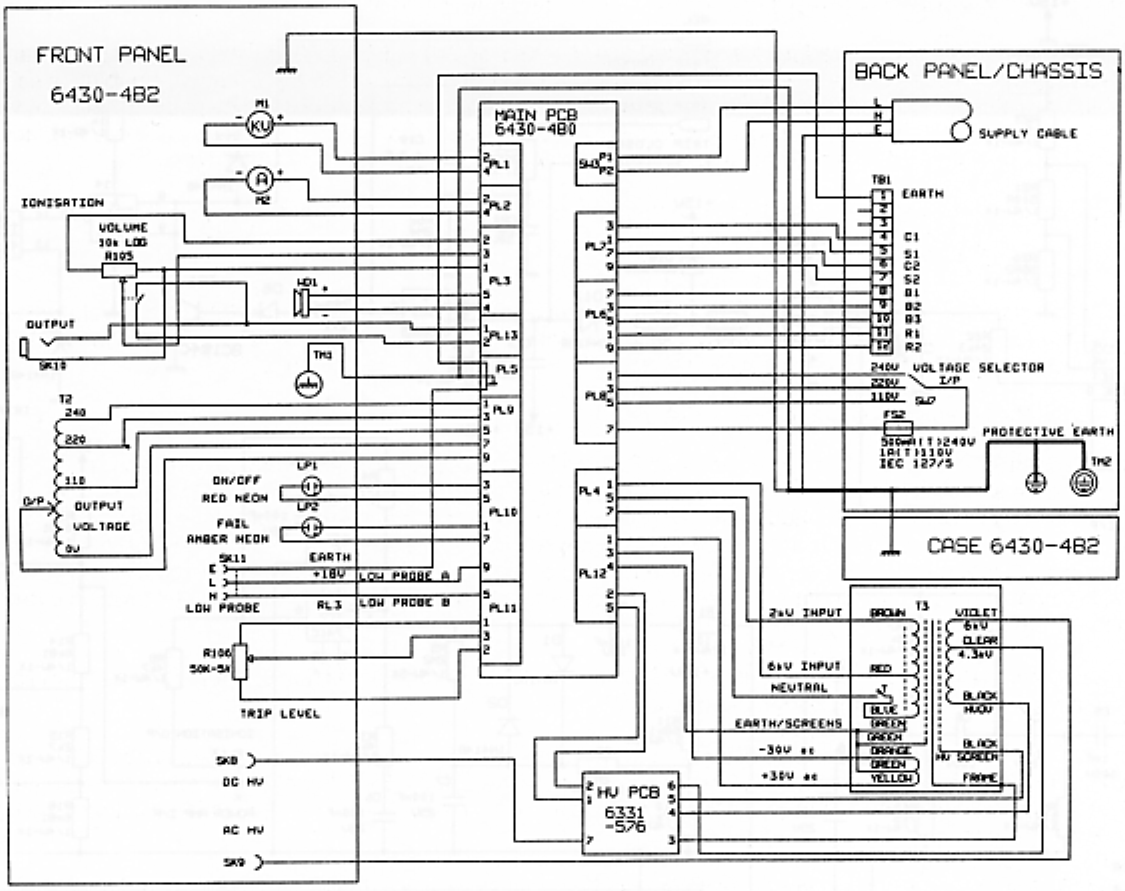
High Voltage P.C.B.

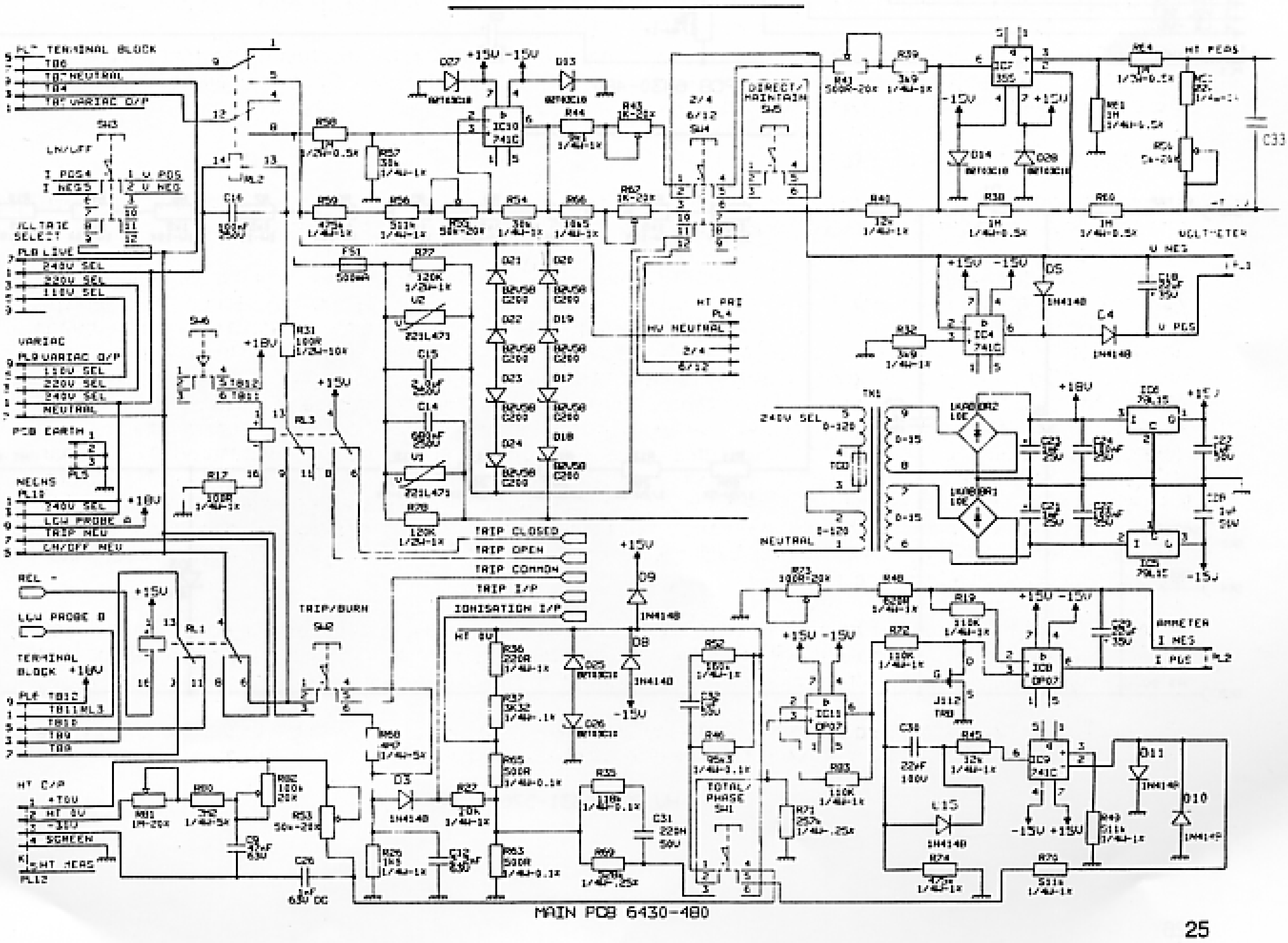
R1 to R10	Resistor	1,5 kΩ ± 10% 1 W
R11 to R15	Resistor	20 MΩ ± 5% 0,5 W
C2	Capacitor	5 nF 15 kV
D1	Diode	VG20
D2	Diode	VG20
D3	Diode	BZX79C8V2

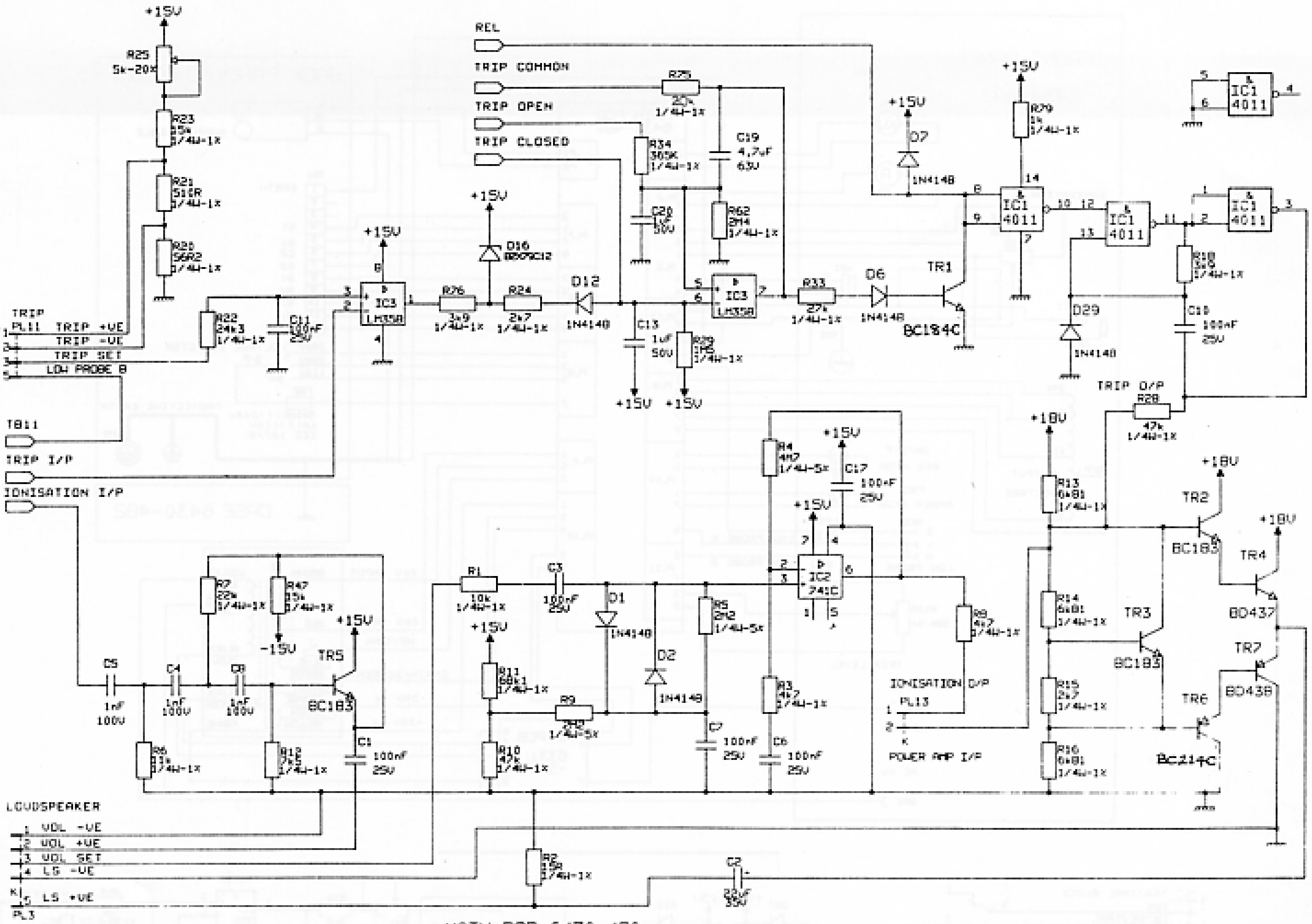
Other components

M1	Voltmeter	part no. 6480-044
M2	Ammeter	part no. 6480-043
LP1	Neon lamp (red)	part no. 25515-679
LP2	Neon lamp (amber)	part no. 25990-004
WD1	Loudspeaker	part no. 27920-013
R105	Potentiometer	10 kΩ ('VOLUME')
R106	Potentiometer	50 kΩ ('TRIP LEVEL')
T2	Transformer	part no. 27900-014 ('% OUTPUT VOLTAGE')
T3	Transformer	part no. 6331-577 (high voltage)

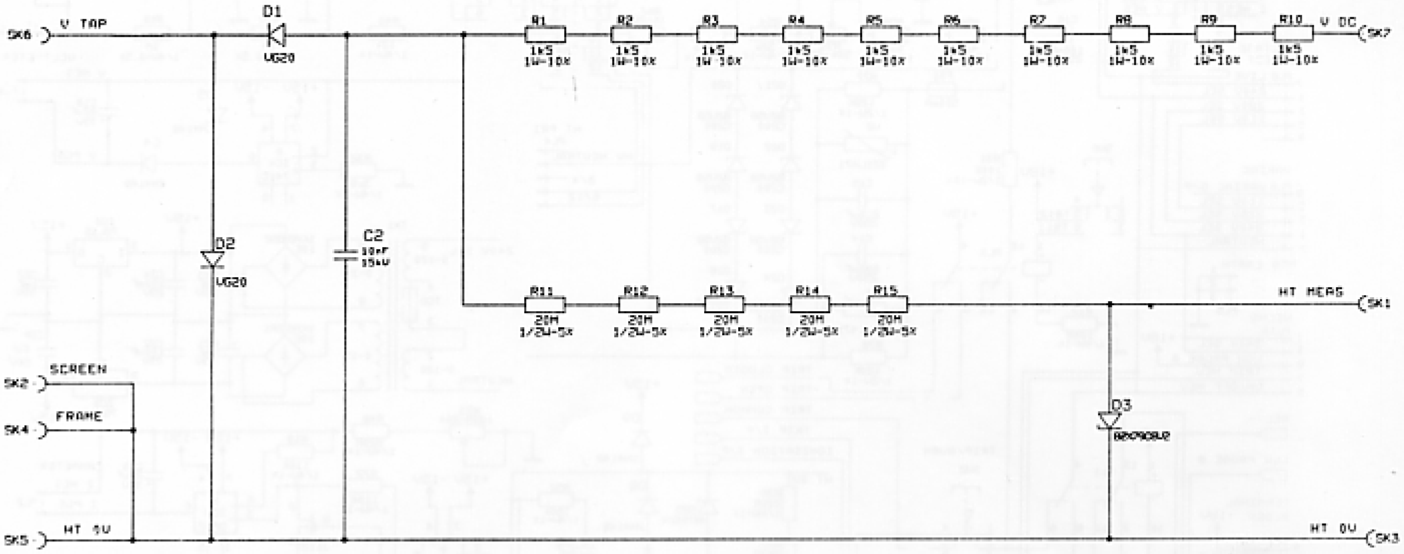
Circuit Diagrams







MAIN PCB 6430-480



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