BIDDLE
INSTRUMENTS

BLUE BELL, PA 19422 • (215) 646-9200

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Instruction Manual 21-81J

for use of the Catalog No. 210900

Digital Battery Megger® Tester

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SAFETY IN THE USE OF ELECTRICAL EQUIPMENT

It should be understood that any use of electricity inherently involves some degree of safety hazard.

While every effort is made by responsible manufacturers to reduce the hazard, it still rests with the user to play his part in ensuring his own safety.

The best way to achieve this is: —

- ★ **Understand the equipment you are proposing to use and its ratings.**
- ★ **Understand the application to which the equipment is to be put.**
- ★ **Be sure that all reasonable safety procedures are followed.**
- ★ **Take no chances, nor short cuts, in safety procedures.**

See also the notes on safety for this particular instrument in the paragraph headed 'WARNING' on page 10.

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GENERAL DESCRIPTION

The Catalog No. 210900 is a portable, hand-held, digital insulation tester in a rugged plastic case. It has a nominal insulation testing voltage of 500 V dc. The instrument readings are shown on a 3½ digit liquid crystal display, and the analog to digital conversion is achieved using a M.O.S.L.S.I. integrated circuit. The output voltage for insulation tests is produced by a stored energy inverter.

The terminal sockets fitted into the top of the case are recessed and accommodate the safety test lead set. When an insulation test is performed, the voltage present at the red socket is positive with respect to that at the black one.

The tester functions are selected by the slider switch which has a central 'off' position. Moving the slider switch upwards selects the continuity ('200 Ω') range. Moving the slider switch further, to the top position, selects the continuity buzzer facility, which has the same measuring range, but when the audible continuity is selected a buzzer will sound if resistances below 20 Ω (typical) are encountered. This audible facility aids rapid continuity checking when reference to the display reading, which is shown simultaneously, is not required. Below the central 'off' position is the voltage range ('500 V ⎓ ⎓') for ac r.m.s. or dc measurements. The range (i) enables a check to be made to ensure that the circuit under test is de-energized before any resistance measurements are made and (ii) will monitor the discharge voltage following tests on capacitive circuits. The lowest switch position selects the 500 V insulation resistance ('200 MΩ') range. The switch is spring-loaded and must be held while a test is being made. On release, the switch will automatically go back into the voltage position so that the discharge, (which is automatic) can be monitored. The insulation range will measure the values of resistance between 0 and 199,9 MΩ. For increased resolution an auto-ranging facility is included and range changing occurs at between 10 MΩ and 15 MΩ. A 'warning flash' on the front panel of the tester illuminates when an external high voltage is applied to the terminals. This warning is given on each switch position except '200 MΩ'. Capacitive circuits discharge automatically through the neon 'warning flash' lamp. This therefore illuminates momentarily while discharge is occurring.

GENERAL DESCRIPTION

The digital display shows the units of measurement together with the reading. Over-range and low battery voltage indications are given when needed.

The case has a fold away support stand for propping the tester at 30° from the horizontal. This stand can be folded through 180° to make a loop so that the meter can be hung from a convenient hook. Non-slip rubber feet are also fitted to the back of the case.

The power for the instrument is supplied by a single 9 V battery housed in its own compartment which is accessible from the rear of the case.

AUTOMATIC TURN-OFF

A circuit has been included in the design which will turn the meter off after one hour if it has been inadvertently left on. This is to ensure that the battery power is not wasted. Although the 'turn-off' circuit takes only minimal current it is always best to switch the meter off after use. The 'turn-off' circuit is operative on all functions, and is re-activated by changing the slider switch position. Therefore, if after a period of non-use the meter appears to be 'dead', move the slider switch to another position to re-energize the unit.

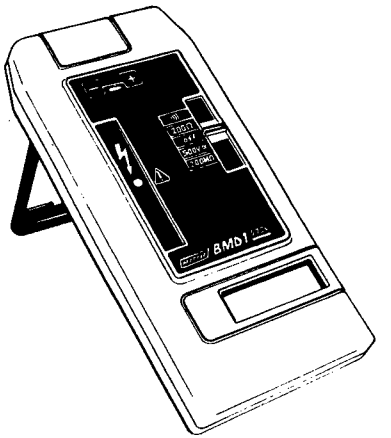

Fig. 1 Cat. No. 210900. Megger Tester

APPLICATIONS

The Cat. No. 210900 is an insulation and continuity tester that is simple to operate. Insulation tests are performed at nominally 500 V dc. It gives a direct digital reading of either insulation resistance, continuity or voltage and displays the appropriate units.

INSULATION RESISTANCE

The safety of electrical installations and apparatus depends on the condition of the insulation. It is essential to thoroughly test the insulation of equipment while subjecting that insulation to a voltage in excess of the normal voltage rating of that equipment.

In order to avoid interruptions or breakdowns, it is desirable that routine tests of the insulation condition of the equipment or installation are made from time to time, to ensure that deterioration is not occurring. The accumulation of dirt or moisture and mechanical wear or breakage can all lead to a deterioration of the insulation.

CONTINUITY TESTING

The instrument will give direct readings for circuit and earth continuity in ohms or provide an audible indication of continuity. Broken joints or contacts can therefore be quickly measured, traced and repaired.

SPECIFICATIONS

Ranges	
Insulation resistance range	0.01 — 199,9 MΩ (auto-ranging — two ranges)
	dc test voltage — 500 V
Continuity range	0.1 — 199,9 Ω
Continuity buzzer (selectable)	gives audible indication of low resistance, typically <20 Ω
Voltage range	0 — 500 V ac/dc for safety check only
Display	3½ digit liquid crystal
Accuracy	
Insulation resistance range	± 1% of reading ± 1 digit
Continuity range	± 1% of reading ± 2 digits
Voltage range	± 1% of reading ± 2 digits
Terminal Voltage	
Insulation resistance range	500 V ± 10% from 1 MΩ to ∞
Continuity range and buzzer	10 V max.
Voltage range	input impedance varies between 200 kΩ and 1,2 MΩ depending on input voltage.
Terminal Current	
Insulation resistance range	1 mA max. on short circuit
Continuity range and buzzer	1,5 mA max. on short circuit

SPECIFICATIONS

Temperature Coefficient	± 0, 1%/°C — all ranges
Temperature Range	operation −5°C to +50°C storage −20°C to +70°C
Humidity	operation 80% R.H. max. up to 35°C (to give specified accuracy) storage 95% R.H. max. up to 35°C
Input Overload Ratings	maximum voltage on all ranges is 500 V (voltage range; up to 1 kV for 10 seconds) a neon lamp indicates the presence of external high voltages
Capacitive Loads	suitable for capacitive circuits up to 1 μF.
Discharge	capacitive circuits are automatically discharged when the switch is released from the 200 MΩ position.
Power Supply	single 9 V battery NEDA Type 1604 or 1604A (IEC 6F22 or 6LF22) e.g. Ever-Ready 216 or Duracell MN1604 or equal. typical battery life for 6LF22: — Megohm range 8 hours, (equivalent to 5760 operations of 5 seconds duration), to 50 hours depending on load. Other ranges > 140 hours.
Dimensions	7½ × 3½ × 1½" (193 × 90 × 40 mm).
Weight	12 oz. (325 g approx.)

SPECIFICATIONS

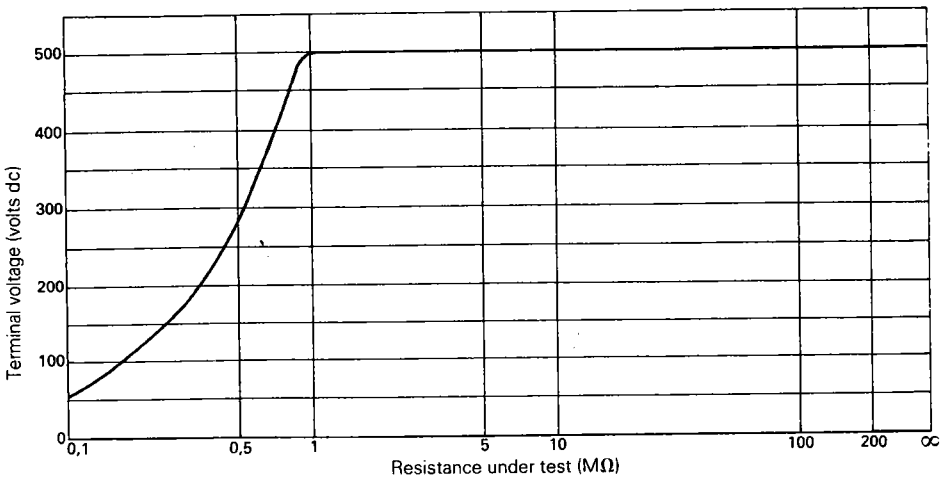

Fig. 2 Typical terminal voltage characteristic

WARNING!

1. This instrument must only be connected to circuits or equipment which are de-energized and isolated.
2. The circuit or equipment becomes charged with electricity when tested; it must not be touched until it is discharged to a safe level and then grounded.

   A neon light indicates when high voltage is being applied to the circuit or equipment under test. This light continues to be illuminated while the discharge is in progress. The instrument provides an automatic discharge path.
3. The voltage range is intended only to indicate the presence of an unexpected voltage or to monitor the progress of discharge. It will indicate if the unexpected voltage is ac or dc but without polarity indication. There is no over-range indication.
4. This instrument and its accessories should not be used for any purpose other than those described in this instruction manual.
5. Other notes relating to safety appear in other parts of this manual; all of this manual should be studied for safe operation.

DISPLAY SYMBOLS

The 3½ digit liquid crystal display indicates the value of all measurements taken. On the insulation resistance, ('200 MΩ') and continuity, ('200 Ω') ranges (and when switched to audible continuity), the decimal point appears. No multiplying factors are necessary. The over-range symbol appears if the meter is required to indicate a reading outside the measuring capability of the range selected on '200 MΩ' or '200 Ω'. On the '200 MΩ' range this may be interpreted to mean that the insulation resistance is high and is somewhere between '200 MΩ' and infinity. The over-range symbol is a 'I' at the extreme left hand digit of the display with the remaining digits blank. The decimal point and the units of measurement will remain visible.

The units of measurement 'V', 'Ω' or 'MΩ', according to the function selected, appear at the right hand side of the display as soon as the instrument is turned on.

The symbol ▬ appears in the top left hand corner of the display when the battery voltage is becoming low. The battery should be changed as soon as the symbol appears. On the '200 MΩ' range where the heaviest current consumption can occur, the symbol

may appear but the battery may be still satisfactory on the voltage or resistance ranges.

After use the meter should be switched off to conserve battery power.

FITTING OR REPLACING THE BATTERY

The battery compartment is in the rear of the case. With the tester switched 'off' and disconnected place it face downwards on a bench and release the captive screw in the center of the battery compartment cover.

Remove the battery compartment cover and fit (or replace) a new battery to the terminal connector in the slot at the bottom. Be sure that the correct polarity is observed.

Replace the battery compartment cover and secure it with the screw before using the tester again.

CONNECTING AND CHECKING THE TEST LEADS

Push the red test lead into the red terminal socket, marked '⊞', and push the black test lead into the black terminal socket, marked '⊟'. Terminate the ends of the test leads by pushing on the covered alligator clips or the prods as required. (The black prod has a retractable tip.)

It is advisable to check the condition of the test leads before making measurements.

(i) Inspect the test leads to see that they have good, unbroken insulation.

(ii) Connect the test lead prods or clips together and slide the switch to the '200 Ω' position. The display should show the lead resistance which will be low. If a high resistance reading or the over-range symbol is obtained check the connections. If the reading is still high suspect that the test leads may be at fault. Faulty test leads should be replaced.

INSULATION TESTING

The circuit which is to be the subject of the test must be switched off before connecting the test leads.

First connect the test leads to the instrument and check the condition as described above. Slide the switch into the 500 V⎓ position and then make connection to the circuit under test. Connect the red lead to the equipment frame, cable sheath or earth point and the black lead to the circuit under test or cable conductor. (The red '⊞' terminal is the source of 500 V dc with respect to the black '⊟' terminal.)

Observe that the display is indicating that there is no voltage present i.e. that the circuit is off. If a voltage reading is obtained, the circuit must be de-energized before proceeding.

Slide the switch to the '200 MΩ' position and hold it there against the return spring pressure. The insulation resistance will be shown directly on the display. If the over-range symbol appears the resistance being measured is in excess of 200 MΩ.

After the reading has been observed release the slider switch. It will return to the '500 V ⎓' position, and if a capacitive circuit has been tested the discharging voltage will be shown instantaneously.

Discharging: —

The instrument will automatically discharge capacitive circuits following insulation tests on all switch positions except '200 MΩ'. In the '500 V ⎓' position the discharge voltage level is given. A capacitance of 1μF will be discharged to a safe level in less than 1 second. From the rate of this discharge it is possible to tell if a capacitance of this magnitude is present in the circuit being measured. The 'warning flash' neon lamp is used to discharge any capacitance present, and may be seen to strike momentarily as the circuit discharges.

VOLTAGE MEASUREMENT

The voltage measurement function is intended for (a) checking that the circuit to be tested is de-energized and (b) monitoring the discharging voltage of capacitive circuits following tests. There is no indication of ac or dc or polarity.

Connect the test leads to the instrument, and check their condition as described above. Slide the switch to the '500 V ⎓' position and to the circuit under test. Read the voltage directly on the display.
Note: — The neon indicator light will illuminate to warn of the presence of a high voltage.

CONTINUITY TESTING

The circuit which is to be the subject of the test must be switched off before connecting the test leads.

First connect the test leads to the instrument and check their condition as described above, then make connection to the circuit under test.

Caution: — if, when connecting the test leads, the neon warning light illuminates, an external high voltage is present. This must be switched off before proceeding with the test.

Slide the switch to the '200 Ω' position and read the resistance on the display. If the over-range symbol appears this indicates that the resistance is in excess of 200 Ω. Switch the instrument off and disconnect the test leads.

AUDIBLE CONTINUITY TESTING

When the resistance reading is not required and checks are being made purely for continuity, the audible continuity position may be used. The circuit which is to be the subject of the test must be switched off before connecting the test leads.

First connect the test leads to the instrument and check their condition as described above, then make connection to the circuit under test.

Caution: — If when connecting the test leads, the neon warning light illuminates, an external high voltage is present. This must be switched off before proceeding with the test.

Slide the switch to the '·ıı)' position and the internal buzzer will give a continuous sound for resistance less than 20 Ω (typical). The display will also show the resistance value simultaneously, and will continue to indicate up to the limit of the continuity range i.e. 199,9Ω. After the test, switch the instrument off and disconnect the test leads.

ANALOG TO DIGITAL CONVERSION

This function is performed by IC11, a 40 pin integrated circuit and its related components using the method of dual slope integration with auto-zeroing.

During the conversion two voltages are compared by the A/D converter chip. These voltages are applied via analog switches and filters to pins 30 and 31 and to pins 35 and 36 respectively of IC11. The clock frequency is fixed by R5/C14 to be nominally 40 kHz, ensuring 2,5 readings per second and assisting in 50 Hz/60 Hz noise rejection.

DISPLAY DRIVING

All display figures are driven directly by the A/D converter chip which provides square waves (nominally 5 V) either in phase or in antiphase with the backplane waveform. The frequency is nominally 50 Hz, derived from the system clock.

Decimal points, annunciators and the battery low indication are driven by logic signals from the function switch in conjunction with 'OR gates'. These 'OR gates' drive the display symbols with either an in phase or an antiphase backplane waveform depending on the control logic applied by the function switch.

IC2 provides this control logic level for the battery low voltage symbol selection. A fraction of the battery voltage set by R44/R45 is compared to the common voltage of IC11. IC3 output will change state when the battery voltage is 7 V nominal.

NEON INDICATOR

A neon light with parallel resistor R2, is connected in series with R1 and switched across the terminals on every position except 'MΩ'. This gives (i) a warning of the presence of a dangerous high external voltage, and (ii) acts as an automatic discharge path for capacitive circuits following an insulation test.

CONTINUITY MEASUREMENT

For measurement of continuity, the battery supplies current via protection and current limiting circuitry to the unknown resistance and back via R20. The A/D converter monitors the voltage across the resistance under test and also the voltage across R20. A ratiometric measurement is then performed on these two voltages and the resistance value of the unknown is evaluated and displayed. The ratiometric

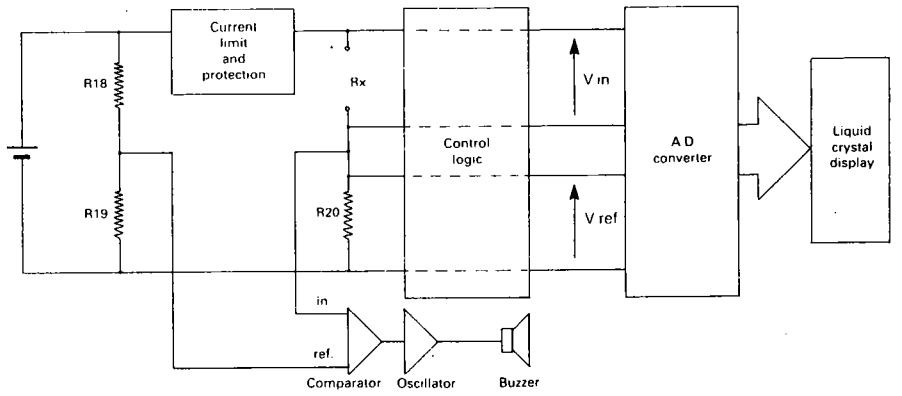

Fig. 3 Block diagram — continuity measurement

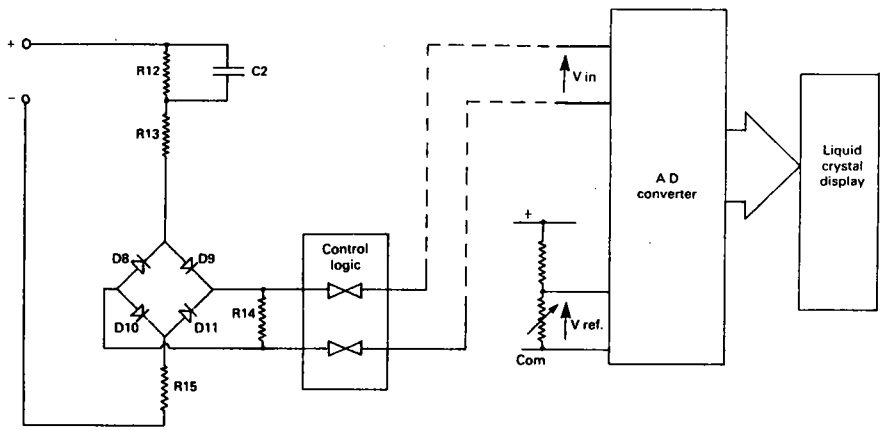

Fig. 4 Block diagram — voltage measurement

technique compares the ratio of the two voltages and thus if the battery voltage were to fall due to a long period of discharge, the ratio of the voltages across Rx and R20 would not change and hence the reading would not be affected.

If the audible buzzer range is selected then the above still applies, however, an additional comparator and oscillator are connected. The comparator switches the oscillator either on or off when its input either goes above or below the reference voltage. By appropriate selection of R18 and R19 a buzzer trip point for Rx = 20 Ω typical has been defined.

VOLTAGE MEASUREMENT

Resistors R12, R13, R14 and R15, together with a bridge circuit D8, D9, D10 and D11 form a potentiometer chain across the input terminals. Voltage applied to the terminals is attenuated (and rectified if it is ac) and appears across R14. This provides the input via analog switches to the A/D converter. To compensate for ac signals R12 is shunted by C2 in the potentiometer chain. The reference voltage for the A/D converter chip is provided by an attenuator chain between the positive rail and the common rail.

INSULATION RESISTANCE MEASUREMENT

The 500 V converter unit supplies the test voltage to the terminals. The current, passed through the unknown resistor under test, then flows through a potentiometer chain R22 and R24. The voltages developed across R22 and R24 are very small and are passed via controlled analog switches to an amplifier IC3. The output of this amplifier provides the reference signal to the A/D converter.

The analog switches are controlled by one of the amplifiers in the IC2 package, which is connected as a comparator, to give the auto-ranging change-over point of the input signals to IC3 at between 10 MΩ to 15 MΩ.

The input signal to the A/D converter is obtained across R15 which forms the lower potential resistor in a divider chain across the instrument terminals. The input voltage signal to the A/D converter is proportional to the voltage across the resistance under test, and the input reference voltage signal is proportional to the current through the resistance under test.

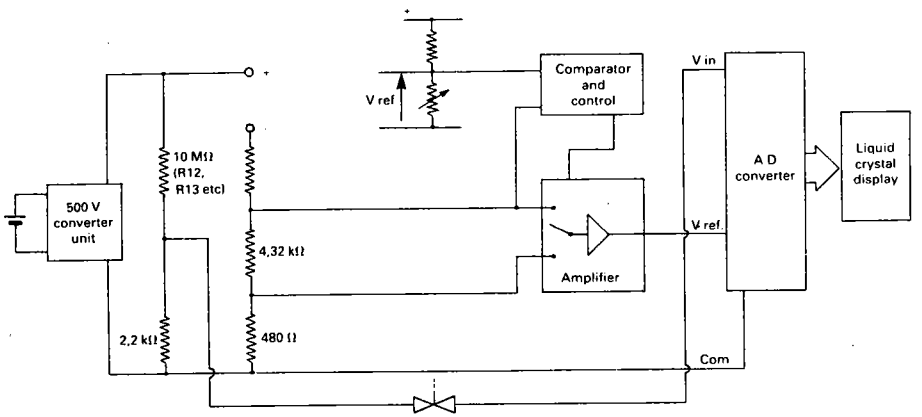

Fig. 5 Block diagram — insulation resistance measurement

AUTOMATIC TURN-OFF

A timing circuit is provided by the integrated circuit IC1 and components R4, R5, R6 and C1. The output of IC1 controls the gate of TR1. TR1 conducts when the instrument is switched on and is turned off after one hour, causing the internal power supply rails of the meter to be turned off. Changing the slider switch to a different position re-sets the timing circuit. The purpose of the circuit is to conserve battery power by reducing the current drain in the main circuit leaving just the consumption of the timer circuit.

OPENING THE INSTRUMENT

The instrument should not be connected to any external circuit and the test leads should be removed. All parts should be stored carefully ready for re-assembly.

Remember that 500 V is generated within the instrument and care must be exercised while working on the circuit when it is energized. The instrument should be laid face down on the work bench and the battery compartment cover removed by first releasing the screw in the center and lifting clear. Remove the battery from its compartment and unclip the terminal connectors.

Remove the cross head screws, one in each corner of the case. Access to the top two is obtained by lifting the support stand to its first position. Lift off the rear case and support stand complete and expose the printed circuit board and components. Test measurements on the circuit and adjustments can be made with the instrument in this condition.

REMOVING THE CIRCUIT BOARD ASSEMBLY

This allows access to the slider switch mechanism, the buzzer and the neon indicator.

Remove the cross-head screws at the bottom of the printed circuit board and lift out the board assembly and terminal sockets complete. Be careful because the buzzer is mounted on the inside of the front cover and wired to the printed circuit board.

Note: — It is only necessary to remove the assembly if components are to be unsoldered or access to the switch mechanism or buzzer is needed. The remaining two cross-head screws on the printed circuit board hold the display cover and only need to be removed when that item or the display itself is being replaced.

To re-assembly the instrument perform the dismantling procedure in the reverse order, taking care not to trap the buzzer wires or the battery supply wires.

CALIBRATION

To set or check the calibration of the instrument open it up as described above and then proceed as follows. Temporarily fit a good battery to the battery terminal connector.

Voltage Reference

Connect a multiplier calibrator (or similar accurate voltage supply) to the terminal sockets and supply a voltage of say 250 V dc. Set the slider switch to the '500 V⎓' position and adjust R52 until the display indicates 250 V.

Switch off and remove the applied voltage.

Note: — This adjustment also changes the auto-ranging point.

MΩ Range Input Off-Set

Connect pin 3, the non-inverting input, of IC3 to common (best located on the center pin of R52) and connect a voltmeter set to a millivolt range between pin 6 (output) of IC3 and common. With nothing connected to the terminal sockets, switch to the '200 MΩ' position and adjust the off-set potentiometer R32 until the voltmeter reads zero. Remove the voltmeter and shorting link.

MΩ Range

Connect a resistor of say 150 MΩ (and able to withstand 500 V) to the terminal sockets. Set the slider switch to the '200 MΩ' position and adjust the gain control potentiometer R57 until the display indicates 150,0 MΩ.

After re-assembly the instrument should perform within its specification. This can be checked on the voltage range by using a multimeter calibrator or other known voltage source. The Continuity and Insulation Resistance ranges can be checked by using resistance boxes or known resistors but they must be able to withstand 500 V on the Insulation range.

SERVICE AND MAINTENANCE

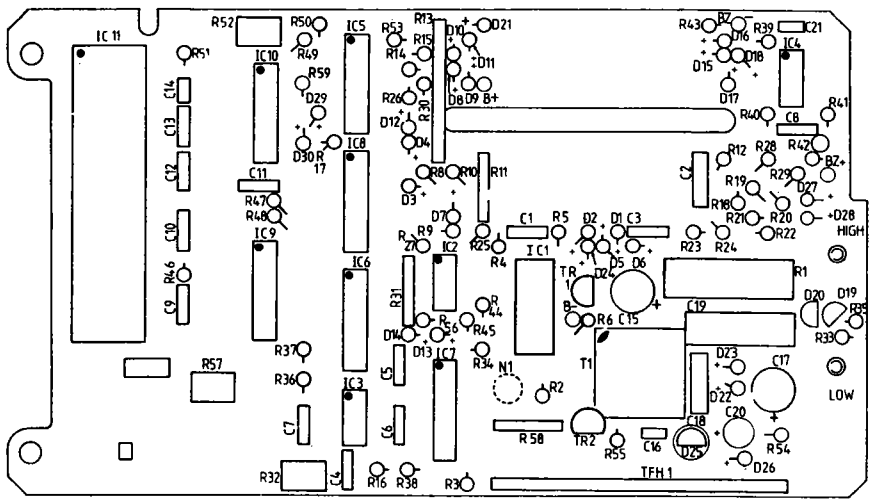

Fig. 6 The printed circuit board

WARRANTY AND REPAIR

WARRANTY

All products supplied by BIDDLE Instruments are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warranty is void in the event of abuse.

REPAIRS

BIDDLE Instruments maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend it be returned to the factory for repair by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

PARTS LIST

R1	Resistor	180kΩ ±2%	2W
R2	Resistor	1 MΩ ±5%	¼W
R3	Resistor	82kΩ ±5%	¼W
R4	Resistor	510kΩ ±2%	¼W
R5	Resistor	240kΩ ±2%	¼W
R6	Resistor	2,2kΩ ±5%	¼W
R8	Resistor	82kΩ ±5%	¼W
R9	Resistor	82kΩ ±5%	¼W
R10	Resistor	1kΩ ±5%	¼W
R11	Posistor	1kΩ 500V	
R12	Resistor	1 MΩ ±0,5%	50 ppm
R13	Resistor	9 MΩ ±0,5%	50 ppm
R14	Resistor	2kΩ ±0,25%	50 ppm
R15	Resistor	2,2kΩ ±0,25%	50 ppm
R16	Resistor	1 MΩ ±5%	¼W
R17	Resistor	1 MΩ ±5%	¼W
R18	Resistor	20kΩ ±0,25%	50 ppm
R19	Resistor	100kΩ ±0,25%	50 ppm
R20	Resistor	100Ω ±0,25%	50 ppm
R21	Resistor	560kΩ ±5%	¼W
R22	Resistor	4,32kΩ ±0,25%	50 ppm
R23	Resistor	560kΩ ±5%	¼W
R24	Resistor	480Ω ±0,25%	50 ppm
R25	Resistor	560kΩ ±5%	¼W
R26	Resistor	1 MΩ ±5%	¼W
R27 to R29	Resistor	560kΩ ±5%	¼W
R30	Resistor	1 MΩ ±5%	¼W
R31	Resistor	100 MΩ ±5%	¼W
R32	Potentiometer	22kΩ ±20%	½W
R33	Resistor	560kΩ ±5%	¼W
R34	Resistor	330kΩ ±5%	¼W
R35	Resistor	100kΩ ±5%	¼W
R36	Resistor	180kΩ ±0,25%	50 ppm
R37	Resistor	43kΩ ±0,25%	50 ppm
R38	Resistor	3,3 MΩ ±5%	¼W
R39	Resistor	1 MΩ ±5%	¼W
R40	Resistor	1 MΩ ±5%	¼W
R41	Resistor	220kΩ ±5%	¼W
R42	Resistor	1 MΩ ±5%	¼W
R43	Resistor	1 MΩ ±5%	¼W
R44	Resistor	100kΩ ±5%	¼W
R45	Resistor	82kΩ ±5%	¼W
R46	Resistor	47kΩ ±5%	¼W
R47 to R50	Resistor	330kΩ ±5%	¼W
R51	Resistor	100kΩ ±5%	¼W
R52	Potentiometer	4,7kΩ ±20%	½W
R53	Resistor	45,5kΩ ±0,25%	50 ppm
R54	Resistor	20 MΩ ±5%	½W
R55	Resistor	4,3kΩ ±2%	½W

PARTS LIST

R56	Resistor	200kΩ ± 1%	50 ppm	
R57	Potentiometer	22kΩ ± 20%	½ W	
R58	Posistor	1kΩ 500V		
R59	Resistor	1MΩ ± 5%	¼W	
C1	Capacitor	0,1 µF ± 10%	63V	
C2	Capacitor	0,1 µF ± 20%	250V	
C3 to C6	Capacitor	0,022 µF ± 20%	63V	
C7	Capacitor	0,01 µF ± 20%	63V	
C8	Capacitor	2,2 nF ± 20%	100V	
C9	Capacitor	0,22 µF ± 10%	63V	
C10	Capacitor	0,47 µF ± 20%	63V	
C11	Capacitor	0,022 µF ± 20%	63V	
C12	Capacitor	0,1 µF ± 10%	63V	
C13	Capacitor	0,022 µF ± 20%	63V	
C14	Capacitor	0,1 nF ± 2%	63V	
C15	Capacitor	220 µF 16V	electrolytic	
C16	Capacitor	330 pF ± 2%	63V	
C17	Capacitor	220 µF 16V	electrolytic	
C18	Capacitor	4,7 nF 500V		
C19	Capacitor	0,068 µF 630V		
C20	Capacitor	4,7 µF 40V	electrolytic	
C21	Capacitor	0,1 nF ± 2%	63V	
D1 to D6	Diode	1N4148		
D7	Diode	1N4007		
D8 to D18	Diode	1N4148		
D19	Diode	J PAD 50		
D20	Diode	J PAD 50		
D21	Diode	1N4148		
D22	Diode	BY207		
D23	Diode	BY207		
D24	Diode	1N4148		
D25	Zener diode	ICL8069DCZR		
D26 to D28	Zener diode	BZX79C12V		
D29	Diode	1N4148		
D30	Diode	1N4148		
TR1	Transistor	VN10KM		
TR2	Transistor	VN10KM		
IC1	Integrated circuit	MC14541		
IC2	Integrated circuit	TL062CP		
IC3	Integrated circuit	LF355N		
IC4	Integrated circuit	TL062CP		
IC5 to IC8	Integrated circuit	MC14066		
IC9	Integrated circuit	MC14070		
IC10	Integrated circuit	MC14070		
IC11	Integrated circuit	ICL7106		

PARTS LIST

TFH1	Thick film hybrid	part no. 6180-203
T1	Transformer assembly	part no. 6131-398
N1	Neon	part no. 25515-677

RECOMMENDED SPARES LIST

	Part no.
Front cover assembly	6430-170
Rear cover assembly	6331-264
Battery cover assembly	6131-333
Printed circuit board assembly	6430-172
Contact carrier assembly	6231-094
Wound bobbin assembly	6131-399

ACCESSORIES

Supplied with the Instrument:
Lead set including prods and clips,
Cat. No. ~~210970~~. 210980

Supplied at Extra Cost:
Carrying case, Cat. No. 210835.

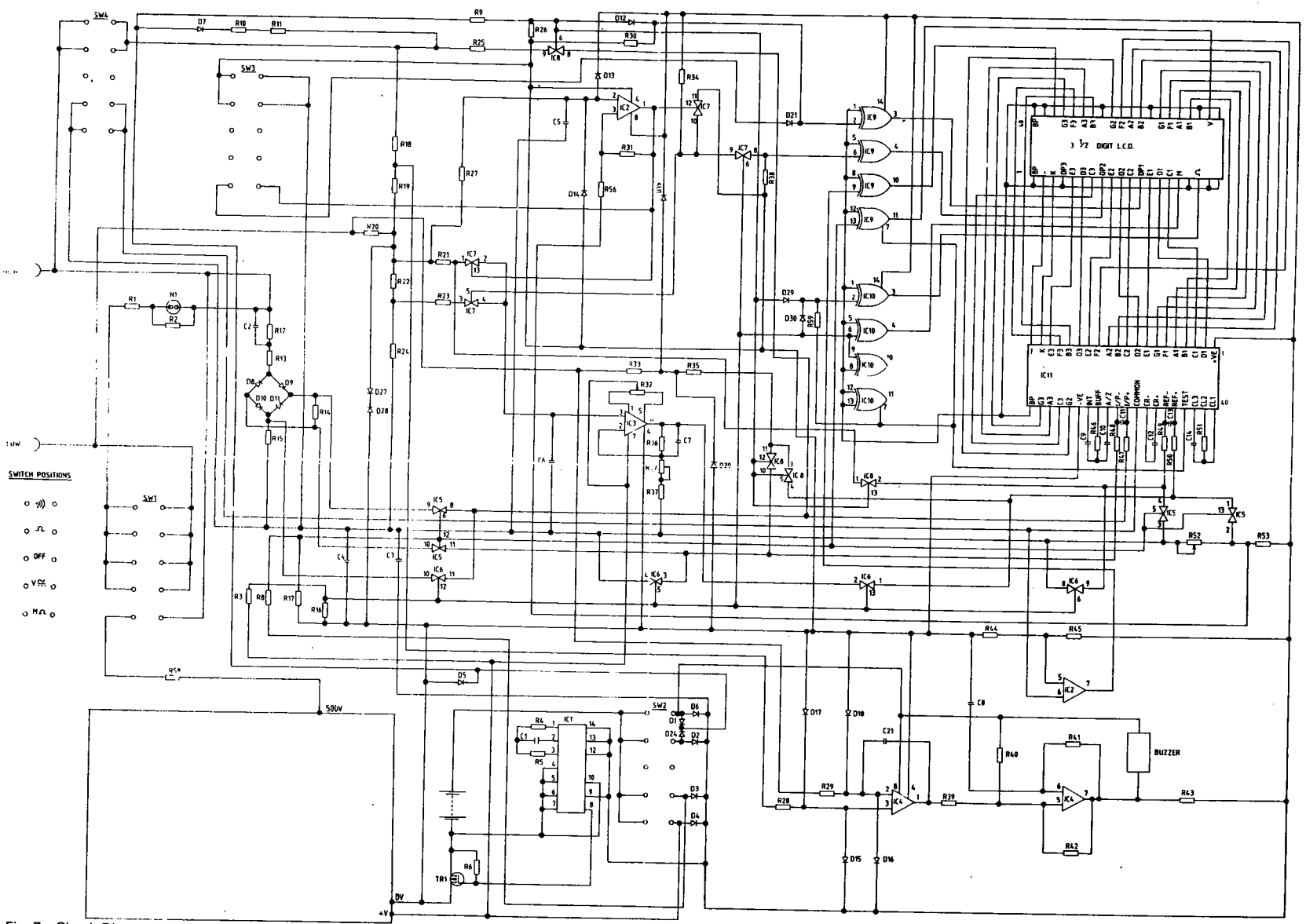

Fig. 7 Circuit Diagram for Cat. No. 210900