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2/93 IFS

# *Instruction Manual*
# *AVTM21-83J*

## *For the*
## *Battery Megger® Insulation Tester*
## *Catalog Numbers 210800-3 & 210801-3*

## *BM100/3 BM101/3*

## SAFETY IN THE USE OF ELECTRICAL EQUIPMENT

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

- Safety is the responsibility of the user
- La Sequridad es el cargo del operador

While every effort is made by responsible manufacturers to reduce the hazard, it still rests with the user to play his part inensuring 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.
- Ensure 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.



## CONTENTS

## GENERAL DESCRIPTION

The 210800-3 and 210801-3 are hand-held insulation testers incorporating resistance and continuity ranges. The 210800-3 can also indicate ac voltage up to 600V. The 210800-3 and 210801-3 test insulation at 500 V d.c (normal).

Each tester has a 250 μA moving coil meter with a black scale plate, white calibrations and an orange pointer. The test leads connect to fully shrouded terminal sockets at the top of the case. The test lead set includes prods and clips. The insulation, resistance or continuity functions are selected by a single switch and a test is initiated by pressing the 'Test' push-button. The condition of the internal battery can also be checked. The 210800-3 acts as a voltmeter with the switch in any position and the 'Test' push-button **not** pressed. Therefore an immediate indication can begiven of whether a circuit is energized or not as soon as the test leads are connected. Capacitive circuits are automatically discharged after insulation tests.

The case is fitted with a fold-away support stand and non-slip rubber feet.

The instructions given in this book are common to both of the testers except where stated.

Note:— (i) Each tester is protected against 500 V a.c. on all resistance ranges.

(ii) The window covering the meter of this instrument has been given an antistatic treatment which should be effective for many months. If in the course of time the cover is found to retain electrostatic charges, it should be re-treated with a suitable antistatic solution.



## APPLICATIONS

These insulation testers are intended for installation and maintenance work on domestic and industrial wiring systems, transformers, motor windings, electrical appliances etc. They are for use on electrical systems rated for up to 300 V a.c.r.m.s. to ground (500 V a.c. phase to phase).

## ACCESSORIES

### SUPPLIED WITH THE INSTRUMENT

A test lead set including prods and clips

An operating instruction book.

## SPECIFICATION

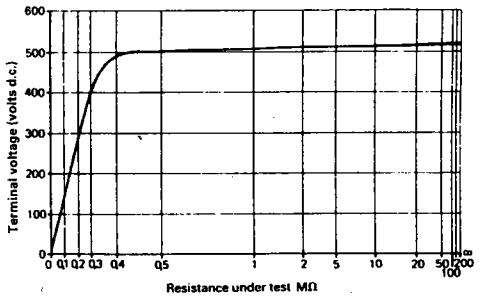
| **Model:—** | | **210800-3** | **210801-3** |
|---|---|---|---|
| **Insulation Test Voltage** | | 500V d.c. | 500 V d.c. |
| **Ranges** | Insulation resistance | 0—200M Ω | 0—200M Ω |
| | Resistance | — | 0—1M Ω |
| | Continity (i) | 0—200 Ω | 0—200 Ω |
| | (ii) | 0—2 Ω | 0-2 Ω |
| | Volatge | 0—600 V a.c. | — |
| **Terminal Voltage d.c.** (on o/c) | | | |
| | Insulation resistance range | <600V (>500 V at 0.5 M ) | <600V (>500 V at 0.5 M ) |
| | Resistance range | — | 53V (nominal) |
| | Continuity ranges (i) | 0.76V (nominal) | 0.76 V (nominal) |
| | (ii) | 1.6 V (nomonal) | 1.6 V (nominal) |
| **Terminal Current** (nominal on s/c) | | | |
| | Insulation Range | 1.6 mA | 1.6 mA |
| | Resistance range | — | 325 µA |
| | Continuity ranges (i) | 12.3 mA | 12.3 mA |
| | (ii) | 26 mA | 26 mA |
| **All Models:—** | | | |
| **Accuracy** (at 20°C) | | ± 2.5% of scale length on all ranges (i.e.±1.9 mm (0.075 in) on insulation resistance range). | |



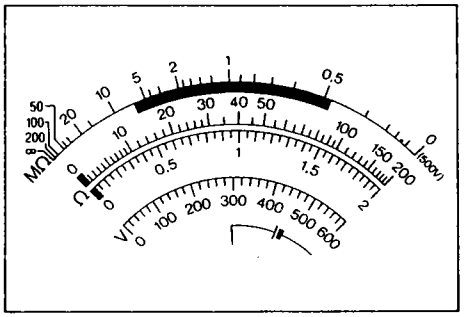
| | | |
|---|---|---|
| **Movement** | | 250 µAf.s.d. |
| **Discharge** | | Automatic discharge of capacitive circuits via an internal resistor (<500K ) when 'Test' push-button is released following an insulation test. |
| **Voltmeter Input Impedance** | | 210800-3 only. 330kΩ |
| **Temperature Range** | operation | -5°C to +40°C |
| **Temperature Coefficient** | | ±0.1%/ °C |
| **Humidity** | operation | 90%R.H. max. at 20° C<br>80% R.H. max. at 35° C |
| | storage | 95% R.H. max. at 35° C |
| **Fuses** | | 500mA 250V ceramic HBC type F, 20 mm x 5mm, IEC 127/1 2 A 500V ceramic HBC type F, 32 mm x 6 mm, 50k A breaking capacity |
| **Power Supply** | | Single 9V battery IEC 6 LR 61 type e.g. Duracell MN1604. Current consumption: 110 mA max. on insulation range, 40 mA max. on resistance and continuity ranges.<br>Battery life: more than 2000 X 5s operations in accordance with VDE 0413 Part 1 (clause 6.12). |
| **Safety** | | The instruments will, in general, meet the requirements of the IEC 1010-1 (1990) safety specification. Safety Class II. Rated impulse withstand voltage 4 kV. These instruments have been designed for use on high energey systems with phase to ground voltages not exceeding 300Va.c. and with phase to phase voltages not exceeding 500 Va.c. |
| **Dimensions** | | 175 mm x 95 mm x 57 mm (6 7/8 in x 3 3/4 in x 2 1/4 in approx.) |
| **Weight** | | 485 g (1 lb 1 oz) approx |

## SPECIFICATION

### Typical Terminal Voltage Characteristic 210800-3 and 210801-3

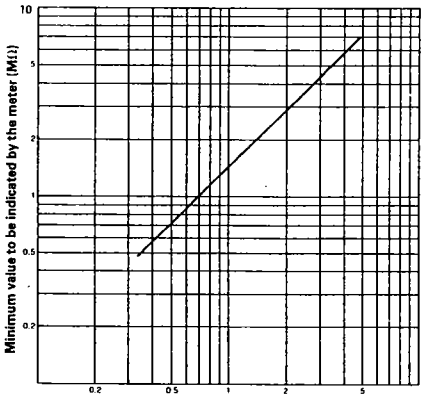



### Typical 210800-3 Scale (210801-3 scale is similar)






### Minimal Values — Insulation Resistance Range




The VDE 0413 part 1 specification stipulates that these instructions should contain a diagram showing the minimum value which the instrument must indicate in certain conditions. An insulation test being performed on any item of equipment would normally be carried out to a particular specification for that type of equipment. Therefore, even at the instrument's worst accuracy (over the marked part of the scale) the reading indicated should be such that the actual value is never below the limiting value required by the particular specification in question.

The graph opposite shows the maximum value which shall be indicated by the instruments (at their maximum error) to ensure that the limiting value of the insulation resistance given in the relevant equipment specification is met.

# OPERATION

## WARNING

1. **THE CIRCUIT UNDER TEST MUST BE SWITCHED OFF, DE-ENERGIZED AND ISOLATED BEFORE INSULATION, RESISTANCE OR CONTINUITY TESTS ARE MADE.**

   **Switch the circuit off and check that it is so by making a voltage test. The 210800-3 will automatically indicate any a.c. voltage present as soon as the test leads are connected. If this does happen, do not press the 'Test' button.**
2. **Voltage measurements may be made with the 210800-3 tester. Take great care when the system voltage is greater than 50V.**
3. **Where capacitive circuits have been tested allow a suitable time to elapse before disconnecting the test leads in order for the circuit to discharge.**
4. **All measuring ranges of the instrument are protected by a 2 A 500 V fuse. Additionally the 2 Ω and 200 Ω continuity ranges are protected by a 500 mA 250 V user-replaceable fuse. Replacement fuses MUST be of the correct type and rating(see the specification).**
5. **In order to satisfy the requirements for the protection of the user in IEC 1010-1 (1990), the following points should be noted.—**
   **(I) A 500 V rated fuse has been fitted in the instrument's input circuit to provide protection against the risk of fire should the instrument be connected to a high energy source producing up to 500 V between the terminals. Adequate protection must be ensured if voltages in excess of 500 V are to be encountered.**
   **(II) The instrument has been designed to withstand 4 k V impulse voltages between the terminals and also with respect to ground. It must not therefore be used on high energy systems with phase to ground voltages exceeding 300 V or phase to phase voltages exceeding 500 V.**



## PRECAUTIONS

1. Instruments used in dusty environments should be stripped and cleaned periodically. (Refer to the Service and Maintenance section page 16 and the Instrument Repairs and Spare Parts section page 23).
2. Do not leave the meter exposed to direct heat from the sun for long periods.

## PRELIMINARY PROCEDURE

**(a) Fitting a battery or 500 mA fuse**
Ensure that the instrument is not connected to any external circuit. Remove the battery and fuse compartment cover from the rear of the case by releasing the screw in the center and prying upwards. The battery and fuse compartment will be exposed. Observe the correct polarity as shown on the holder when replacing the battery. Replace the cover.

**(b) Checking battery condition**
Set the selector switch to and press the 'Test' push-button. The meter pointer should deflect to within the 'battery check' arc on the scale.

Note:— It is advisable to remove the battery if the tester is not to be used for any length of time. Never leave discharged batteries in the tester because of the possibility of causing damage by leaking electrolyte

**(c) Setting the meter mechanical zero**
With the tester horizontal set the meter pointer to zero (oo on insulation range) if necessary, using the mechanical adjuster located centrally on the front panel.

**(d) Connecting and checking the test leads**
Connect the red and black test leads, terminated with the appropriate prods, or clips, to the '+' and '-' terminal sockets respectively. Inspect the test leads to see that they have good, unbroken insulation. Connect the test lead prods or clips together and set the selector switch to '2 Ω'. Press the 'Test' push-button and check that the meter reads 0. If a high resistance reading is obtained or one greater then full scale, check the connections. If the reading is still high suspect that the test leads may be at fault.

## INSULATION TESTS

The red test lead is connected to ground, frame of the equipment or cable sheath etc. and the black test lead

## OPERATION

is connected to the circuit under test or cable core. With the selector switch set to '200 MΩ ' and the 'Test' push-button pressed, the insulation resistance can be read from the top meter scale after the pointer has become steady.

Capacitive circuits automatically discharge through the tester when the 'Test' push-button is released. Therefore, wait a few moments before disconnecting the test leads to allow this to happen. The suggested time to allow for discharge of capacitance is 1.5 seconds per microfarad. The 210800-3 automatically monitor the discharge on its voltage range, thus showing when it is safe to remove the test leads. Be aware that dielectric absorption may take place during an insulation test on a capacitive item allowing the voltage across the item to rise after the test leads have been removed.

### RESISTANCE AND CONTINUITY TESTS

The test leads are connected across the circuit under test and the selector switch set to the required resistance or continuity range.When the 'Test' push-button is pressed the resistance is indicated on the appropriate meter scale. There is a separate scale for each range so the readings are direct. Release the push-button and remove the test leads.

### A.C. VOLTAGE INDICATOR (210800-3)

The voltage range is automatically selected when the switch is in any position and the 'Test' push-button not pressed. Connect the test leads across the circuit under test. The tester will indicate if the circuit is energized, and the level of the voltage present(up to 600 V a.c.) will be shown on the inner scale.

### FUSE CHECK

With the test leads open circuit, switch to the 200 Ω range and press the 'Test' push-button. A reading of < 200 Ω indicates a ruptured 500 mA fuse.

Note:— The fuse is located in clips in the battery and fuse compartment at the rear of the case.

An additional 2 A 500 V fuse is fitted for overall safety protection. This fuse is not replaceable by the user. If there is no response from the meter to an insulation test with the leads shorted together, this fuse may have ruptured. The instrument must be returned to the manufacturer or one of his approved agents for repair.



## USING THE INSULATOR TESTER

### DESIRABILITY OF INSULATION TESTING

The safety of electrical installations and apparatus depends on the condition of the insulation. It is essential that this is thoroughly checked when new equipment is installed, while being subjected to a voltage high enough to break through any mechanical flaws arising from manufacture or installation.

It is also desirable, in order to avoid interruptions or breakdowns, that tests on the condition of the installation and equipment are made from time to time to ensure that deterioration is not occurring because of the accumulation of dirt or moisture, or caused by mechanical factors of wear or breakage.

In every case the insulation resistance can be measured very simply by using the MEGGER® Tester.

### PREVENTIVE MAINTENANCE

It is good practice to make regular tests of the insulation resistance of all larger machinery and thus detect any incipient faults. When the tests are entered in the logbook a considerable variation between test results will be noted.

It is therefore important to test under similar conditions each time and to note the current weather status.

Damp weather—or damp conditions of use or storage—can cause large reductions in insulation resistance. Drying out by heat or by running for a period, should give a more consistent and appropriate insulation resistance value.

A counter effect to that above occurs because the insulation resistance of the varnishes used in the construction of machine windings becomes lower when hot than when cold. Thus for constant comparisons the temperature of the machine under test should also be noted.

The best plan is regularly to make the time for testing a machine as soon as possible after it has been shut down. The insulation resistance is then likely to be at its lowest operational value. This then would become the figure which would show any continuing mechanical depreciation or potential insulation breakdown.

If the machine stands idle in humid conditions a worse picture might well apply but this would normally be assumed to be safe during the running up to temperature, provided that the resistance at working temperature remained unchanged.

## USING THE INSULATION TESTER

### TESTING MOTORS AND GENERATORS

1. Disconnect the equipment from the supply by opening the main switch and removing the main fuses.
2. Join together BOTH terminals on the motor side of the double pole main switch.
3. With a contactor operated starter where all the lines to the motor are disconnected at 'off' it is necessary to make tests to ground on both the incoming and outgoing terminals of the starter.
4. Connect the red test lead to ground using the frame of the motor.
5. Using the black test lead measure the resistance of each part of the circuit in the usual way. If the value is unsatisfactory then separate tests in starter, motor and cables must be carried out to locate the defect.
6. If the motor itself is suspect, disconnect its supply cables and with one lead connected to the frame carry out the following tests:
7. Test with the armature and field windings connected together.
8. Test with the brushes lifted from contact with the commutator.
9. Test on the armature only, section by section.
10. If all resistances are low the fault can usually be remedied by complete and careful cleaning of the machine. Equipment that has been in service for a period can accumulate metallic, or other conducting dust especially when mixed with oil from bearings etc. The leakage paths from such deposits are eliminated by thorough cleaning.



## CIRCUIT DESCRIPTION

### INSULATION TEST RANGES

An inverter provides a stable 500 V test voltage for the 200 M Ω range. The circuit is arranged so that the pointer gives a slight 'kick' before settling back to a steady reading. This is noticeable only above about 100 M Ω and is included to show that the instrument is functioning correctly when measuring resistances corresponding to small deflections of the pointer.
A 470 k Ω resistor is connected automatically between the positive and negative test terminals on releasing the 'Test' button, to allow for capacitive circuits to discharge.

### VOLTAGE RANGE (210800-3)

On any position with the 'Test' button not pressed, the instrument acts as a voltmeter, reading 0-600V a.c.

### CONTINUITY RANGES (2 Ω and 200 Ω)

The nominal test voltage on these ranges is 1.6 V for the 2 Ω range and 0.76V for the 200 Ω range. Overload protection is provided by a 500mA 250 V ceramic fuse type F. Changing the fuse will have no effect on the calibration of the ranges.

### RESISTANCE RANGES (210801-3)

The nominal test voltage is 53 V. Protection against overload is provided by a positive temperature coefficient (PTC) thermistor.

### BATTERY CHECK

In the battery check position the instrument functions as a voltmeter of approx. 12 V f.s.d. (6 V mid-scale). The battery is rejected if its voltage is less than 6.4 V. During this test the battery is drawing approx. 110mA, so the 'Test' button should not be pressed longer than necessary to make the check.

## SERVICE AND MAINTENANCE

In order for any servicing and maintenance work to be carried out on the instrument it must be opened up. NOTE: THIS WILL AUTOMATICALLY INVALIDATE ANY WARRANTY COVERING THE INSTRUMENT.

**It is important that any servicing or repair work is carried out by a suitably qualified instrument technician who is aware that high voltage is present at various points on the p.c.b. when the circuit is energized.**

Caution:—The instrument circuit contains static sensitive devices. If the instrument casing is opened for any reason, care must be exercised in handling the printed circuit board. This should be done in accordance with DFE STAN 59-98 and BS 5783, specifications for handling electrostatic sensitive devices.

### OPENING THE TESTER

The tester 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.

1) Lay the tester face down on the work bench.
2) Remove the battery and fuse compartment cover plate. Release the screw in the center and then lift up and towards the top of the tester until the cover is completely free. Do not lose the spare fuse which is attached to the inside of the cover.
   Note:—The tester stand is not fixed in place once the cover has been removed. Be careful that it is not lost.
3) Remove the battery.
4) Release the four cross-head screws,one in each corner of the rear cover.
5) Lift the rear cover assembly vertically off the tester.
6) Lift off the protection screen around the edge of the p.c.b.
7) The printed circuit board and components are now exposed so that test measurements and settings can be made.

### REMOVING THE PRINTED CIRCUIT BOARD

If it is necessary to unsolder components, service the selector switch or push-button or remove the movement, the printed circuit board must be taken out.

1) Unclip the red and black wires connecting the meter to the board, at the board end.
2) The push-button prevents the board from being lifted straight out. Therefore hold the front cover assembly



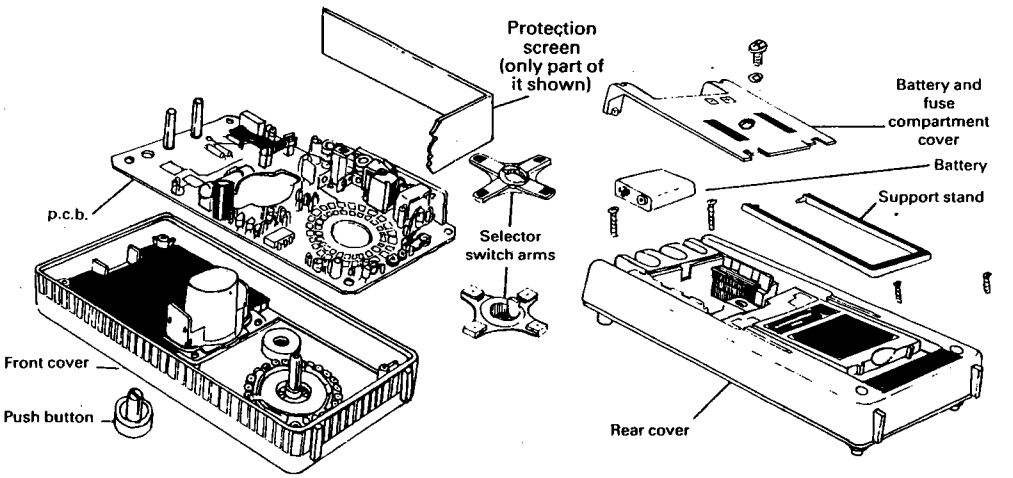



Fig. 1 The tester dis-assembled (detail not authentic)

in one hand and grip the push-button S2 with the other. Pull firmly until the button is released from the switch, (take care that it is not lost), then continue to lift until the selector switch mechanism separates from its knob.

3) The removal of the selector switch arms from the board should not normally be necessary. However, to achieve this, hold the rear switch arm moulding still and rotate the front one until they spring apart. (The two sections are identical and interchangeable).

Note:—The contacts are retained and will not drop out. To replace the selector switch arms, position them either side of the board and line up the tab on one with the recess on the other. Push together and turn counter-clockwise until locked.

## RE-ASSEMBLY

The tester is re-assembled by performing the dismantling operations in the reverse order. When replacing the p.c.b. in the front cover assembly, ensure that the slots in the selector switch mouldings line up with the 'keys' on the knob tab. Ensure that the parts are properly in place before securing the screws. It is most important that the protection screen is replaced correctly. The battery must be fitted properly, therefore observe the correct polarity as indicated in the battery compartment.

## CALIBRATION

Refer to the circuit diagram and to fig. 2 to find the positions of the adjustment potentiometers. There is no adjustment of the battery check function nor of the 210800-3 a.c. voltage range.

Open up the tester as described in 'Opening the Tester' and connect a 9 V battery (IEC 6 LR 61type) to the circuit. This may be done using short leads with crocodile clips, for convenience. The positive being connected to the leg of R18 and the negative to the pin from which a lead connects to the push-button switch.

### Setting the 2 Ω range

1) Set potentiometers R7 and R19 to their mid-positions.
2) Connect the test leads to the instrument terminals and join their ends together.
3) Press the push-button and adjust R19 to give a reading of zero.



4) Connect the test leads to a known 2 Ω ±0.5% resistor.
5) Press the push-button and adjust R7 to give a reading of 2 Ω on the '2 Ω scale'.
6) Because the adjustments of R7 and R19 could be interactive the setting procedure may need to be repeated until the required accuracy is obtained.

Note:— It is necessary to ensure a good connection between the test lead clips and the resistor terminals in order to keep contact resistance as low as possible.

### Setting the 200 Ω range

1) Connect the test leads to a known 200 Ω ±0.3% resistor
2) Press the push-button and adjust R8 to give a reading of 200 Ω on the '200 Ω scale'.

### Setting the insulation resistance range

1) Set R25 fully counter-clockwise and connect the test leads to a 0.5M Ω 0.3% resistor
2) Press the push-button and adjust R26 for 505V ±3V.
3) With the push-button pressed adjust R20 to give a reading of 0.5M.
4) Short the test leads together, press the push-button and adjust R15 to give a reading of zero.
5) Connect the test leads to a 0.3 MΩ ±0.3% resistor.
6) Adjust R25 to give a reading of 0.3MΩ.
7) Check that the voltage at 100MΩ is 600V.
8) Check that the short circuit current is 1.6mA ±400 μA.
9) Because the adjustments of R15, R20, R25 and R26 could be interactive the setting procedure may need to be repeated until the required accuracy is obtained.

Note:— All the resistors used must be able to withstand the voltage applied to them.

### Setting the 1 M Ω range (210801-3)

1) Connect the test leads to a known 1M Ω ±0.3% resistor.
2) Press the push-button and adjust R28 to give a reading of 1M Ω on the '1M Ω scale'.

Having set all the potentiometers the calibration of all the scale points may be checked against the specification using appropriate value resistors or resistance boxes. Following the setting-up and calibration checks, the potentiometers should be locked in place using a suitable varnish, and the tester re-assembled.

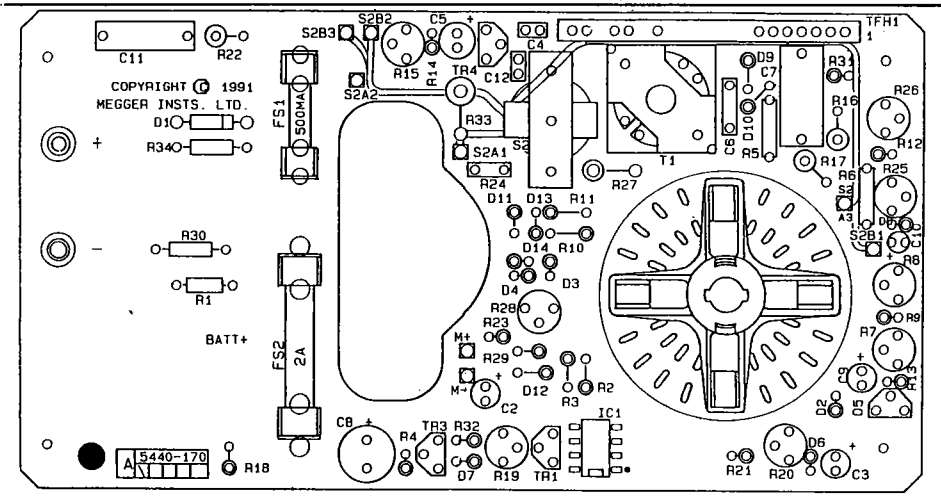



Fig. 2 The printed circuit board



## CLEANING THE TESTER

A mild solution of detergent in water is recommended for cleaning the instrument case. Wipe the exterior surface with a moistened cloth taking particular care not to scratch the meter cover. This has been given an antistatic treatment.

## CARE OF THE BATTERY

If the tester is not in regular use, the condition of the battery should be checked periodically. Preferably the battery should be removed and stored separately, to avoid possible damage caused by leaking electrolyte.

Notes referring to fig.2 page 20:—
R24—on 210800-3 only
R27—on 210801-3 only
R28—on 210801-3 only
R29—on 210801-3 only
D11—on 210800-3 only
D13—on 210800-3 only
TR2—not used

## WARRANTY AND REPAIRS

### 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 or failure by the customer to perform specified maintenance as indicated in the manual.

### REPAIRS

Biddle Instruments maintains a complete instrument repair service. Should this instrument ever require repairs, we recommend that 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

(Components are common to both instruments except where stated)

| | | | | |
|---|---|---|---|---|
| R1 | Resistor | 91Ω | ±1% | 1/4W |
| R2 | Resistor | 100Ω | ±1% | 1/4W |
| R3 | Resistor | 47Ω | ±5% | 1/4W |
| R4 | Resistor | 3.65kΩ | ±1% | 1/4W |
| R5 | Posistor | 10kΩ | | |
| R6 | Posistor | 10kΩ | | |
| R7 | Potentiometer | 200Ω | ±20% | 1/2W |
| R8 | Potentiometer | 1kΩ | ±20% | 1/2W |
| R9 | Resistor | 1.5kΩ | ±1% | 1/4W |
| R10 | Resistor | 47kΩ | ±1% | 1/4W |
| R11 | Resistor | 68Ω | ±2% | 1/4W |
| R12 | Resistor | 2kΩ | ±1% | 1/4W |
| R13 | Resistor | 82,5kΩ | ±1% | 1/2W |
| R14 | Resistor | 1kΩ | ±1% | 1/4W |
| R15 | Resistor | 1kΩ | ±0% | 1/2W |
| R16 | Resistor | 18MΩ | ±5% | 1/2W |
| R17 | Resistor | 20MΩ | ±5% | 1/2W |
| R18 | Resistor | 3,32kΩ | ±1% | 1/4W |
| R19 | Potentiometer | 5kΩ | ±20% | 1/2W |
| R20 | Potentiometer | 5kΩ | ±20% | 1/2W |
| R21 | Resistor | 15kΩ | ±1% | 1/4W |
| R22 | Resistor | 100kΩ | ±20% | 1/2W |
| R23 | Resistor | 4.3kΩ | ±1% | 1/4W |
| R24 | Resistor | 1.08MΩ | ±1% | 1/2W 210800-3 only |
| R25 | Potentiometer | 50kΩ | ±20% | 1/2W |
| R26 | Potentiometer | 1MΩ | ±20% | 1/2W |
| R27 | Resistor | 1MΩ | ±5% | 1/2W 210801-3 only |
| R28 | Potentiometer | 1MΩ | ±20% | 1/2W 210801-3 only |
| R29 | Resistor | 180kΩ | ±5% | 1/4W 210801-3 only |
| R30 | Resistor | 0.39Ω | ±5% | 1/2W |
| R31 | Resistor | 100kΩ | ±1% | 1/4W |
| R32 | Resistor | 4.3Ω | ±1% | 1/4W |
| R33 | Resistor | 470k | ±10% | 1 W |
| R34 | Resistor | 62Ω | ±2% | 1/2W |
| C2 | Capacitor | 10 µF | 35v | electrolytic |
| C3 | Capacitor | 10 µF | 35V | electrolytic |
| C4 | Capacitor | 150pF | ±2% | 100V |
| C5 | Capacitor | 47 µF | 25V | electrolytic |
| C6 | Capacitor | 4.7nF | 400V | |
| C7 | Capacitor | 68 FΩ | 630V | |
| C8 | Capacitor | 470 µF | 16V | electrolytic |
| C9 | Capacitor | 10 µF | 35V | electrolytic |
| C10 | Capacitor | 4,7 µF | 25V | tantalum |
| C11 | Capacitor | 15nF | ±20% | 1000V |
| C12 | Capacitor | 150pF | ±2% | 100V |

## PARTS LIST

| | | | |
|---|---|---|---|
| D1 | Zener diode | 1N5337B | |
| D2 | Zener diode | BZX79C15 | |
| D3 | Diode | 1N4148 | |
| D4 | Diode | BZV46C2V0 | |
| D5 | Band gap diode | ICL8069DCZR | |
| D6 | Diode | 1N4148 | |
| D7 | Zener diode | BZV46C2V0 | |
| D8 | Zener diode | BZX79C30 | |
| D9 | Diode | BA159 | |
| D10 | Diode | BA159 | |
| D11 | Diode | 1N4148 | 210800-3 only |
| D12 | Diode | 1N4148 | |
| D13 | Diode | 1N4148 | 210800-3 only |
| IC1 | Integrated circuit | TLC271ACP | |
| TR1 | Transistor | BC183 | |
| TR3 | Transistor | BC213 | |
| TR4 | Transistor | VN10KM | |
| TFH1 | Thick film hybrid | | |
| T1 | Transformer assembly | | |
| FS1 | Fuse | 500mA ceramic | |
| FS2 | Fuse | 2 A ceramic | |
| SW2 | Switch | | |



## CIRCUIT DIAGRAM