609 D.C. CURRENT

CALIBRATOR

TECHNICAL MANUAL

609 TECHNICAL MANUAL

All Time Electronics' instruments are subject to continuous development and improvement and in consequence may incorporate minor detail changes from the information contained herein.

609 D.C. CURRENT CALIBRATOR

AND

609N D.C. CURRENT SOURCE

WITH NULL MEASURING FACILITY

The 609 incorporates several novel circuit design features for which patents have been applied.

TIME ELECTRONICS LTD.

BOTANY INDUSTRIAL ESTATE, TONBRIDGE, KENT, ENGLAND.

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609 TECHNICAL MANUAL CONTENTS

4. REPAIR AND RECALIBRATION

5.CIRCUIT AND LAYOUT DIAGRAMS

SECTION 1

GENERAL DESCRIPTION & SPECIFICATIONS

1.1. GENERAL DESCRIPTION.

The 609N is a precision D.C. current source suitable for calibration and test applications from nanoamp levels up to 100mA. The maximum output can be extended to 1 amp by an optional unit which is mains powered and operates externally to the 609N.

The 609N is a solid state battery powered instrument which is easily portable and convenient for laboratory, field or industrial use. It incorporates many of the well proven features of the Time Electronics Type 2003 D.C. Voltage Calibrator.

The null balance system enables the 609N to be used for making accurate current measurement in addition to its basic function as a calibrator. Operation is by backing the current source output against the current being measured with the difference being displayed on a sensitive centre zero null meter.

The 609N enploys a precison aged reference diode as a basic reference source. Excellent zero stability is ensured by the use of a high performance FET chopper amplifier system. Precision metal film resistors with temperature coefficients of less than 10 ppm per ^{o}C are used to maintain the accuracy and stabiyity of the initial calibration.

The battery supply condition is monitored by a front panel indicator which also serves as a supply on-off display. A minimum line on the indicator shows when the batteries should be replaced or recharged.

1.2 SPECIFICATIONS.

Output :	0-100mA in 5 ranges. 0-99.999mA in 1uA steps. 0-9.9999mA in 100uA steps. 0-999.99uA in 10nA steps. 0-99.999uA in 1nA steps. 0-9.9999uA in 0.1nA steps.
Accuracy :	+/- 0.02% of setting, +/- 0.005% of range, +/- 0.2nA.

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Accuracy :	+/- 0.02% of setting, +/- 0.005% of range, +/- 0.2nA.

Voltage Capabitity :	15V with new batteries or mains power. (11V with minimum allowable battery level).
Regulation :	Load : Better tham 5ppm per Volt. Supply : Better than 5ppm per Volt.
Output polarity :	Positive of negative switch selected. A centre off position provides an open circuit on the output terminals.
Out of limit warning :	A front panel indicator provides a warning of insufficient drive voltage.
Output stability :	Less than 30 ppm per ^{o}C (0^{o}C to $+50^{o}$C). Less than 10 ppm per hour at constant temperature. Less than 75 ppm per 6 months.
Output noise :	100, 10 and 1mA ranges : less than 5ppm of full scale. 100 and 10uA ranges : less than 10 ppm of full scale +/- 0.1nA.
Null sensitivity :	Adjustable from +/- 25 mA to +/- 25uA FSD via front panel control. Maximum resolution is 0.5uA.
Power supply :	Time Electronics power unit type PU2 which is housed in the rear of the 609N. The PU2 will power the 609N direct from the mains or an internal rechargeable battery. The battery is automatically charged when mains power is connected. Alternatively an optional battery unit taking ten 1.5V U2 size cells may be fitted in place of the PU2. Access to the batteries is from the rear of the instrument.
Dimensions :	220 X 160 X 190 mm.
Weight :	3.3 Kg including batteries.

SECTION 2

OPERATING INSTRUCTIONS

Despite the precision nature of the 609 it does not require special operating conditions or procedures. Its robust construction and stable solid state circuitry enables it to be used in nearly all applications with only the normal operating precautions. The battery powered version housed in the carrying case is most suitable for field use.

2.1 FRONT PANEL

a) Output terminals:

The 609 output current is from two front panel terminals which are suitable for wire compression or 4mm 'wander' plug insertion. The output current will flow from the + (red) terminal when the polarity switch is 'normal'.

b) Case terminal:

The case terminal is connected only to the instrument case and is isolated from the circuitry. The case provides an overall electrostatic screen for the 609 and can be earthed as required to improve rejection of noise pick-up.

c) Supply ON-OFF:

A miniature toggle switch interrupts the supply line to the circuitry. Indication of supply 'on' or 'off' condition is provided by the battery level indicator.

d) Output Polarity:

A change-over toggle switch enables the output current polarity to be reversed. A centre 'off' position provides an open circuit on the output terminals.

NOTE: Early versions (before Ser. No. 187) of the 609 have output polarity switches which when in the 'off' position cause the voltage limit indicator (see 2.1 h) to display. This performance is correct since it indicates that the 609 output circuitry is also looking into an open circuit. Later versions (after Ser. No.187) incorporates a modification which prevents the above - this is to prevent the user suspecting a fault condition.

e) Battery Level:

The battery (or mains power supply PU2) output is continuously monitored on a front panel indicator which also serves as a supply 'on-off' indication. A minimum mark indicates when the batteries need replacing or recharging.

f) Range:

One of the five output ranges can be selected.

g) Digit switches:

A 5-decade thumbwheel switch enables the output current level to be set with a resolution of 0.01% of full scale.

h) Voltage limit:

An L.E.D. indicator shows when the 609 is unable to supply sufficient drive voltage to maintain the set output current.

e.g. The 609's maximum drive voltage (voltage capability) is 15 Volts. This means that it is able to supply a current of 1mA into 15K ohms but NOT 1mA into 16K ohms. In the latter condition the voltage limit indicator would display.

The above is an example and applies similarly for any product of current and load resistance that exceeds 15 Volts. Non-resistive loads are still bound by the same output voltage limit with the indicator displaying when the voltage at the output terminals reaches about 15V.

NOTE:

When the 609 is operated from partly discharged batteries, the voltage limit is reduced to a minimum of about 10V for nearly fully exhausted cells.

The battery level indicator gives a clear indication of battery state.

i) Null meter

Scaled 0 to 25 for displaying the difference current when the 609N is used in the null mode.

j) Sensitivity control:

A continuously variable control for adjusting the null meter sensitivity, range of adjustment is from 25mA minimum (fully anticlockwise) to 25uA maximum (fully clockwise).

k) Source - null switch:

A two position toggle switch which selects the mode of operation. In the SOURCE position the 609N operates as a current source (same as a 609) while the null position allows measurement of current.

IMPORTANT NOTE:

Under no circumstances must an additional voltage be connected in series with the 609 output in an attempt to increase the voltage capability. This practice will cause damage to this 609's output circuitry.

Under certain conditions the voltage capability can be increased to a maximum of 50 volts. This requires special circuit modifications and is only applicable to certain ranges. Please consult Time Electronics (or their authorised dealer) for information.

2.2 OPERATING PROCEDURE AND PRECAUTIONS

a) Normal operation:

Operation of the 609 is self-explanatory from the front panel controls and specification. It is important to understand the 609's voltage capability and voltage limit indicator (2.1 h) to ensure that your requirement is within the limit. It is also important to read section 2.3 if your requirement is for current levels of less than a few tens of microamps.

When the 609 is operating from batteries and required to supply currents in excess of 10mA it is important to check the battery condition with the load connected since the battery's condition may be adequate for small output currents but not large ones.

Operation of the 609 in conjunction with the 1 AMP OUTPUT UNIT is described in section 2.5.

Measurement of an unknown current: (609N only)

1) Select 'NULL' position on the front panel function switch.

2) Select 'NORM' output.

3) Adjust 'SENS' for minimum sensitivity (fully anticlockwise).

4) Select range consistent with current to be measured.

5) Connect the unknown current to the terminals in the same polarity i.e. unknown current flows into the + Ve terminal.

6) Adjust digit switch and sensitivity control for null balance on meter as required.

7) When balance at required sensitivity is reached the unknown current is equal to the digit switch setting.

b) Overload conditions:

The 609 can withstand indefinitely either short or open circuit on the output terminals. Overload conditions can easily result if any attempt is made to drive current into the 609 by applying a voltage to the output terminals. In most cases this will cause the output fuse (ref. 2.5) to blow but can still cause damage to the output circuitry.

2.3 OUTPUT NOISE

a) Inherent Noise:

The electrical noise on the output current consists of chopper intermodulation, thermal noise and random variations. These are generated inside the 609 and originate from the active circuitry. At current levels of greater than about 1mA the noise fluctuations are those of the accurate voltage reference circuitry. These are similar in character and amplitude (as a % of the output) to the Time Electronics 2003 Voltage Calibrator - this is to be expected since the Voltage reference section of the 609 is almost identical to that of the 2003.

A typical 609 noise level at 1mA output is as shown in the typical stability graph given in the specification (section 1).

At currents below a few hundred microamps it becomes difficult to differentiate between the 609 inherent noise and picked-up noise (see section 2.3b).

b) Noise pick-up:

In addition to the inherent noise from the 609 circuitry the output can contain fluctuations which originate from outside sources.

As with voltage signals the effects of noise on current signals are usually measured as a fraction of the signal (in % or P.P.M.) and in general this fraction becomes larger as the signal level is reduced.

A good deal of care must be taken in attempting to understand the cause and effect of noise pick-up on precision current sources such as the 609 and it is not proposed that this manual should cover them in detail.

It is important when confronted with a problem of noise pick-up to stop and think logically about the cause and effect - a good deal of time can be wasted by indiscriminate screening and earthing!

This is particularly important when dealing with current signals since many of the effects are the exact opposite from those for voltage signals e.g. earthing one side of a voltage signal may reduce the noise pick-up but earthing the same side of a current signal may increase the pick-up. Before looking at possible sources of noise pick-up it is also important to consider the way in which the presence of noise is being detected.

being detected.

In many cases it will appear as an incorrect readout. Special care must be taken if additional equipment (such as an oscilloscope or DVM) is connected for the detection of noise - there is a possibility that this can introduce further noise.

Two of the more common causes of noise pick-up are discussed below. The actual level of pick-up cannot be predicted and will depend on a number of factors.

(i) 50-60 Hz Mains Supply: This is probably the largest single source of noise pick-up. The noise from this source can be divided roughly into two parts.

a) 50-60 Hz Signal pick-up and

b) transient signal pick-up.

a) is generally caused by the close proximity of unscreened mains cables or mains powered equipment. The effects of this type of noise can usually be considerably reduced by correct screening and earthing.

IMPORTANT NOTE;

When the 609 is operated from the mains using a PU2 power unit special attention should be paid to the possibility of noise pick-up occurring. Battery operation is recommended for applications requiring the lowest noise pick-up condition.

b) is generally caused by heavy load switching on the mains from equipment such as electric motors, electric ovens, etc. Its effect on the 609 is to cause a transient variation in the output which can last longer than the actual duration of the noise. This is because the 609 has been transiently overloaded and needs time to recover. The noise is often in the form of a burst of radio frequency energy which in addition to being carried in mains cables is also radiated into the atmosphere. It is often difficult to detect its presence due to its transient nature and short duration (down to a few 10's of microseconds). The effects of this sort of noise on radio and television reception are well known and a transistor radio is often a useful tool in locating the source of the noise.

This type of noise often covers a very wide spectrum of frequencies and the most effective solution is to locate its source and provide suitable filtering - such as conventional capacitor suppression on arcing contacts.

(ii) Common Mode Noise:

Additional noise and variation of the output current can be caused by large common mode voltages. These occur when the 609 is used to calibrate any input which is above ground potential or has an a.c. component with respect to ground.

The battery powered version of the 609 has inherently a very high d.c. common mode rejection, but it is not recommended under normal circumstances that 100V d.c. common mode be exceeded. The a.c. common mode rejection is determined by the capacitive unbalance to ground of the output terminals and associated connections.

2.4 POWER SUPPLIES

The power supply is located in the rear of the instrument by 4-2 B.A. screws.

To remove the supply, remove these screws and withdraw. The supply leads are connected by press studs.

The supply section of the instrument is divided from the rest of the circuitry by a plastic cover through which the supply leads are brought.

Two types of power supply are available a) Battery b) Mains - Rechargeable battery. They are interchangeable.

2.4a BATTERY UNIT

Access to the battery unit is via the rear of the instrument.

(i) Battery Replacement Procedure:

1) Remove the battery unit locating screws

2) Remove battery unit by extracting rearwards from the instrument (handle provided)

3) Disconnect press stud connectors

4) Replace the 10 cells, taking care to ensure that they seat correctly in the holders with the spring contacts centrally located on the cell bases, rotating the cells when they are in position helps to centralise the spring contact. It is easier to withdraw the 'stud' end of the cell end first when removing the cells, and when replacing them to compress the spring contact before inserting first the 'base end'.

NOTE: the spring contact always connects with the battery negative.

5) Reconnect the press stud connectors - ensure these are a tight fit, bend 'female' connectors slightly if necessary.

6) Replace battery unit in instrument.

(ii) Recommended Battery Types:

Any U2 size (60mm L,30mm D) cell can be used to power the instrument. It is recommended that the sealed type of battery be used in the instrument since leakage can cause corrosion of the battery unit contacts. The following are estimates of the operational life of one set of cells under typical laboratory usage (6 hrs/day) at current levels less than 10mA:
Mallory Manganese Alkaline Type No. MN1300 - approx. 12 weeks.

Ever Ready U2 (Zinc Carbon) : 6-8 weeks.

Nickel-Cadmium Rechargeable cells (without recharging) : 6-8 weeks

The Zinc-Carbon type of cell is probably the most economical type to use for the intermittent operation of the instrument. Manganese Alkaline cells are clearly best for long term performance and will outlast the Zinc-Carbon type in operation and shelf life by a factor of 3-4 times. Rechargeable cells may be attractive in some cases.

IMPORTANT NOTE:

It is strongly recommended that when Zinc-Carbon batteries are used they are replaced every six months irrespective of condition. This is because the limited shelf life of commercially available types is only 6-9 months and the risk of leakage is much greater after this period. A small percentage of the so-called LEAKPROOF cells have also been found to be unsatisfactory after long periods.

For this reason it is also important to ensure when replacing cells that they are ALL 'BRAND NEW'.

The above caution is not necessary with Manganese Alkaline or rechargeable types.

2.4b MAINS POWER UNIT PU2

(i) The PU2 incorporates a rechargeable Nickel-Cadmium battery and electronic charge control circuitry. The circuitry is arranged to enable the PU2 to provide power directly from the mains if the mains input is connected or alternatively from the rechargeable battery if mains is not connected.

When the mains is connected the charging circuitry provides the correct charge current (40-45mA) for the battery and automatically reduces this to a trickle rate (3-4mA) when the battery is fully charged. This means that it is impossible to overcharge the battery.

The D.C. performance is as follows:

With mains connected: D.C. Output 15.5-17V (0-100mA load)

With mains disconnected (& battery fully charged): D.C. Output 14.5-15.5V (0-100mA load).

Mains input range is 200-250V a.c. 40-60 Hz.

The capacity of the rechargeable battery is aproximately 450mA hrs. This allows about 40-50 hrs. continuous use of the 609 at output currents of less than 10mA. To fully recharge the battery requires 14-16 hrs. with mains connected.

Two fuses protect the PU2 from overload, the mains input fuse (on the rear panel) is a 20 mm size fuse, rated 1 amp. The d.c. output fuse, located on the P.C.B. before the output connectors is a 16 m.m. (5/8") size 00 fuse, rated 0.5 amp. Both are available from Time Electronics (see spare parts list) or from your local supplier. The fuse manufacturer is Belling Lee Ltd., 540 Great Cambridge Road, Enfield, Middlesex.

2.4c CONSTRUCTIONAL DETAILS PU2

The P.C.B. is located on the rear panel by 4 6BA screws and is spaced off approx. 10mm. A metal cover protects and screens the P.C.B. and components. The output connectors and output fuse are located outside the cover. The cover is fixed to the rear panel by 4 6BA screws. Circuit and layout diagrams are given in section 3.

IMPORTANT NOTE:

It is extremely important to take care when checking and dismantling a PU2. Even though disconnected from the mains, there is still sufficient power stored in the rechargeable battery to cause catastrophic damage to the electronic circuitry if inadvertent short circuits occur. These can easily occur when the metal cover is being removed.

2.4d 240V TO 110V CONVERSION

The PU2 mains transformer has tappings for 240V and 110V a.c. mains. The following procedure should be adopted to convert from 240V to 110V. Refer to PU2 P.C.B. layouts in section 4.

1) Remove mains power unit from 609.

2) Remove P.C.B. metal screening cover.

NOTE : TAKE CARE NOT TO SHORT ANY PART OF THE CIRCUITRY WHEN CONVERTING A PU2.

3) Connect mains transformer windings in parallel by re-wireing the mains input to the transformer. (As shown on the side of the transformer.)

4) Replace the screening cover.

2.5 FUSES

a) Power supply fuses :

The mains power supplies contains two fuses. One is located on the rear panel is rated at 1 amp. The other is located on the P.C.B. adjacent to the press stud connectors and is rated at 0.5 amps.

The front panel P.C.B. also contains two fuses, F1 and F2. Access is by removing the front panel as described in section 3.

b) Front panel supply fuse:

F2 is in series with the supply leads and protects the instrument from fault conditions on the power supply (i.e. over voltage or reverse polarity). When the 609 is powered from batteries F2 is the only fuse in the supply line. When mains power units are used it is in addition to output fuse (see above) on the power unit. F2 is rated at 1.0 amps.

c) Output fuse:

F1 is the output fuse and protects the instrument from fault conditions on the output terminals (i.e. injection of current into the terminals). F1 is rated at 0.25 amps.

2.6 1 AMP OUTPUT UNIT

A mains powered unit which operates external to the 609 and multiplies the 100mA range by a factor of 10.

a) Specification:

Output: 0 to 1 amp

Maximum output voltage: 15V

Transfer accuracy: 0.01%

Input: 0-100mA from 609

Stability: Better than 50 ppm/deg.C. 25 ppm/hr at constant temperature.

Supply: 200-250V a.c. or 100-120V a.c.

Dimensions: 97 x 180 x 75 mm.

b) Operation:

The input to the unit is via two flying leads from the rear panel. Connect these to the 609 in the correct polarity.

The 1 amp unit's output can be reversed or disconnected by a front panel switch.

A front panel voltage limit indicator is provided and operates in a similar way to the one on the 609 (ref. see 2.1h) i.e. it will indicate when the 1 amp unit is unable to provide sufficient drive voltage.

It should be noted that the 1 amp unit is capable of delivering a maximum of 15 watts power into the load and consideration should be given to power rating of the load.

c) Construction and Recalibration

Access to the circuitry is by removing the top cover which is located by 4 screws.

Two preset trimmers are provided. One provides adjustment of the zero and the other full scale. If readjustment is necessary the output should be set up against suitable standards.

SECTION 3

CONSTRUCTIONAL LAYOUT DETAILS

The complete instrument assembly (except the power unit) is mounted on the front panel. A printed circuit board which carries the components and range switch is located immediately behind the front panel. The front panel assembly can be removed as follows:-

1) Remove Power Unit - located in instrument rear by 4 screws.

2) Disconnect Power Unit - connection is by 2 press stud connectors.

3) Remove 4 front panel locating screws.

4) Withdraw front panel assembly from the instrument case - the supply leads are withdrawn through a hole in the plastic power unit cover.

Access to the component parts is now straightforward. Component layout details are given in section 5.

For recalibration the power unit may be connected without rehousing in the instrument case.

3.1 FRONT PANEL P.C.B.

The front panel P.C.B. has mounted on it the range switch, output circuitry, and range resistors with their associated trimmers. The 609's active circuitry is located in an encapsulated module which plugs into the P.C.B. Adjustment of the range resistor trimmers is detailed in section 4.

3.2 CHOPPER AMPLIFIER MODULE

a) Description:

The module contains the F.E.T. chopper amplifier, precision zener and associated circuitry. It is a fully encapsulated unit and connections are via a 16 pin connector moulded into it. The modular form of the 609's basic circuitry protects it from damage due to adverse conditions and thermal gradients which could give rise to thermal emf errors. A replacement procedure should be adopted in the case of failure or malfunctioning of the module.

b) Module replacement:

1) Remove and disconnect the power unit located in the instrument rear by 4 screws.

2) Remove the 4 front panel locating screws.

3) Carefully withdraw the front panel and associated P.C.B. The power supply lead can also be withdrawn through a hole in the plastic power unit cover.

4) Remove the 4-6BA nuts which locate the module on the P.C.B.

5) Withdraw the module from the P.C.B.

6) Replace the new module in the reverse order ensuring that the connector pins align correctly in the socket on the P.C.B.

7) Set module zero and calibration trimmers as described in section 4.

3.3 DIGIT SWITCH ASSEMBLY

a) Description:

It consists of 5 thumbwheel edge switches with gold plated contacts. Nine resistors are mounted on each switch. After several years' usage the contact system sometimes needs cleaning. If the 609 has been used in a dusty or corrosive environment, contamination of the contacts is more likely. Contamination causes the contact to become open circuit or intermittently open circuit in one or more switch positions. This fault condition causes the output current to rise to a larger than full scale value.

b) Repair:

If the 609 has been in service for some time it is usually best to return the complete unit to Time Electronics or their authorised dealer for repair. In addition to repairing the switch, the 609 will be completely overhauled, updated where possible and recalibrated. Where this is not possible, the digit switch assembly can be removed as described below and returned for repair.

c) Cleaning the switch contacts:

Where it is not possible to return either the complete instrument or the switch assembly it is possible for the customer to overhaul the assembly provided suitable tools and the correct cleaning materials are available.

d) Digit switch removal and dismantling procedures:

i) Remove front panel assembly from unit, see section 3.

ii) Unsolder the two wires connecting the P.C.B. to the switch assembly.

iii) Compress the spring clips which locate the assembly on the front panel and push the complete assembly out through the panel aperture.

iv) Remove the 2-6BA studs which pass through all 5 switch sections.

v) Locate the faulty switch section and remove the switch P.C.B. by removing the plastic pips which located it in the switch casing. This can be done with a sharp knife. The functional parts of the switch can now be removed for cleaning. Care must be taken to note the exact position of the parts so that they can be reassembled correctly. The P.C.B. is relocated on the plastic studs by melting the top of the stud with a hot soldering iron. Alternatively the P.C.B. can be located by covering the top of the stud and surrounding P.C.B. with a small amount of epoxy adhesive.

vi) Contact cleaning fluid:
The correct cleaning fluid for this type of switch is a general purpose degreasant with a trichlorothane base. Take care not to let this fluid touch the plastic parts of the switches. It is good practice to coat the contacts with silicon switch grease before reassembly.

It is important before considering recalibration to ensure that an apparent error in output current is not due to inadequate measuring equipment or noise pick-up. (See section 2.3). The latter is a common cause of trouble at low settings of output current particularly when mains power is being used.

It is also important to ensure that the correct equipment is available before attempting recalibration. There are two ways in which the 609's output can be checked accurately - these are:

a) By a current balancing method using an external Standard D.C. Current Source of known accuracy and a nanoammeter with ranges from +/- 1nA to +/- 100uA. It is then possible to display the difference between the 609 output and the standard current source.

b) The 609's output can be converted to voltage by using precision resistors on the 609 output. High performance resistors are required with accuracies of better than 0.01%, 1 ohm, 10 ohms, 100 ohms, 1 K ohm and 10 K ohms are usually adequate. The low values must have excellent stability at currents up to 100mA if errors are not to be introduced due to the temperature rise in the resistor under load.

Power dissipation is 1 watt in the 10 ohm at 100mA.

The voltage across the precision resistors can be measured by normal voltage measuring techniques provided adequate precautions against noise pick-up are taken, these are more likely to occur with the higher resistor values.

Method a) is to be preferred since the problems of noise pick-up, conversion and dissipation errors, and thermal emf's are much less.

It is also recommended that the 609 be operated in its battery powered mode for all calibration procedures. This is to reduce the possibility of noise pick-up which can give erroneous results.

A total of 8 multiturn trimmers is provided, 3 for zero adjustment and 5 for range full scale calibration. The sequence of adjustment is important since some of the trimmers affect more than one range.

The calibration procedure is as follows:

Power the 609 from batteries or the rechargeable cell in the PU2 for all calibration.

Remove the front panel and locate the 7 trimmers, VR1-VR5 are located on the front panel P.C.B. and are positioned as shown on the front panel P.C.B. layout diagram (section 5). The other 2 trimmers are located on the side of the encapsulated circuit block and marked 'CAL' and 'ZERO'.

Switch on the 609 and allow the circuits to stabilise for a few minutes. Ensure that no draughts or direct heating (e.g. sunlight) affect the 609's circuitry. Calibrate at a stable temperature of between 20-24 deg.C if possible.

CALIBRATION PROCEDURE

For serial numbers 1218K6 and later.

1) Set the digit switch to zero and select 100uA range. Adjust output to zero (+/- 0.5uA) with 'ZERO TRIMMER' on module.

2) Select 10uA range and adjust output to zero (+/- 0.3nA) with VR1.

3) Set digit switch to 99999 and select 100uA range. Adjust output to 100uA +/- 5nA with 'CAL TRIMMER' on module.

4) Select 10uA range and set output to 10uA +/- 1nA with VR2.

5) Select 1mA range and set output to 1mA +/- 50nA with VR5.

6) Select 10mA range and set output to 10mA +/- 500nA with VR4.

7) Select 100mA range and set output to 100mA +/- 5uA with VR3.

NOTE:

If method b) is being used for calibration 7) above, a highly stable 10 ohm resistor is required since 1 watt is dissipated in the resistor. A 1 ohm may be used as an alternative if a suitable 10 ohm is not available. 0.1 watt will be dissipated in a 1 ohm resistor.

LINEARITY

The linearity of the output is not adjustable and is determined by the precision resistors mounted on the digit switch. These have been selected and adjusted in the factory and should not require further alteration.

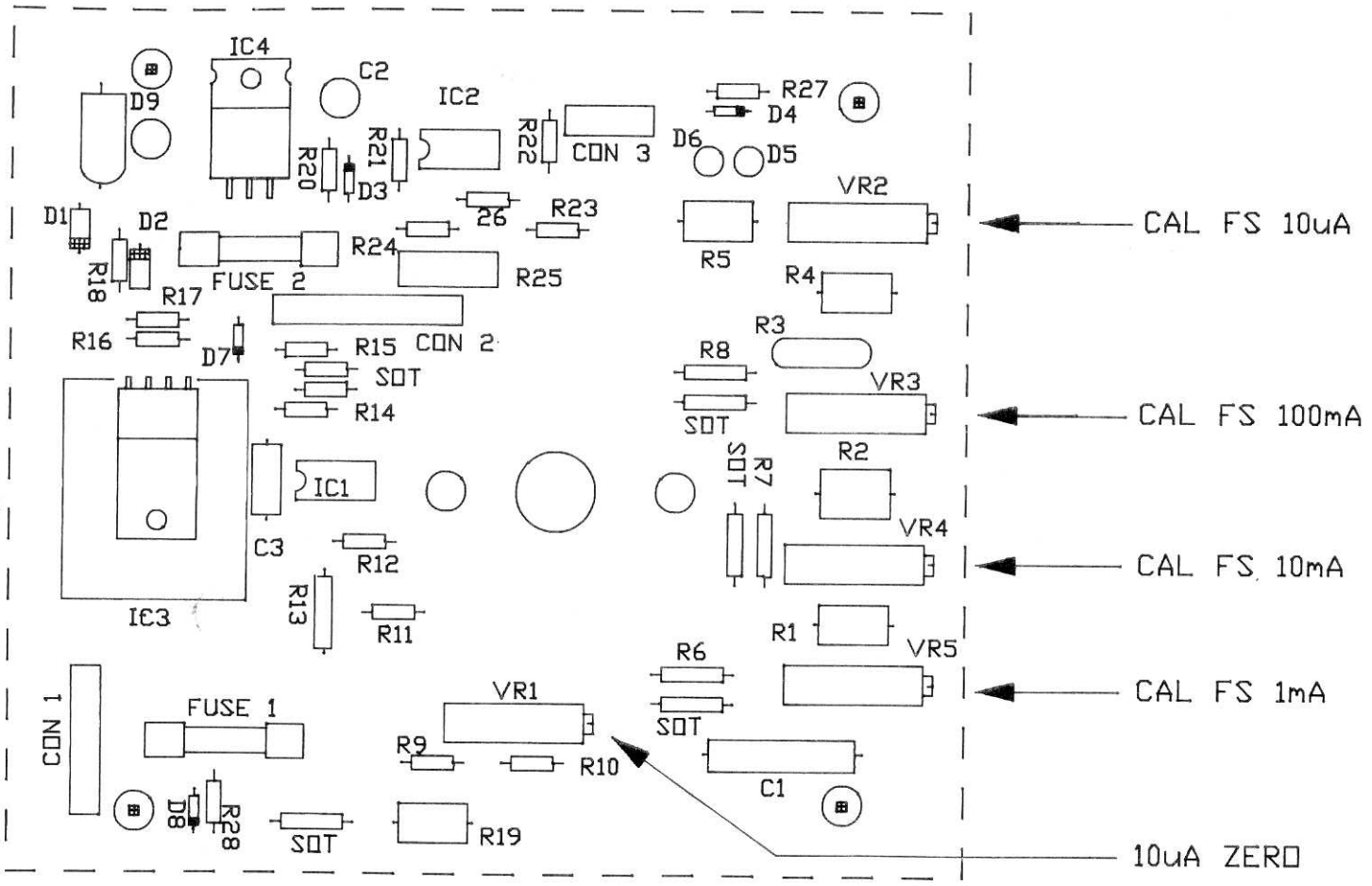
4.3 GUARANTEE AND SERVICE FACILITIES

The 609 is guaranteed for a period of one year from its delivery to the purchaser.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to us (or our authorised dealer) for servicing. The type and serial number of the instrument should always be quoted, together with details of any fault and the service required.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. WE CAN ACCEPT NO RESPONSIBILITY FOR INSTRUMENTS ARRIVING DAMAGED. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee period has expired, the repair will be put in hand without delay and charged unless other instructions are received.

ISSUE	CHANGES



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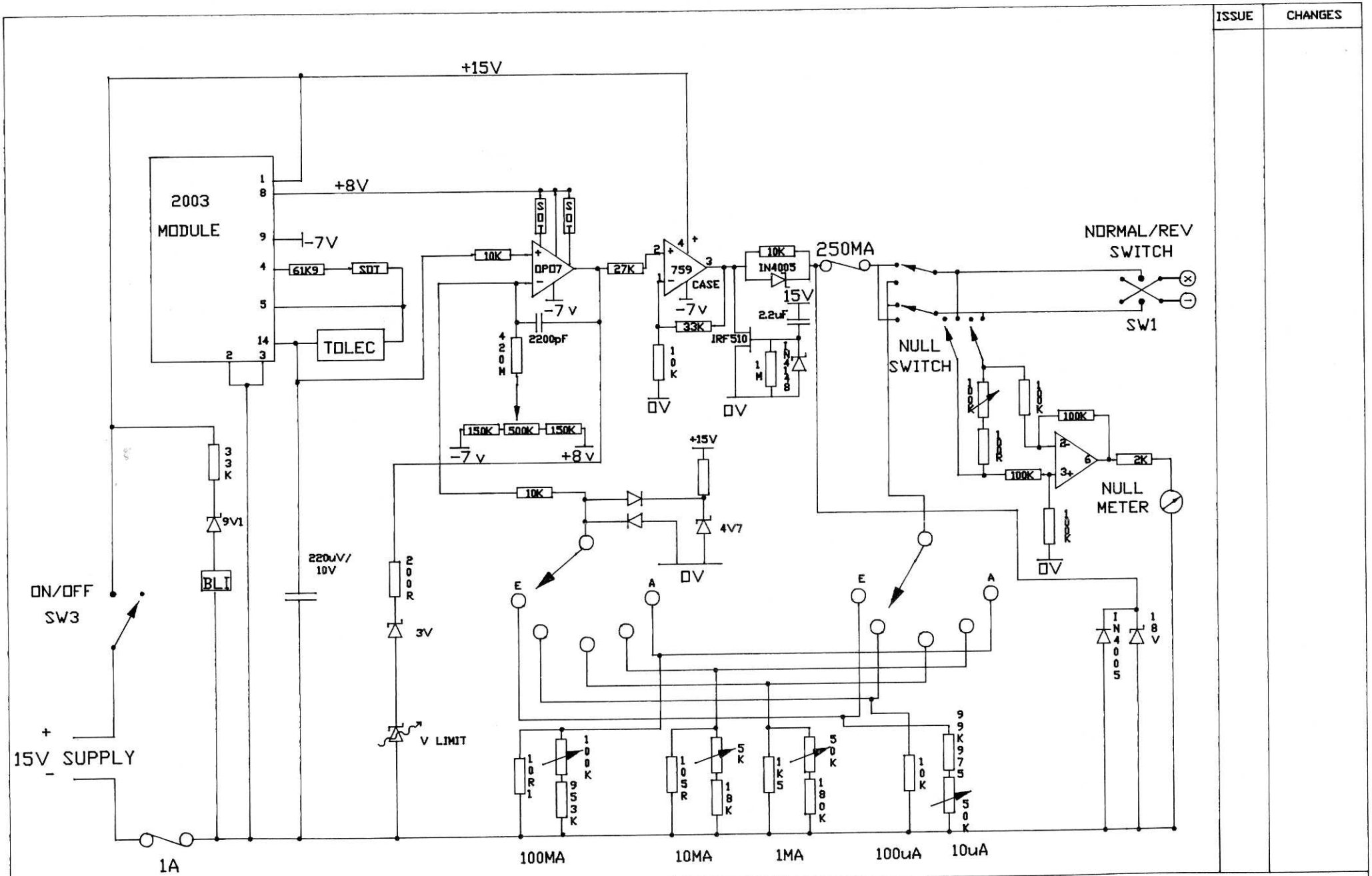
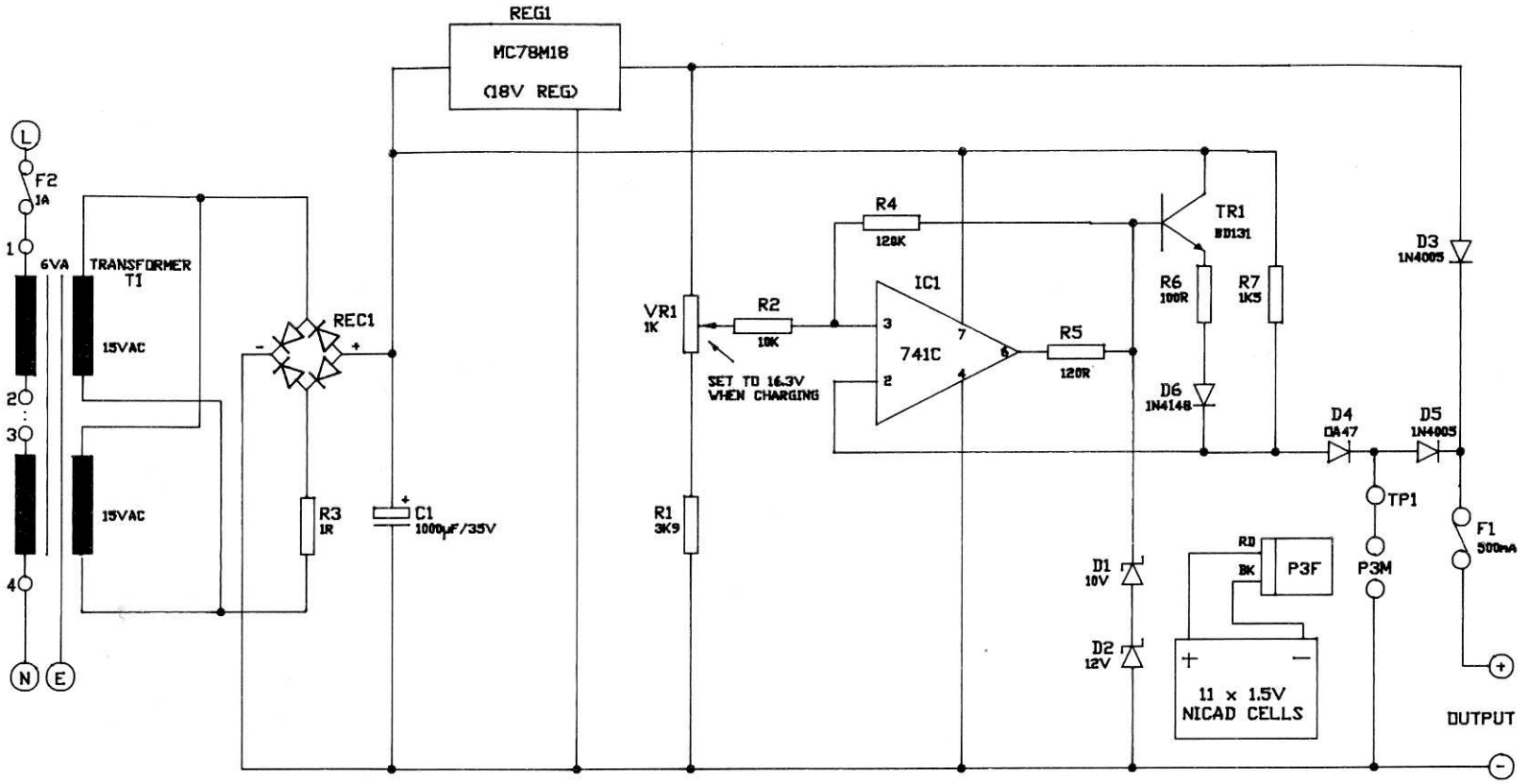
	SCALE		THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED	DRG No	1024L01
	DATE	24.11.86			


ISSUE
CHANGES
+15V
2003
MODULE
+8V
-7V
61K9
SOT
TOLEC
10K
OP07
-7 V
2200pF
420M
150K
500K
150K
-7 v
+8 v
27K
759
CASE
-7v
33K
10K
0V
IRF510
1M
1N4148
10K
1N4005
250MA
15V
2.2uF
0V
NORMAL/REV
SWITCH
SW1
NULL
SWITCH
100K
100K
100K
100K
2K
NULL
METER
0V
+15V
10K
4V7
0V
33K
9V1
BL1
220uV/
10V
200R
3V
V LIMIT
ON/OFF
SW3
+
15V SUPPLY
-
1A
E
A
E
A
101R
100K
953K
105R
5K
18K
1K5
50K
180K
10K
99K975
50K
100MA
10MA
1MA
100uA
10uA
IN4005
18V
TIME
ELECTRONICS
LTD
DRAWN
C,A,L
APPRD
SCALE
DATE
15,10,86
TITLE
609 CIRCUIT DIAGRAM
THE CONTENTS OF THIS DRG MUST NOT BE COPIED OR USED WITHOUT PRIOR WRITTEN CONSENT OF TIME ELECTRONICS LIMITED
DRG No
1024C01



TRICKLE CHARGE OF 5mA. (VIA R7) APPROX.

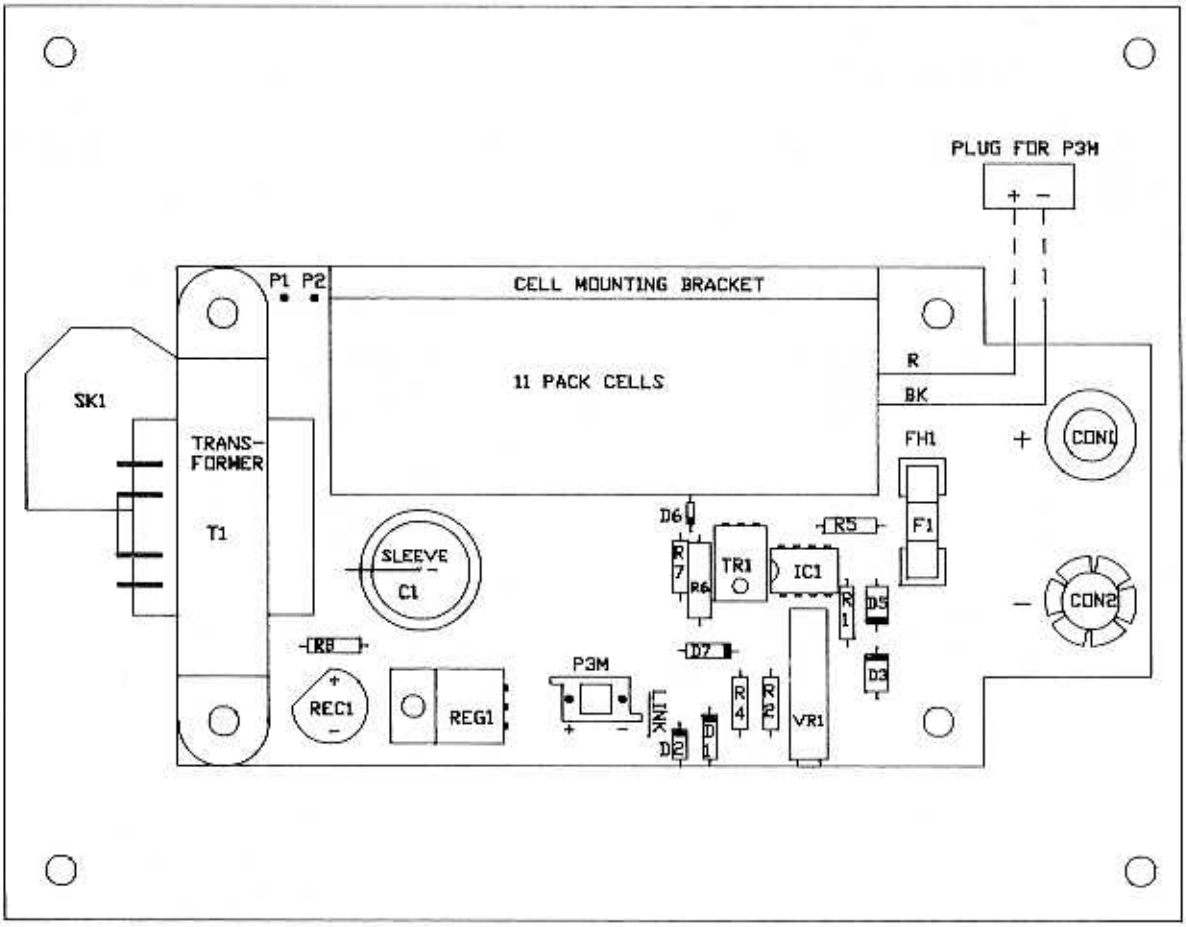
POINTED LINE SHOWS 240V
TRANSFORMER CONNECTION

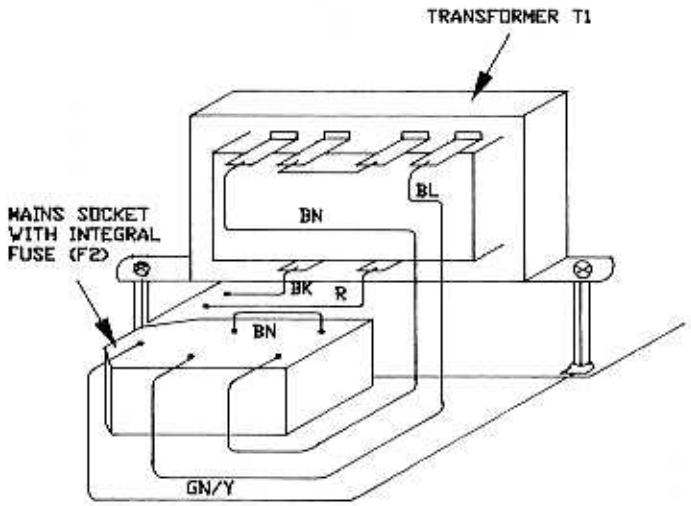
FOR 110V LINK 1 TO 3 AND 2 TO 4,
REMOVE LINK BETWEEN 2 AND 3

ISSUE	CHANGES
C	Redrawn with CAD 19/6/85

TIME ELECTRONICS LTD	DRAWN	STONE	TITLE: RECHARGEABLE BATTERY UNIT PU2R1 CIRCUIT DIAGRAM
	APPRD		
	SCALE		
	DATE	19/10/77	DRG No: 1010C02

ISSUE	CHANGES
C	Redrawn with CAD 18.6.85 B.D.





TIME ELECTRONICS LTD	DRAWN	STONE	TITLE: RECHARGEABLE BATTERY UNIT PU2R1 GENERAL LAYOUT
	APPRD		
	SCALE	1 : 1	
	DATE	26/10/77	DRG No: 1010L04