GUILDLINE INSTRUMENTS LIMITED

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CONSTANT CURRENT SOURCE

model TYPE 9770A

INDEX

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Patents applied for TYPE 9770A

OPERATING INSTRUCTIONS

1. Principle of Operation

The principle of operation is illustrated in Fig. 1. The 110 volt 60c/s supply is transformed, rectified and smoothed to give a d.c. supply at approximately 40 volts. Current from this source flows in the loop consisting of the six dial variable resistor, the meter, the load and a light sensitive amplifier which functions as a light actuated variable resistor. The voltage developed across the 6 dial resistor is arranged to be approximately 1.018 volt for all current values within the range of the instrument. This voltage is connected in series opposition to an internal saturated standard cell and any difference voltage is detected by the galvanometer G. An external cell may be used if required. Light from the galvanometer mirror falls on a pair of photo-transistors which, depending on the amount of illumination received, control the current in the loop. A continuous correction to the current value is applied in the presence of changes in line voltage and load resistance. Load resistance may be varied from zero to the value which will produce approximately 36 volts at the load terminals at the selected current value. If the combination of current and load resistance produce a voltage greater than 36 the by-pass circuit begins to conduct. A change of setting of the six current control dials to produce a greater current will then produce no change in the meter reading because the additional current is flowing in the by-pass circuit and not in the load. Similarly an increase in load resistance to produce a load voltage in excess of 36V will result in a reduction of current

as indicated by the meter although the total current remains unchanged.

2. Construction

The Constant Current Source is in two units. The power supply unit consists of the 110/36 and 110/12 volt transformers together with rectifiers and smoothing capacitors which are located in the small expanded metal case. The control resistors, the reference cell and the galvanometer are located in the Current Source unit.

3. Front Panel Controls

Dials

The six dials marked x10, x1, x0.1, x0.01, Fine 1 and Fine 2 constitute the variable detector resistor shown in the diagram as R_1. The same knobs actuate the variable resistor R_2 in the emitter of the 2N1488 transistor.

Cell Terminals

The internal standard cell is located in the oven and is connected into the detector circuit by the two pole SC switch. If an external cell in an external oven is used in preference to the internal cell, connection should be made to the EXT CELL terminals in correct polarity, the leads being connected at the Current Source panel first and at the standard cell last to avoid accidental short circuit. Rotation of the SC switch from the INT to EXT position through the center 'off' position connects the external cell in place of the internal cell.

Meter

The milli-ammeter indicates load current to $\pm 2\%$. More precise selection of a current value is obtained from the measured standard cell value and the resistance value selected on the six dial variable resistor which is accurate to better than $\pm 0.1\%$. (See Section 6, page 5)

Pilot Lights

The heater lamp switches on and off with the oven heater and the glass thermometer indicates the oven temperature. The heater is controlled by the HEATER toggle switch. The lamp marked OVERLOAD is illuminated by the back contact of the overload relay and indicates that the current is not being controlled.

Filter

The toggle switch marked FILTER switches a 22uF capacitor across the load terminals to eliminate any trace of 60 or 120 cycle which may be present. The use of this capacitor slows down the time of response to a change of load resistance which, in the absence of the capacitor is instantaneous.

Fuses

The fuse immediately below the meter is connected in series with the load current and is rated at 125mA. The fuse in the 110V line is located in the separate power supply unit and is rated at 0.5 amp.

Zero Control

The control on the galvanometer zero is located on the back of the box. When the Current Source has been set up in its working position the zero control knob should be used to bring the galvanometer light spot as seen through the hole in the back of the box centrally onto the phototransistors. A coarse control on galvanometer zero is provided by the rotatable head of the galvanometer but this adjustment is not likely to be required. The central cap on the galvanometer suspension tube can be rotated to position the light spot after the knurled clamping nut has been loosened.

Current Switch

The rotary switch marked CURRENT has three positions which give off, current on, and lamp on. The center 'off' position is not marked. The three positions are

provided so that the application of supply voltage to the load circuit and illumination of the galvanometer lamp always occur in the correct sequence.

4. Internal Refcrence Cell

The saturated standard cell which is used as a control reference is located within the oven. A current of 10^{-2} microamp in the control galvanometer coil can produce a load current change of 20%. Typical changes in load current would require correction currents in the standard cell and galvanometer of a few milli-microamps and the characteristics of the cell used are such that this current can be taken for many hours without a significant change in terminal voltage.

Although the operating oven temperature is reached in less than one hour it may take several hours for the standard cell to reach the same temperature and several additional hours for the cell voltage to stabilize. It may be expected to be within 1 ppm of its final voltage within 36 hours from cold but after shipment involving mechanical shock the cell voltage may drift by 5 to 10 ppm over a period of several days.

If the Constant Current Source is located in a room which has temperature control to $\pm 1F^{\circ}$ it may be found preferable to leave the oven switched off, but if room temperature variations are wide the standard cell and the detector resistors should be held at constant temperature by use of the oven heater.

5. Load Resistance

The load terminals of the Constant Current Source may be short circuited for an indefinite period without damage. The selected current, as indicated by the meter will flow in the short circuit.

The load terminals may also be open circuited without damage to any components including the galvanometer and standard cell. When the voltage across the load

exceeds 30 to 36 volts a zener diode by-pass circuit takes the load current which continues to flow, although not indicated by the meter.

If the load resistance is gradually increased from zero, the selected current as indicated by the meter will remain constant until the load voltage reaches approximately 36. The by-pass circuit will then begin to conduct and further increases in load resistance will result in reductions of that part of the current which flows in the load and the meter. Under such conditions, ie., when the load voltage is about 36 volts the total current is still controlled but the current flowing in the load resistor is not.

NOTE: If the load is grounded it is necessary to disconnect the line ground at the power input plug on the back of the case. (See Section 15)

6. Current Range

The maximum resistance setting of the 6 dial detector resistor is 121.1 ohms. The voltage of the reference cell is 1.0182 so that the minimum current which may be selected is $\frac{1.0182}{121.1}$ = 8.5mA. The maximum current is obtained with the minimum resistance of 10 ohms, $\frac{1.0182}{10}$ = 101.8mA.

The resistance accuracy of the six dial detecting resistor is better than $\pm$0.1%. The voltage of the standard cell is given to $\pm$100uV which does not contribute a significant error in the computation of load current. If the Current Source is operated at room temperature, ie., with the oven cold the cell voltage can be expected to be approximately 0.005% greater for each Centigrade degree below 28°C.

7. Preliminary Tests

The power supply unit should not require attention except for very infrequent access to the 110 volt line fuse and may therefore be located below the bench or in any other convenient place. The Constant Current Source control unit

should be placed on a firm level surface not subject to heavy vibration and within reach of the operator.

After shipment, to ensure that no air bubbles in the galvanometer damping fluid have been trapped behind the galvanometer lens, turn the complete instrument through 90° onto its left side (the side adjacent to the panel meter) and then restore it to its feet.

To bring the instrument into service, follow the steps listed below.

a) Connect the six way plug to the jack in the back of the Current Source and tighten the retaining nut with the flexible ground lead connected to the plug casing. Plug the line cord into a 110 volt 60c/s outlet.

b) Turn the SC switch to the EXT position for the preliminary tests.

c) Connect the load to the load terminals in the required polarity, or a 100 ohm carbon resistor or a decade resistance box with the dials set to 100 ohms.

d) Turn the CURRENT switch through two steps to the fully clockwise position. In the center position the meter should show a deflection due to a current flowing in the load. In the fully clockwise position the galvanometer lamp should be on as seen by light from the ventilation holes in the back of the box. At the instant that the galvanometer lamp comes on the OVERLOAD lamp should flash momentarily. Open the inspection cover in the back of the instrument and observe that a bright rectangular galvanometer light spot is falling centrally on the two phototransistors. If the light spot is bright but not centrally located on the phototransistors turn the ZERO control knob, located on the back panel, to rotate the galvanometer and bring the light spot into the correct position. If the light spot is not bright remove the instrument from its case and adjust the galvanometer lamp as described in Para. 11.

e) Turn the CURRENT switch counter clockwise to the OFF position and turn the SC switch to INT.

f) Turn the CURRENT switch to the ON position. The OVERLOAD lamp should flash momentarily and remain out. The selector dials may now be turned to adjust the current to any required value within the instrument range.

g) To check that the control galvanometer is being deflected by the minimum amount turn the SC switch to mid position when the Current Source has been placed in its working location. Note the current and the amount by which the meter deflection changes when the SC switch is turned. If there is a noticable change in deflection, turn the galvanometer zero control on the back panel to adjust the current to the controlled value with the SC switch in the mid position. An offset of 5% in the current when the control cell is disconnected will result in a 1ppm offset in the controlled current when the cell is connected.

3. Normal Operation

It is assumed that the oven has been switched on long enough for the internal cell to have achieved voltage stability or alternatively that the oven is not being used and that voltage stability has been achieved at a stable room temperature.

a) Connect the load.

b) Turn the CURRENT switch fully clockwise.

c) Select the required current on the six dials noting that this current in the resistance of the connected load will not produce a voltage in excess of about 33 volts.

d) Turn the SC switch to the middle, off position, and adjust the galvanometer zero so that when the cell is reconnected by turning the SC switch to INT there is no noticable change in deflection.

9. Operation as the Current Source for a D.C. Potentiometer

a) Connect the potentiometer battery terminals to the Constant Current Source LOAD terminals in correct polarity & disconnect the ground wire on the power plug.

b) Select the approximately correct current for the particular potentiometer, (eg. 20mA). The meter indication will be sufficiently accurate.

c) Connect the standard cell which is to be used for standardization to the standard cell terminals on the potentiometer and standardize according to the operating instructions for the potentiometer but using the six dials of the Current Source in place of the the current control rheostat on the potentiometer.

Note that when the potentiometer is correctly standardized the current is immediately constant and that a change in the potentiometer current control rheostat does not affect standardization. DO NOT make this test with the FILTER capacitor switch in. The change in load resistance causes a change in load voltage. This results in a temporary change in potentiometer current (but no change in total current) which recovers to the original value with a time constant determined by the load resistance and capacitance values.

10. Check on Current Stability

To check current stability to parts in a million it is necessary to compare a known constant voltage with the voltage produced when the current is passed through a known constant resistance.

For example, approximately 20mA from the Constant Current Source passed through a 50 ohm resistor will produce a voltage which can be compared with a standard cell by back to back connection. The difference may be measured on a simple Lindeck potentiometer from which no accuracy is required. A suggested circuit is given in Fig. II.

In using this circuit it is important to note that variation in the 50 ohm resistor or in the standard cell voltage would be just as effective in changing

the potentiometer balance point as would be a change in the 20mA current. If the resistor has a 10ppm temperature coefficient a temperature change of one degree would be significant, and if the standard cell is of the saturated type a temperature change of 0.02° would similarly produce an unbalance of 1ppm. For best results therefore, both of these items should be in constant temperature ovens.

11. Galvanometer lamp

The bracket supporting the galvanometer lamp may be rotated about its central post or may be moved vertically after the knurled locking nut has been loosened. The Type M1493, 6.3 volt lamp is operated at approximately 5 volts and should seldom need to be replaced. After replacing the lamp unlock the vertical shaft with the locking nut and move the lamp until a bright rectangular image falls on the phototransistors. When this has been obtained lock the lamp bracket securely. Check that the relay operates and releases quickly when the light beam is momentarily interrupted.

12. Overload Relay

The overload relay contact closes the circuit for the control cell and the galvanometer. It is operated when the galvanometer light spot is correctly falling on the photodiode OAP12. If an external control cell should be connected in the wrong polarity the galvanometer will be violently deflected, but immediately the light spot leaves the photodiode the relay releases and disconnects the cell and galvanometer. Simultaneously the OVERLOAD lamp is illuminated to indicate the fault condition.

The same conditions apply if the galvanometer lamp should burn out. The control cell and galvanometer cannot be damaged because they are immediately disconnected.

13. Line Voltage Variations

Variations of load current of approximately $\pm$1ppm may be expected for line

voltage variations of ±5 volts. If the line voltage varies widely the effect of line voltage variations may be reduced to near zero by the inclusion of a 110/110 volt constant voltage transfomer in the 110 volt line.

14. Load Resistance Variations

The output resistance of the Constant Current Source is of the order of 1000MΩ. The load resistance can therefore be increased from zero to 1000 ohms for a change in load current of 1ppm. Additional increases of 1000 ohms will have similar effect up to the point where the load voltage exceeds the Zener voltage (approximately 33 volts).

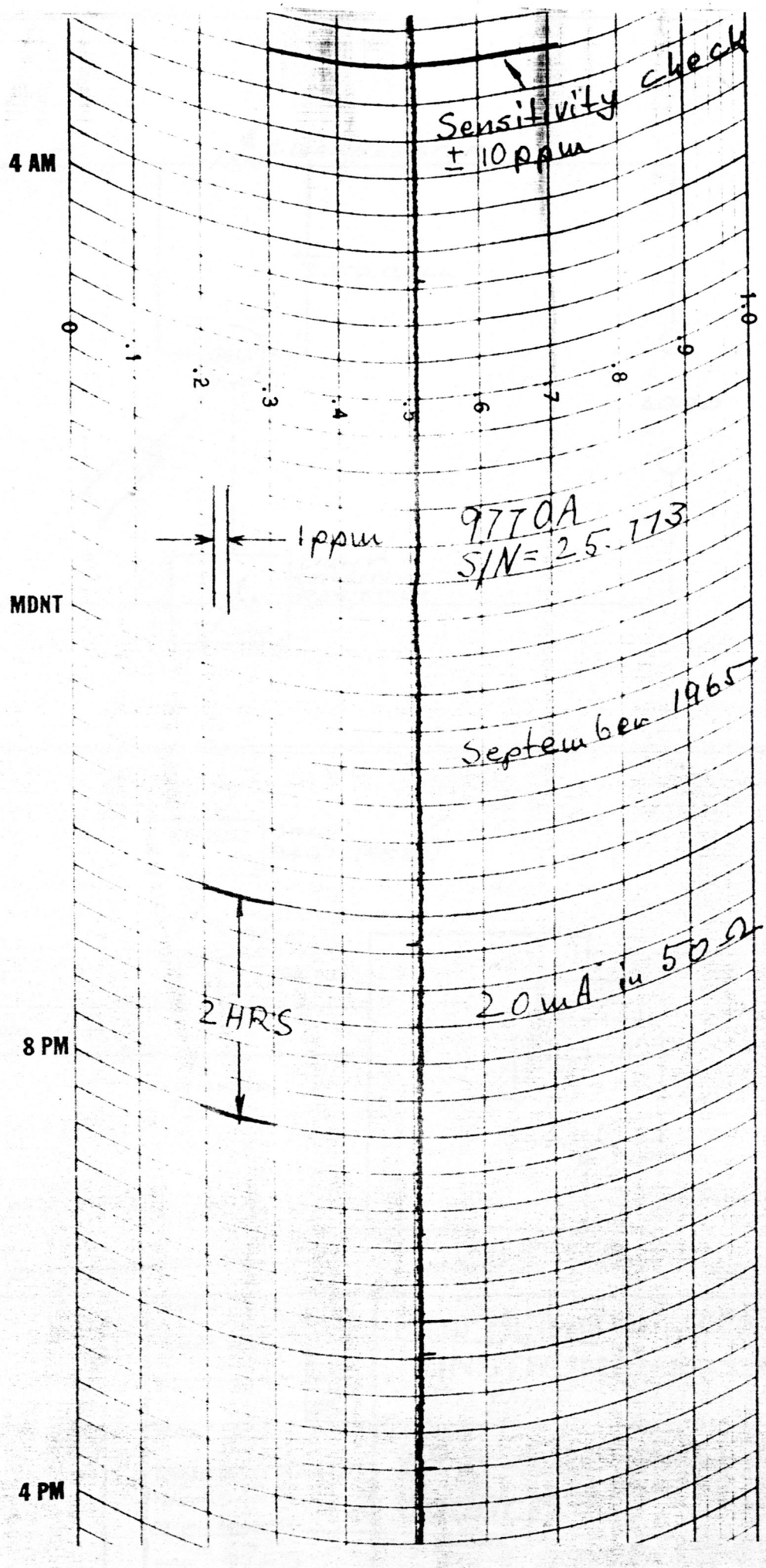
15. Grounding

The power cable shields are connected to the mains third wire in the power supply unit. At the back of the Constant Current Source the cable shields are connected by a flexible wire to the plug casing and so to the chassis, front panel and the collector of the 2N1488. The chassis and oven casing function as guard surfaces and should always be connected to the 2N1488 collector. If the load is grounded the flexible wire on the power plug should be disconnected from the plug casing. Similarly, when using the Constant Current Source to replace a potentiometer supply battery it is probable that a ground connection on the current supply will not be permissible and again the flexible connection on the power plug should be removed.

16. Internal Standard Cell Voltage

At the time of shipment the internal standard cell voltage was 1.01810 volts. The internal cell may be checked against an external standard by connection to the two terminals which are mounted on an insulating plate on the back of the meter. To reach these terminals the chassis must be withdrawn from the box.

This necessitates disconnection of the power plug. If the duration of the disconnection is to be longer than two or three minutes the chassis should be withdrawn from the box completely and the plug reconnected so that the oven will not cool.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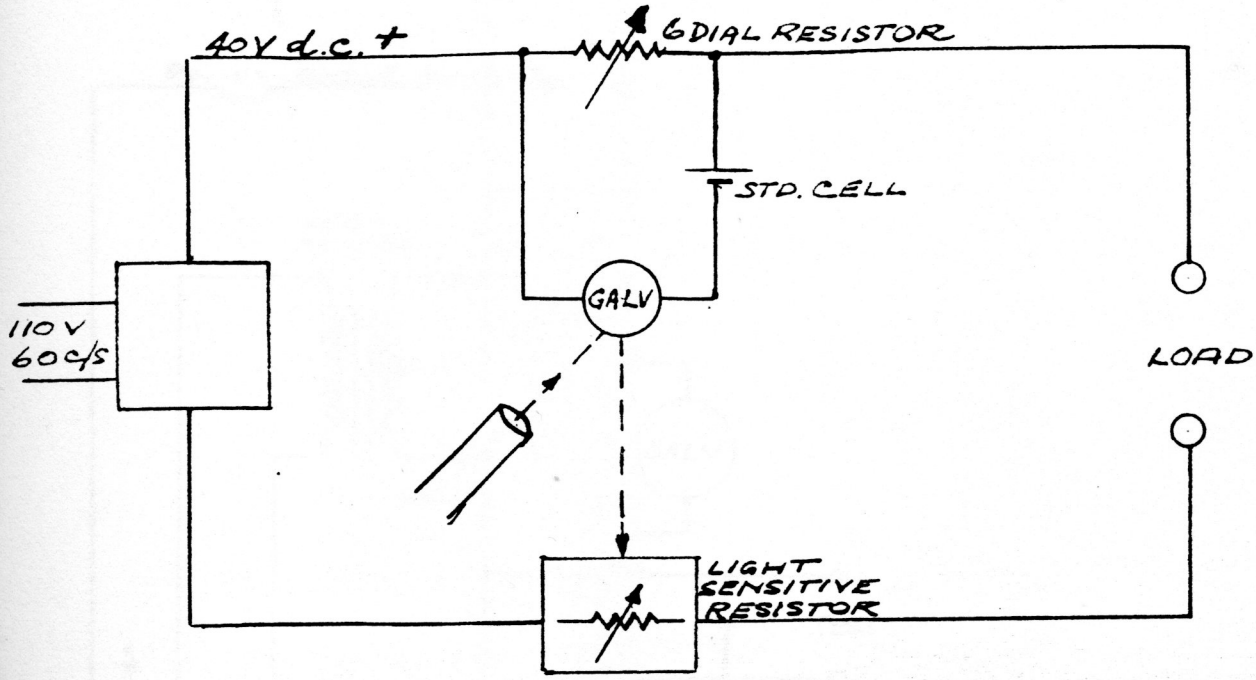

FIG. 1

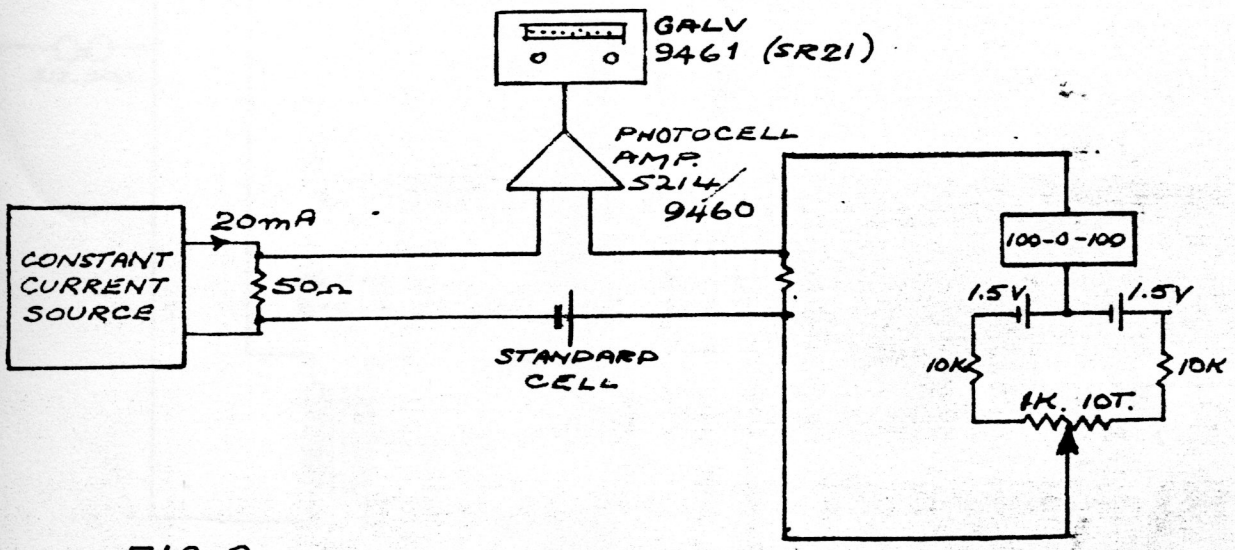

FIG. 2
TEST CIRCUIT

DRAWN BY:	GUILDLINE INSTRUMENTS LTD. SMITH FALLS ONT. CANADA
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APPROVED BY:	
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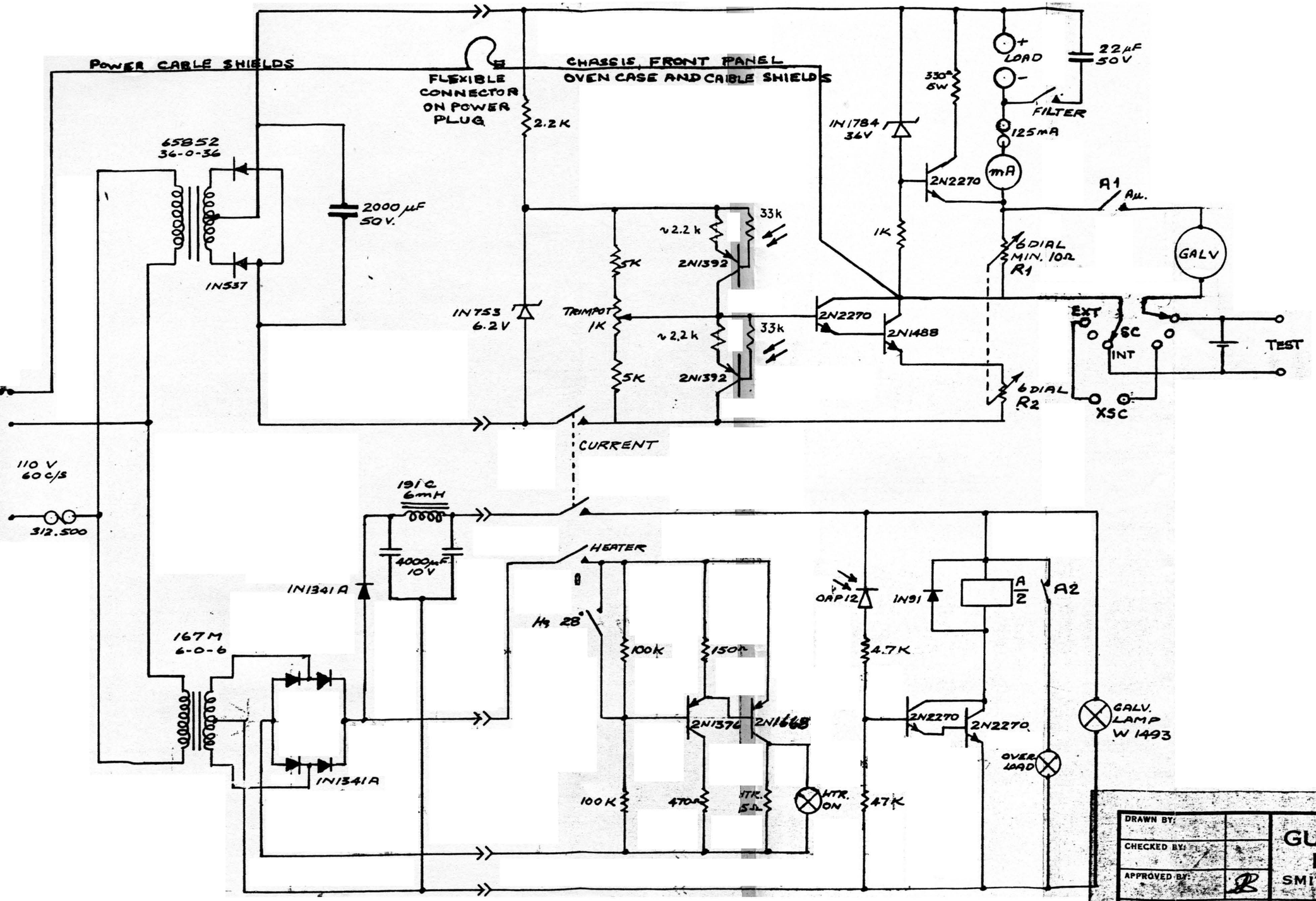
DIMENSIONS ARE IN INCHES. FRACTION TOLERANCE: DECIMAL TOLERANCE:	
DATE: 9/63	DRAWING NUMBER 9770A REV. F



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CHECKED BY:		
APPROVED BY:		
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