Thurlby

1905 intelligent multimeter

OPERATING MANUAL

INDEX

1. INTRODUCTION

The Thurlby 1905a is a 5½ digit manual ranging multimeter with keyboard programmable computing and datalogging facilities. Features include:

±210,000 counts scale length
1μV, 1mΩ, 1nA sensitivity
AC functions and current ranges
0.015% basic 1 year accuracy
Wide range of computing functions:
Ax+b, Hi-Lo-Pass, % deviation,
Min-Max, Running Average, dB
Single key null/relative and hold functions
Adaptable intelligent digital filter
Data-logging with programmable timing.

2. PREPARATION FOR USE

2.1 Operating power

The 1905a is operated from AC line power either 220V, 240V ±10% 50Hz, or 110, 120V ±10% 60Hz. The voltage range to which the instrument is set is marked on the rear panel, and should be checked before power is connected.

The IEC standard cable supplied should be connected to a captive plug with an integral earth connection and wired as follows: brown to Live, blue to Neutral, green/yellow to Earth.

2.2 Power on/off switch

The power switch is mounted on the rear panel of the instrument. At switch-on the display will briefly show a code representing the software level.

2.3 Stand

The instrument can be set at various angles using the tilt-stand. To rotate the stand, it should be pulled outwards at each side of the instrument.

3. MULTIMETER OPERATION

3.1 Basic operating sequence

a. Select the required function, either V (voltage), Ω (resistance), or A (current).

b. Depress the AC button if an AC voltage or AC current measurement is required. Ensure it is released if a DC measurement is required.

c. Connect the black test lead to the black (common) socket, and the red test lead to the lower red socket (V or Ω measurement) or the upper red socket (A measurement).

d. Select a range whose maximum reading is higher than the input you wish to measure.

e. Connect the source to the input terminals and take the measurement.

! CAUTION

1. Read the safety considerations (see section 4).
2. Do not raise the common socket more than 500V DC or AC pk above ground.
3. Do not apply inputs above the maxima stated in section 3.2. Doing so could damage the instrument.

3.2 Maximum Inputs

Function	Ranges	Max. Input
V (AC or DC)	200mV, 2000mV	1100V dc or pk ac 10 seconds 400V dc or ac RMS continuous
	20V, 200V, 1100V	1100V dc or 750V RMS
A (AC or DC)	200μA to 200mA	1A dc or ac RMS
	2000mA and 5A	5A dc or ac RMS
Ω	All ranges	400V dc or ac RMS

Note: When measuring current in inductive circuits do not change ranges, since breaking the current path could generate high voltages across the switchbank and cause damage.

3.3 Overrange Indication

Where the input exceeds the maximum reading of the range, the display will indicate this by displaying OR. Note that resistance ranges will always show overrange with no input connected.

3.4 Negative Indication

On DC voltage and current ranges, a negative symbol will automatically appear on the left hand side of the display if the red input socket is taken negative with respect to the black (common) socket.

3.5 5½ digit scale length

When first switched on, the instrument will give a 4½ digit scale length. If more resolution is required, pressing the key marked 5½ will increase the scale length to 5½ digits, pressing it again will return it to 4½ digits.

5½ digit scale length is not available for AC voltage or current ranges, and the key will have no effect when the AC switch is depressed.

3.6 DC voltage measurement

The instrument measures DC voltage between $1\mu V$ and 1100V. Maximum displayed reading is ±209999 except for the highest range. Input impedance is $10M\Omega$ (±0.1%).

In 5½ digit mode it may be necessary to use the 'null' key to obtain an accurate zero reference when using the 200mV range (see section 3.14).

Zero for both the 200mV and 2000mV ranges can only be examined with the input leads shorted together, since when the input is open circuit the input bias current flowing through the $10M\Omega$ input network will cause an offset to appear. This offset will not be present when the input is connected to a voltage source.

3.7 Hi-Z DC voltage measurement

Voltages between $1\mu V$ and ±2.1 volts can be measured at an input impedance greater than $1,000M\Omega$ thus eliminating loading errors in very high impedance circuitry.

To do this, depress the V and A buttons simultaneously and select the 200mV or 2000mV range.

N.B. With no input connected the display will show a random reading.

3.8 AC voltage measurement

The instrument measures AC voltage between $10\mu V$ and 750V rms. Maximum displayed reading is 20999 except for the highest range.

AC measurements are mean responding, rms calibrated for sinusoidal signals.

Note 1: Even with the input terminals short circuited the AC voltage ranges may show a slight zero offset, this offset will not cause significant measurement errors when an input substantially greater than zero is applied, and it should **not** be removed by using the 'null' key.

Note 2: The AC ranges do not respond to a DC input. However, if it is required to measure AC superimposed on DC, the sum of the DC level plus AC rms level must not exceed the maximum value of the range. This restriction may be eliminated by placing a capacitor in series with the input.

3.9 DC current measurement

The instrument measures DC current from 1nA to 5A. Maximum reading is ±209999 except for the highest range. The 5 amp range is selected by simultaneously depressing the 2 right hand range buttons.

In 5½ digit mode it may be necessary to use the 'null' key to obtain an accurate zero reference.

3.10 AC current measurement

The instrument measures AC current from 10nA to 5 amps rms. Maximum reading is 20999 except for the highest range. The 5 amp range is selected by simultaneously depressing the 2 right hand range buttons.

AC current ranges do not respond to DC. If it is required to measure AC superimposed on DC, the sum of the DC level plus AC rms level must not exceed the maximum value of the range.

With no input applied the AC current ranges may show a slight zero offset. This offset will not cause significant measurement errors when an input substantially greater than zero is applied, and it should not be removed by using the 'null' key.

3.11 Current protection

AC and DC current ranges up to 200mA are protected by a rear panel mounted 1 amp fuse. Currents in excess of this will rupture the fuse.

The 2000mA and 5 amp ranges are protected by a separate 5 amp fuse mounted internally. See section 5.

3.12 Resistance measurements

The instrument measures resistance from $1m\Omega$ to $21M\Omega$. Maximum reading is 209999 on all ranges.

To make accurate measurements at low values the resistance of the test leads must be removed using the 'null' key (see section 3.14).

N.B. When making high impedance measurements using either voltage or resistance ranges, errors may be experienced if a measurement is made directly after application of high voltages. In common with all multimeters, dielectric absorption causes charge to be stored in the components of the input circuitry and it may take some minutes for this to discharge fully. Consequently, high accuracy measurements on impedances above about $100k\Omega$ should not be made directly after applying voltages in excess of say 50 volts.

3.13 Diode test measurements

The 2000Ω range can be used to measure the forward voltage drop of diodes and transistors at a current of 1mA with a direct reading in millivolts. The anode should be connected to the red socket, and the cathode to black.

The higher resistance ranges can also be used for this purpose but the decimal point will be wrongly positioned. Each resistance range provides a linear current output reducing in decade steps. Thus the $20k\Omega$ range outputs $100\mu A$, $200k\Omega$—$10\mu A$, $2000k\Omega$—$1\mu A$ and $20M\Omega$—$0.1\mu A$. Maximum output voltage is about +5 volts but non-linearity commences above 2.1 volts.

3.14 Using the 'null' key

Depressing the 'null' key causes the present displayed measurement value to be stored and subtracted from future readings. A second depression cancels this function. When 'null' is operating an 'n' symbol appears on the right hand side of the display.

One use of the null function is the removal of zero offsets. For example, when measuring low value resistors, the resistance of the test leads can be removed by shorting them together and depressing the 'null' key.

A further use of the null function is in changing the reference point to which measurements are being made. For example, if voltages in a circuit are being measured with the 'common' test lead connected to the circuit's negative rail, they can instead be measured relative to its positive rail simply by measuring the positive rail and depressing the 'null' key.

When the null function is operating the overrange limits are changed to 209999-N and —(209999+N), (max. ±399999).

Depressing the 'null' key when the dB program is running will cause the present measurement value to be stored as the 0dB reference level (see section 9.6).

Note 1: The null value is stored numerically without reference to the decimal point position. Consequently, when the user changes range any null value stored may become invalid. To remind the user that he may wish to cancel or reset the null value, a 'null set' message is displayed whenever range or function is changed with the null function operating.

Note 2: Null can neither be set nor cancelled when a program is operating except for the Filter, Dec Pt and dB programs. 'In Pro' will be displayed briefly if null is depressed.

3.15 Using the 'hold' key

Depressing the 'hold' key causes the present displayed measurement value to be frozen on the display. Depressing the 'hold' key again, or depressing any other key, causes a return to a normal display. When the display is 'held' an 'h' symbol appears on the right hand side.

3.16 Using the 'store' key

The 'store' key is used in conjunction with the Logger function (see section 9.2).

3.17 Invalid function and range combinations

Any invalid combination of function and range switches will cause the display to show 'error'.

3.18 Deferred facilities

The key marked ** is for use with future facilities and has no direct function on the basic meter.

Simultaneous selection of the A and Ω function switches is also intended for a deferred facility.

4. GENERAL SAFETY CONSIDERATIONS

This instrument has been designed to the highest safety standards, but safety depends on the user and the following basic precautions should be observed.

1. This instrument is safety class I by IEC classification.

2. Before connecting to an AC line supply, check that it is set to the correct voltage as indicated by the label on the rear panel.

3. Ensure that an appropriate AC line plug is connected to the IEC standard cable supplied, and that a secure earth connection is made. Connections are brown=live, blue=neutral, green/yellow=earth.

4. Never raise the voltage on the input ground (black) socket more than 500 volts peak above the ground.

5. Never apply a voltage to the input that exceeds the maximum allowable voltage for the range.

6. Never remove the test leads from the instrument whilst they are still connected to a source of high voltage.

7. When working with circuits containing voltages in excess of 40 volts, disconnect power from the circuit before connecting test leads.

8. Do not apply voltages in excess of 40 volts to the instrument while the covers are removed.

5. FUSE REPLACEMENT

The AC power fuse for the instrument is mounted on the back panel close to the power on-off switch. It should only be replaced by a 250mA anti-surge type 20mm cartridge fuse.

The fuse for the 200mA and lower current ranges is mounted on the back panel on the opposite side from the power on-off switch. If blown, it should be replaced by a 1 amp quick-blow H.R.C. type 20mm fuse.

The fuse for the 2000mA and 5 amp ranges is mounted internally. If these ranges cease to operate whilst the lower current ranges continue to operation, it can be concluded that this fuse has been blown. To replace it, unscrew the four bolts through the instrument feet and dismantle the case. The fuse is located on the right hand side of the main PCB just behind the switchbank. Replace with a 5 amp quick-blow H.R.C. type 20mm fuse.

6. WARM-UP TIME

The instrument uses a high performance ovened reference which has a 5 minute warm-up period. In addition, other components warm up gradually and full accuracy is not guaranteed until one hour after switch-on, a reduced accuracy is guaranteed for use after 5 minutes. See section 12.

The instrument has a measurement sensitivity of $1\mu V$ on the 200mV range and on current ranges. This very high sensitivity can result in variation of the zero position with temperature caused by thermocouple effects in the input connections.

A typical junction of two different materials (e.g. a copper lead soldered to a brass clip) generates a thermoelectric output of several tens of microvolts per °C. Consequently, care must be taken to ensure that pairs of connection leads are of similar materials and are not subject to temperature differentials when trying to resolve microvolt levels.

The null key can be used to remove zero errors, but if either the instrument or the measurement source is still warming up, it may be necessary to re-check the zero position at intervals.

7. MAINTENANCE AND REPAIR

The manufacturers or their agents overseas will provide repair for any unit developing a fault. Where owners wish to undertake their own maintenance work, this should only be done by skilled personnel in conjunction with the service manual which may be purchased directly from the manufacturers or their agents overseas.

In the UK, defective instruments should be returned, carriage paid, to the manufacturers' Service Department. Careful and substantial packing is essential—no responsibility can be accepted for damage caused in transit to the manufacturer—if possible, retain the original packing material. If the guarantee has expired or if the fault is the result of misuse, the repair will be carried out and charged unless other instructions are received.

Customers outside the UK should contact the dealer from whom the unit was purchased to ascertain service arrangements for that country.

8. GUARANTEE

The instrument is guaranteed as free from defects in workmanship or materials. The terms of the guarantee will vary dependent upon the country in which it is sold. Information concerning the guarantee can be obtained from the agent from whom the instrument was purchased.

9. COMPUTING AND DATALOGGING FUNCTIONS (PROGRAMS)

A range of intelligent functions are available which require more than one key depression to operate them. These functions are marked in orange above the digit keys 1 to 9, and are selected by depressing the appropriate digit key followed by additional keys as described in section 10.

9.1 *—deferred facility, no function on basic instrument.

9.2 Logger—enables up to 100 readings to be stored in memory for recall later. Storage can be automatic at a pre-programmed time interval, or manual. Stored readings can be recalled to the display when required. The mode of storage is defined by entering a value for the constant 'Period'.

If automatic storage is required, Period should be set to the number of seconds which represents the interval required between each reading stored. The minimum is 1 second and the maximum 9,999 seconds. For example, if storage every 5 minutes is required, Period should be set to 300.

If storage is required more frequently than once per second, Period may be set to zero, in which case readings will be stored at conversion rate (approx. 3 per second).

If manual storage is required, Period must be set to —0000. Readings are then stored every time the 'store' key is depressed.

As each reading is stored, the storage location number will be displayed briefly. This is inhibited for Periods of 3 seconds or less. Stored data is lost as soon as power is interrupted. At switch-on Period is initialised to 0000.

9.2 AvLoHi—enables the running average, lowest reading and highest reading that occur while the program is being run to be stored in memory for recall later. Stored data is lost as soon as power is interrupted.

9.4 Filter—enables varying amounts of additional digital filtering to be selected by setting a single digit constant for the required filter characteristics and running the program. Filter=1 gives minimum filtering, Filter =5 gives maximum filtering. See Appendix 14.1. At switch-on the constant is initialised to 1.

9.5 Dec Pt (decimal point)—enables the decimal point to be be repositioned in order to change the engineering units of the display. This is done by setting a single digit constant for the required position and running the program. Dec Pt=1 places the decimal point to the right of the least significant digit (5½ digit mode). Dec Pt=2 puts it to the right of the next digit etc. Dec Pt=0 will blank the decimal point. At switch on the constant is initialised to zero.

9.6 dB—enables voltage, current or resistance to be displayed in logarithmic form.

In order to facilitate the display of voltage in decibels, the result of the calculation $20\log_{10}\frac{x}{\sqrt{Ref}}$ is displayed where x is in volts. The display can be in dBV (dBs relative to 1 volt), dBm (dBs relative to 1mW of power into a reference impedance), or dB rel (dBs relative to a measured voltage representing 0dB).

For dBV the constant Ref should be set to 1.000.

For dBm the constant Ref should be set to the value in kΩ of the required reference impedance. This can lie between 0.001kΩ and 9.999kΩ.

For dBrel the constant Ref can be set to any value (1.000 is convenient). Then the dB program should be set operating, the required 0dB voltage level applied and the 'riull' key depressed.

N.B. The dB function calculates to 0.01dB, but where the input is too small to calculate an accurate result, one or both of the least significant digits will be suppressed.

The function can be used to display other logarithmic relationships in addition to dBs, see Appendix 14.2. At switch-on Ref is initialized to 1.000.

9.7 Ax+b (scaling with offset)—enables a reading to be multiplied by a scaling factor A and an offset b to be added. The result of the calculation Y=Ax+b is displayed.

A must lie between ±0.00001 and ±9.99999. b must lie between zero and ±399999 (decimal point positioned according to range). At switch-on A is initialised to 1, and b to zero.

9.8 △% (percentage deviation)—enables the percentage amount that a reading differs from some nominal value (represented by the constant n) to be displayed according to the formula $Y=\frac{x-n}{n}\times100$. n must lie between ±000010 and ±399999 (decimal point positioned according to range). At switch-on n is initialised to 100000.

9.9 Limits—enables the reading to be compared with high and low limit readings set as constants. A 3½ digit reading is displayed along with a two-letter code as follows: x<low limit—LO, low limit <x>high limit—PA(Pass), high limit<x—HI.

The limit values may lie anywhere between +399999 and —399999 (decimal point positioned in accordance with range), but the high limit must be greater than or equal to the low limit. At switch-on both limits are initialised to zero.

10. USING A PROGRAM

10.1 Select the required program by depressing the key below the program name. Observe the prompt word on the display.

Enter?—indicates that constants for the program remain as initialised at switch-on, and that the user has not yet reviewed them or entered different ones. (Not relevant to AvLoHi).

Run?—indicates that the user has already stored constants for the program and may therefore wish to run the program without first using the review/enter sequence.

Cancel?—indicates that the selected program is already running.

Recall?—relevant only to AvLoHi and Logger. Indicates that stored data exists which would be cleared if the user was to press the 'run' key.

10.2 To review or enter program constants (having first selected the required program).

Depress $\boxed{\begin{array}{c}\text{enter}\\\hline\text{review}\end{array}}$ —name of first constant is displayed, followed by the existing stored value of first constant.
Enter new digits if required (follow the flashing prompt).
Use +/— key to change sign if required.

Depress $\boxed{\begin{array}{c}\text{enter}\\\hline\text{review}\end{array}}$ —displayed value of first constant is entered into memory. Name of second constant is displayed (where applicable), followed by the existing stored value of second constant.
Enter new digits and sign if required.

Depress $\boxed{\begin{array}{c}\text{enter}\\\hline\text{review}\end{array}}$ —displayed value of second constant is entered into memory.
Observe display prompt word.

Notes on constant entry:
i. When the instrument is first switched on, all program constants are initialised to the values shown in Table A. **Once entered, all constants are retained until power is interrupted.**
ii. The decimal point is set automatically (usually as per the range).
iii. Depressing the first digit key will cause all following digits to be set to zero. Trailing zeros need not be entered.
iv. When all digits have been entered, the prompt returns to the left hand side. If an error has been made, it can be corrected by entering the digits again.
v. The RDG key can be used to enter a measured value for the constant 'b' in Ax+b, 'n' in △%, or either constant in Limits. Depressing RDG in place of a digit key will cause the display to show the reading that it would show if the enter/review sequence was not being used.

vi. The largest value that can be entered for each constant is given in Table A. If a value greater than this is entered, it will not be entered into the memory when the enter/review key is depressed. 'Error' will be displayed briefly and the constant will be changed to the maximum allowable value.
vii. The smallest value that can be entered for each constant is given in Table A. If a value smaller than this is entered, it will not be entered into memory when the enter/review key is depressed. 'Error' will be displayed briefly and the constant will be changed to the smallest allowable value.

Table A

Program	Constant	Initialised value	Max. value	Min. value
Logger	Period	0000	9999	—0000
Filter	Filter	1	7	0
Dec Pt	Dec Pt	0	7	0
dB	Ref	1.000	9.999	0.001
Ax+b	A	1.00000	±9.99999	0.00001
	b*	000000	±399999	000000
△%	n*	100000	±399999	000010
Limits	Hi*	000000	±399999	000000
	Lo*	000000	±399999	000000

Constants marked * have their decimal point positioned according to range and function.

10.3 To start a program operating (having first selected the required program).

Depress $\boxed{\begin{array}{c}\text{clear}\\\hline\text{run}\end{array}}$ —(clears existing stored data for AvLoHi and Logger)

To set the selected program operating without clearing existing stored data (AvLoHi and Logger).

Depress $\boxed{\begin{array}{c}\text{continue}\\\hline\text{RDG}\end{array}}$

10.4 To stop a program operating (having first selected the required program)

Depress $\boxed{\begin{array}{c}\text{cancel}\\\hline 0\end{array}}$

10.5 To recall stored data for the Logger program (having first selected Logger)

Depress $\boxed{\begin{array}{c}\text{step}\\\hline\text{recall}\end{array}}$ —number of first location is displayed followed by the value of the stored data.

Depress $\boxed{\begin{array}{c}\text{step}\\\hline\text{recall}\end{array}}$ —number of next location is displayed followed by the value of the stored data
etc.

Notes on data recall for Logger:

i. Storage locations are recalled in cyclic order. The first location recalled is the one most recently used. Unused locations are not recalled.

ii. Depressing the +/— key at any time during a data recall sequence will reverse the order in which locations are recalled.

iii. Holding the step/recall key permanently depressed will cause the locations to be stepped through continuously.

iv. When recalled data is on the display, a flashing 'r' symbol appears.

v. Data storage continues whilst data recall is taking place unless Logger has been cancelled first.

10.6 To recall stored data for AvLoHi (having selected AvLoHi)

Depress $\boxed{\frac{\text{step}}{\text{recall}}}$ –ARG is displayed, followed by the average value of readings taken.

Depress $\boxed{\frac{\text{step}}{\text{recall}}}$ –Lo is displayed, followed by the lowest value of readings taken.

Depress $\boxed{\frac{\text{step}}{\text{recall}}}$ –Hi is displayed, followed by the highest value of readings taken.

Depress $\boxed{\frac{\text{step}}{\text{recall}}}$ –ARG is displayed, followed by the average value of readings taken

etc.

Note: Data storage continues whilst data recall is taking place unless AvLoHi has been cancelled first. When recalled data is on the display, a flashing 'r' symbol appears.

10.7 To exit from a data recall sequence:

Either:
a. Depress $\boxed{\frac{\text{cancel}}{0}}$ – program is discontinued, stored data remains unchanged.

or b. Depress $\boxed{\frac{\text{continue}}{\text{RDG}}}$ program continues operating, stored data is not cleared

or c. Depress $\boxed{\frac{\text{clear}}{\text{run}}}$ –stored data is cleared, program restarts.

10.8 Simultaneous operation of programs

Any number of programs may be operated simultaneously, but the sequence in which data is fed to the various programs is pre-defined as shown opposite.

Thus, if Limits and Ax+b are run simultaneously, the Limits program will operate on the output of the Ax+b program and never the other way round.

10.9 Checking program status

i. Indication that one or more programs are running is given by pulsing of the decimal point at conversion rate.

ii. A check can be made on which programs are operating by depressing the 'review key' without first depressing a program key. This will cause the display to show Pro = followed by the numbers corresponding to the programs which are running. Thus Pro = 7 2 would indicate that Ax+b and Logger were running.

10.10 Cancelling all programs simultaneously

To cancel all programs simultaneously the Cancel/0 key should be depressed without first depressing a program key. The message Pro Cncl will be displayed briefly, and all running programs will be cancelled.

10.11 Decimal point handling

With exception of dB, the programs take no account of function and range settings and ignore the position of the decimal point. Constants are stored and results displayed as integer numbers with the decimal point normally being inserted on the display from the position of the function and range switches.[1]

Consequently, values stored for the constants b, n, Hi and Lo may be invalid when the range is changed since the decimal point will appear in a different position.

Similarly, data stored by AvLoHi or Logger contains no decimal point information, and therefore the function and range switches must be in the same position when the data is recalled as when it was stored.

If range or function is changed when a program is running, 'In Pro' will be displayed briefly as a reminder that the new displayed result may be invalid.

Operation of the Dec Pt program overrides all other control of decimal point position.

10.12 Display overflow

If the result of a computation exceeds ±399999 the display will show OFLO (overflow).

[1]The decimal point position is fixed independently of function or range when the dB or Δ% programs are operating.
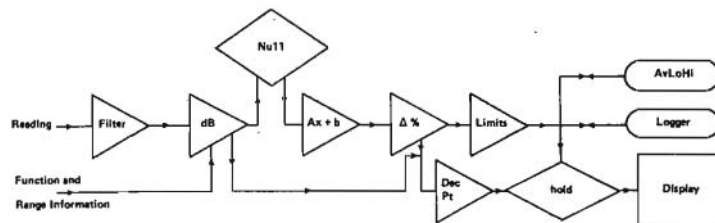
11. PROGRAM EXAMPLES

It is advisable to work through the following examples of the computing and datalogging functions before trying them out in an actual measurement situation.

a. A temp. transducer has an output of 2mV per °K. The user wishes to obtain a direct reading in °C. He can do this by measuring using the 2000mV range and setting the Ax+b program for A=0.5, b=—273.

Depress Key	Display shows	Comment
	x(mV)	
Ax+b 7	Enter?	constants as initialised at switch-on
enter review	A=	Examine constants, and change as required
	1.00000	Present value of A
0	0.00000	0 entered as 1st digit
5	0.50000	5 entered as 2nd digit
enter review	b=	0.50000 entered into memory
	0000.00	Present value of b. Decimal point positioned in accordance with range
0	0000.00	0 entered as 1st digit
2	0200.00	2 entered as 2nd digit
7	0270.00	7 entered as 3rd digit
3	0273.00	3 entered as 4th digit
+/—	—0273.00	Sign changed
enter review	Run?	—27300 entered into memory, program ready to operate
clear run	0.5x—273 (°C)	Program operating (decimal point flashes)
Ax+b 7	Cancel?	Indicates Ax+b is already operating
cancel 0	x(mV)	Program cancelled
A+b 7	Run?	Program constants retained so program ready to operate
cancel 0	x(mV)	Program cancelled

b. The user wishes to measure AC voltage expressed in dBs relative to 1 milliwatt into 600Ωs. The user starts by selecting an AC voltage range which gives the best resolution for the voltage he wishes to measure. He then sets the dB program for a 600Ω reference.

Depress Key	Display shows	Comment
	x(volts)	
dB 6	Enter?	Constant as initialised at switch-on
enter review	Ref=	Examine constant and change as required
	1.000	Present value of Ref
0	0.000	0 entered as 1st digit
6	0.600	6 entered as 2nd digit
enter review	Run?	600 entered into memory, program ready to run
clear run	$20 \log \frac{x}{\sqrt{.6}}$ dBm	Program operating (decimal point flashes)
dB 6	Cancel?	Indicates dB already running
cancel 0	x(volts)	Program cancelled

N.B. Should the user get 'lost' when programming the instrument and become unable to continue, he should switch the instrument off and on, and restart from the beginning.

c. The user wishes to observe the drift of a 15 volt supply as a percentage of its initial voltage. He can do this by using the $\triangle\%$ (percentage deviation function)

Depress Key	Display shows	Comment
	15.000	
$\triangle\%$ 8	Enter?	Constant as initialised at switch-on.
enter review	n=	Examine constant and change as required
	10.0000	Decimal point positioned by range
continue RDG	15.0000	Voltage reading entered as constant for n
enter review	Run?	15.0000 entered into memory program ready to operate
clear run	00.000(%)	Program operating (decimal point flashes)
$\triangle\%$ 8	Cancel?	Indicates $\triangle\%$ is already operating
cancel 0	15.0000	Program cancelled

d. The user wishes to examine the stability of a resistance over a 15 minute period. He decides to log readings at 10 second intervals.

Depress Key	Display shows	Comment
	x(Ωs)	
Logger 2	Enter?	Constant as initialised at switch-on. No previous stored data
enter review	Period=	Examine constant and change as required
	0000	Present value of period
0	0000	0 entered as 1st digit
0	0000	0 entered as 2nd digit
1	0010	1 entered as 3rd digit
enter review	Run?	10 entered into memory program ready to run
clear run	Store 0	Any previous stored data cleared, logging commenced at location 0
	x(Ωs)	Logger running (decimal point flashes)

	Wait about 1 minute	
Logger 2	Cancel?	Indicates that Logger is running
cancel 0	x(Ωs)	Logger cancelled
Logger 2	Recall?	Stored data still in memory
step recall	Store N=	Recall sequence commences at most recently used location
	x(Ω)	Data stored in Location N (flashing r indicates recalled data)
step recall	Store 0=	Recall sequence progresses to first location
	x(Ωs)	Data stored in location 0
step recall	Store 1=	Recall sequence progresses to next location
	x(Ωs)	Data stored in location 1
+/−	x(Ωs)	Reverse recall sequence order
step recall	Store 0=	Recall sequence goes backwards
	x(Ωs)	Data stored in location 0
continue RDG	StoreN+1	Continues storing at next available location
	x(Ωs)	Logger running (decimal point flashes)
Logger 2	Cancel?	Indicates that Logger is running
Cancel	x(Ωs)	Logger cancelled

9

e) The user wishes to sort 10kΩ resistors into batches, those between 0% and +3% of nominal, those above +3%, and those below nominal. He can do this by measuring using the 20kΩ range and simultaneously using the △% and Limits programs.

Depress key	Display shows	Comment
	x(kΩ)	
△% 8	Enter?	Constant as initialised at switch-on
enter review	n=	Examine constant and change as required
	10.000	
enter review	Run?	Constant entered into memory unchanged. Program ready to run
run	x(%)	△% program running
Limits 9	Enter?	Constants as initialised at switch-on.
enter review	Hi=	
	000.000	Present value of high limit
0	000.000	0 entered as 1st digit
0	000.000	0 entered as 2nd digit
3	003.000	3 entered as 3rd digit
enter review	Lo=	3.000 entered into memory
	000.000	Present value of low limit
enter review	Run?	Constant entered into memory unchanged. Program ready to run.
clear run	x(%)PA	△% and Limits program running
cancel 0	x(kΩ)	Both programs cancelled

12. SPECIFICATIONS

Accuracies	±(% reading+% full scale+digits)	
	1yr 18-26°C	24hrs ± 1°C

DC Voltage

±210.000mV	.025%r+002%s+ 2dgt*	.015%r+.0015%s+2dgt*
±2100.00mV	.015%r+.002%s+ 1dgt	.01%r +.0015%s+1dgt
±21.0000V	.02%r +.002%s+ 1dgt	.01%r +.0015%s+1dgt
±210.000V	.025%r+.002%s+ 1dgt	.015%r+.0015%s+1dgt
±1100.00V	.025%r+.002%s+1dgt	.015%r+.0015%s+1dgt

Resistance

210.000Ω	.05%r +.003%s + 2dgt*	.035%r+.003%s +2dgt*
2100.00Ω	.05%r +.002%s + 2dgt	.035%r+.002%s +2dgt
21.0000kΩ	.04%r +.002%s + 2dgt	.03%r +.0015%s+2dgt
210.000kΩ	.04%r +.002%s+ 2dgt	.03%r +.0015%s+2dgt
2100.00kΩ	.08%r +.002%s + 2dgt	.06%r +.002%s +2dgt
21.0000MΩ	.25%r +.002%s + 2dgt	.2%r +.002%s +2dgt

DC Current

±210.000μA	.1%r +.002%s+2dgt*
±2100.00μA	.1%r +.002%s+2dgt*
±21.0000mA	.1%r +.002%s+2dgt*
±210.000mA	.15%r +.002%s+2dgt*
±2100.00mA	.25%r +.002%s+2dgt*
±5.0000A	.45%r +.002%s+2dgt*

*indicates use of null key

AC Voltage

210.00mV	.3%r	+.05%s	+10dgt
2100.0mV	.2%r	+.02%s	+ 4dgt
21.000V	.2%r	+.02%s	+ 4dgt
210.00V	.3%r	+.02%s	+ 4dgt
750.0V	.3%r	+.02%s	+ 4dgt

AC Current

210.00μA	.3%r	+.05%s	+10dgt
2100.0μA	.3%r	+.05%s	+10dgt
21.000mA	.3%r	+.05%s	+10dgt
210.00mA	.3%r	+.05%s	+10dgt
2100.0mA	.45%r	+.05%s	+10dgt
5.000A	.65%r	+.05%s	+ 4dgt

Diode Test (excitation 1mA)
2100.00mV   5%r

Tempco (0-18°C, 26-40°C) — <0.1 of accuracy applicable to range per °C

Additional errors for warm-up period of 5 mins only:
2100mV DC range—0.015%r+1dgt
All other ranges—0.025%r+1dgt

Thurlby maintain a policy of continuous development and reserve the right to alter specifications without notice.

Overload Protection

Voltage	(Spike protection to 6kV)
200mV, 2000mV	400VDC or RMS continuous
	1100VDC or 750V RMS 10 secs.
Higher ranges	1100VDC or 750V RMS
	continuous (max 10^7 volt-Hertz)
Resistance	400VDC or RMS continuous
	Spike protection to 6kV
Current 200mA, 5A	5 amps 250V RMS
Lower Ranges	1 amp 250V RMS
Input Impedance	$10M\Omega \pm .05\% // <150PF$
	$>1000M\Omega$ selectable
	for 200 or 2000mV ranges
Max Voltage Burden	$200\mu A$, $2000\mu A$, 20mA <220mV max
(current)	200mA <350mV max, 2000mA
	<400mV max, 5A<1V max
Max o/c voltage	5V
(resistance)	
AC response	AC coupled. Mean sensing, RMS cali-
	brated for sine wave. Accuracies apply
	above 1000 counts. Current 45Hz-1kHz,
	Voltage 45-65Hz.

Additional errors

AC Voltage

	65 Hz-400Hz	- 5kHz	- 20kHz
200/2000mV	.1%	.2%	.5%
20V	.4%	2%	5%
200V	1%	5%	
750V	2%		

Reading rate	3.125 per second (50Hz versions)
	3 per second (60Hz versions)
Display	13mm red LED, 8 digits
Scale length	4½ or 5½ digits
Overrange	displays OR
Input current	<100pA
Max Common Mode	
Voltage	500V DC or RMS
DC NMR	>60dB at 50Hz (or 60Hz)
1kΩ CMR	>120dB at DC/50Hz (or 60Hz)
Temp Range	—20°C to +60°C storage
	0°C to +40°C operating
Weight	1.85Kg (4 lb)
Dimensions	230 x 230 x 90mm (9″ x 9″ x 3½″)
Power requirement	220 or 240V $\pm$ 10% 48-52Hz
	or to special order:
	110 or 120V $\pm$ 10% 57-63Hz
Safety classification	IEC Class I

13. CALIBRATION REQUIREMENTS

In order to ensure accurate measurements, some simple precautions should be followed. Keep the instrument dry. Do not place on top of equipment that generates heat, or place equipment on top of the instrument. Do not subject the instrument to extremes of temperature.

The specifications apply for a period of 12 months. Re-calibration at 12 month intervals is recommended for applications where conformance to original specifications is of critical performance.

The manufacturers provide a re-calibration service, as will their agents overseas. Where owners wish to carry out their own re-calibration, this should only be done by skilled personnel with access to precision equipment, and using the service manual and calibration cover that may be purchased directly from the manufacturer or their agents overseas.

APPENDICES
14.1 Digital Filtering
The digital filter differs from a conventional filter in that it is able to effectively attenuate noise yet still respond rapidly to a change at the input.

The attenuation of noise is achieved by averaging the last N readings whilst the rapid response to change is achieved by continuously comparing the present average (A) with the most recent reading (R), and displaying A if $|R-A|<J$ or displaying R if $|R-A|\geq J$. J is a constant defined by the filter characteristics and called the Jump-Out.

The characteristics of a digital filter can be modified by changing the number of readings averaged (N) and the Jump-Out figure (J). Increasing J will increase the maximum amplitude of noise that can be filtered. Increasing N will increase the attenuation of that noise. However the instrument will take N readings to settle for a change of input lower than J, and consequently a large value for J would give a slow response for anything other than a large input change. Thus, J should ideally be set as small as possible whilst still being larger than the amplitude of the unfiltered noise.

With J set low, the value of N will not affect the response time for a step input change, but if the input is changing very slowly a large value of N will cause the display to lag behind the input. Thus N should normally be set as low as possible whilst still achieving adequate noise filtering.

To enable the user to make the best use of the instrument over a wide range of circumstances, the Filter program allows the filter characteristics to be varied by the user. Without the Filter program operating the filter characteristics are set to levels suitable for most measurement situations. Eight alternatives are available by running the Filter program. Of these Filter 0 is not intended for normal use, and Filters 6 and 7 are intended for averaging a rapidly changing input signal rather than for filtering noise.

Program Number	Readings averaged (N)		Jump-Out (J) digits in 5½
Filter program not operating	Voltage (except 200mV)	4	10
	200mV and current	8	40
	Resistance (except 10M)	8	40
	10MΩ	8	100
0*	2		10
1	8		40
2	16		100
3	32		100
4	8		1000
5	32		1000
6	8		∞
7	16		∞

*not recommended for normal use

14.2 Logarithmic calculations
The dB function can be used to provide a general logarithmic function in addition to dB calculations.

The displayed value represents $20\log_{10}\dfrac{x}{\sqrt{Ref}}$ where x is in volts, mA or kΩ and Ref is initialised to 1.

If, for instance, it is required to display $\log_e x$, this can be done by applying the equality

$$\log_e x = \log_e 10 \times \frac{1 \times 20\log_{10}x}{20} = 0.11513 \times 20\log_{10}x$$

Thus by combining the dB program (Ref=1.000) with the Ax+b program (A=0.11513, b=0) a display representing $\log_e x$ can be achieved.

Alternatively, if it is required to display $10\log_{10}2x$, this can be done by applying the equality $10\log_{10}2x = \frac{1}{2}(20\log_{10}x + 20\log_{10}2)$. Thus by combining the dB program (Ref=1.000) with the Ax+b program (A=0.5, b= 6.0206) a display representing $10\log_{10}2x$ can be achieved.

Note 1: The dB function always uses 1 volt, 1mA or 1kΩ as the reference for voltage, current or resistance ranges respectively. Thus an input of 1500mV will read the same on the 2000mV and 20V ranges when the dB program is running, despite the change in measurement units above the range button.

Note 2: The 5A range is not correctly encoded for use with the dB function, and if the dB program is run while measuring using the 5A range, the reading will be 20dB too low.

14.3 Ax+b and 4-20mA current loops
The provision of the Ax+b function combined with an overrange point of 21mA makes the instrument ideal for use with 4-20mA current loop systems.

For example, a user may wish to monitor a weighing system which outputs 4mA at 0 kilograms, and 20mA at 10 kilograms. He calculates the values for A and b as follows: $A= \dfrac{10}{20\text{-}4} =0.625$; $b=-(4x.625)=-2.5$

Thus by measuring the loop output using the 20mA range and running the Ax+b program with A=0.625, b=—2.5, a direct readout of weight in kilograms is obtained.