TECHNICAL MANUAL

FOR

MODEL 5031

AIR BATH

TM5031-D1-00
15 May, 2019

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1. INTRODUCTION

Figure 1-1: Front View

1.1. SCOPE

This manual contains technical specifications, a detailed description, maintenance information, and diagrams for the Guildline Instruments model 5031 Air Bath.

1.2. GENERAL DESCRIPTION

The model 5031 Air Bath is a bench top high precision, variable temperature bath which provides 0.08 m^3 (2.9 cu. ft.) of usable temperature controlled chamber. The internal temperature is maintained by a solid state control system. The regulated temperature can be selected from a digital switch control on the front control panel. The temperature range is from 15.00 °C to 50.00 °C with a resolution of 0.01 °C and ± 0.03 °C stability. The design assures minimal thermal gradients within the chamber.

The air bath chamber is of stainless steel construction. This shielded enclosure is tied to earth ground through the power cord to reduce electromagnetic interference. The circulation fan, cooling unit and heater are separated from the air bath chamber to provide full and unimpeded access to the bath chamber.

The design of the bath employs a fixed rate of cooling from a thermoelectric module and balances this to the heating/cooling level required by turning a heater off and on rapidly. This provides the required heating/cooling to balance the heat losses to ambient or the heat generated by apparatus within the chamber.

To protect the contents of the chamber from overheating due to a malfunction of the temperature control, there is an overriding over-temperature control that will disable the heating system if the temperature exceeds 55 °C ± 4 °C.

Uses for the Programmable Air Bath include:

- Maintaining a constant temperature environment for reference resistors such as the Guildline Instruments 9330 series resistors.
- Calibration of thermometers.
- Thermal stressing of precision materials.

Figure 1-2: Control Panel

1.3. FRONT PANEL INDICATORS AND CONTROLS

The front panel indicators and controls are illustrated in Figure 1-2. They are provided to indicate power status, heater operation and temperature status.

1.3.1. Power

The POWER switch controls AC line power to the air bath.

1.3.2. Heater ON and OFF

The HEATER indicator lamps indicate whether or not the heater is energised; alternating illumination indicates that the bath has reached the pre-set operating temperature.

1.3.3. High / Low

This switch, in the HIGH position, energises the heater with full-wave current. In the LOW position a diode in series with the heater provides half-wave operation and so reduces the heater power to half the value obtained on the HIGH position. When operating in the LOW position only one electrode of the neon lamps will glow, while in the HIGH position both will be illuminated.

1.3.4. Cooling

Operation of the cooling switch will energise the circuit supplying current to the cooling modules and also operate the fan, which cools their associated heat sink.

1.3.5. Temperature Set

The temperature setting is controlled by means of the four-digit thumbwheel switch. The table enclosed with this manual indicates the control settings for temperatures over the entire range of 15 °C to 50 °C. The effect of a one step change of these dials on the temperature set point will vary depending upon their settings. The rate of change of resistance setting vs. operating temperature is approximately -4%/°C. The total resistance of the 4-digit TEMPERATURE SET control is 200 Ω more than the value indicated. For example, if the operating temperature is 23 °C when the control is set to 4000 (i.e. resistance is 4200 Ω), then changing the control setting to 3832 (4000 - 4% of 4200) will produce an operating temperature of approximately 24 °C.

1.4. REAR PANEL CONNECTORS AND CONTROLS

The rear panel connectors and controls include power entry, and line voltage selection.

1.4.1. Line Input Connector

The Line input connector is a standard male 3-prong AC connector, with an integral fuse. A 2 amp time delay fuse is provided for 115 VAC operation and a 1 amp time delay fuse is provided for 230 VAC operation.

1.4.2. Voltage Selector

The line input voltage selector is a two-position switch that allows setting for a nominal line voltage of either 115 VAC, or 230 VAC. The actual limits of the line voltage are 90-132 VAC or 200-264 VAC, 47-63 Hz.

2. SPECIFICATIONS

2.1. GENERAL SPECIFICATIONS

SPECIFICATIONS	5031
Chamber Temperature Range	15 °C to 50 °C, (Minimum to 6 °C below ambient)
Temperature Set Point Accuracy	± 0.06 °C over 1 year within ± 5°C of ambient ± 0.1 °C over 1 year outside ± 5°C of ambient ± 0.2 °C over 1 year set point over 40°C
Set Point Resolution	0.01 °C
Temperature Stability	± 0.015 °C over 24 hours within ± 2 °C ambient ± 0.03 °C over 24 hours within ± 5 °C ambient ± 0.06 °C over 24 hours outside ± 5 °C ambient ± 0.2 °C over 24 hours set point over 40°C
Temperature Uniformity	± 0.2 °C relative to chamber center, 5 cm minimum from walls for +15 °C to +40 °C
Temperature Attenuation	± 0.04 °C/°C of ambient temperature
Heating Rate	6 °C/hour
Cooling Rate	5 °C/hour, above ambient temperature 2 °C/hour, below ambient temperature
Cold Power On Stabilization	6 hours to within ±0.1 °C of set point
Over Temperature Protection	Automatic shutdown if temperature exceeds 55 °C ± 4 °C
Maximum Power Dissipation of unit under test (set point above ambient)	5W maximum

Table 2-1: General Specifications

NOTES:

1. These specifications are applicable with the air bath chamber empty.
2. The temperature set point shall be no more than 6 °C below the ambient temperature.
3. 24 hour set point accuracy and stability are defined as the deviation of the mean hourly value from the 24 hour mean for a single ambient temperature point at one point in the air bath chamber (typically the center). The peak to peak stability can be higher (±0.06 °C typical) depending on the temperature selected.
4. Temperature uniformity is relative to the center of the air bath chamber and at least 5 cm from the walls of the chamber for +15 °C to +40 °C.

3. OPERATING INSTRUCTIONS

3.1. INSTALLATION

This instrument was thoroughly tested and inspected before shipment and should be free from damage when received. Inspect it carefully, verify that all items on the packing list are present and check the instrument operation as soon as possible. Refer to the warranty card at the front of this manual if any damage or deficiencies are found.

The installation procedure is as follows:

1. Place the instrument on a stable bench capable of supporting the weight of the air bath.

CAUTION

> Ensure that air flow through the rear door is not obstructed. Allow at least 25 cm clearance.

2. Set the controls as follows:

- POWER:	OFF
- COOLING:	OFF
- TEMPERATURE SET:	9999

3. Ensure that the correct fuse has been installed – 2 A 250 V (T) should be used for a nominal line input of 115 V and 1 A 250 V (T) should be used for a nominal line input of 230 V. Only fuses with the rated current and specified type should be used for replacement.

> The 5031 has been shipped with the line input voltage selector set to 230 V. The line input selector must be set to the correct line voltage before power is applied to the instrument. The settings available are 115 V and 230 V. Remove the warning label positioned across the power line input socket after setting the correct operating voltage.

4. Plug the supplied moulded line cord into the 3-pin power receptacle on the rear panel of the instrument. Ensure that the other end of the line cord is plugged into a wall socket or extension cord that has a protective or safety ground. Where 3-contact power supply outputs are not available, a suitable protective ground connection must be made before switching the instrument power on. Any interruption of the protective ground may possibly render the instrument unsafe.

Where the moulded plug on the line cord supplied with the instrument does not match the local power outlet socket, the plug can be removed and replaced with one that does fit the local service. The plug should be re-wired as follows:

Brown wire-	Line input
Blue wire-	Neutral input
Green/Yellow	Ground (safety)

5. Set the POWER switch to the ON position and observe that the HEATER OFF lamp lights and the circulating fans operate.

6. Set the COOLING switch to the ON position and observe that the fan on the rear door operates and that both cooling fins behind the rear door become warm.

7. Set the TEMPERATURE SET switches appropriately, according to the table enclosed with this manual, for the desired air bath temperature. Set the HIGH/LOW and COOLING switches as recommended in Table 3.1 for that set point temperature.

8. When the inner chamber reaches its operating temperature, the HEATER lamps will indicate periodic cycling. Due to the thermal lagging, it will take several hours to raise the inner chamber to the operating temperature. The bath should be allowed to stabilise at the operating temperature for at least 6 hours before use.

3.2. OPERATING NOTES

Operation of the Model 5031 Air Bath comprises of selecting control settings and monitoring the air temperature. The following paragraphs contain suggested procedures for the use of the controls.

3.2.1. Heater Control Setting

The HIGH/LOW and COOLING switches control the amount of power available to heat the Air Bath chamber. Refer to Table 3.1 for the settings to be used under various conditions. If a large temperature increase is required quickly, select HIGH and switch COOLING off until the HEATER ON and HEATER OFF lamps light alternately then change to the setting recommended in Table 3.1. Optimum stability is achieved when the HEATER ON and OFF lamps light approximately an equal amount of time. Table 3.1 also shows when the COOLING control should be ON. Normally it will be used only if the operating temperature is less than 10 °C above ambient or if a large temperature decrease is required quickly.

RANGE	COOLING	HIGH/LOW
15 °C to 20 °C	ON	LOW
20 °C to ambient+10 °C	ON	HIGH
ambient +10 °C to 40 °C	OFF	LOW
40 °C to 50 °C	OFF	HIGH

Table 3-1: Suggested Control Settings

3.2.2. Bath Temperature Selection

The operating temperature is determined by the TEMPERATURE SET control. A table attached to this manual provides the settings required for the full range of the bath. Temperatures not on the table must be arrived at by interpolation between the "dial settings" presented in the table.

A more precise setting of the bath temperature can be achieved by inserting a thermometer in through the side access hole and making a direct measurement of the air temperature within the chamber. The air bath temperature can then be adjusted by changing the TEMPERATURE SET control by –4%/°C of the TEMPERATURE SET resistance. For example, if the desired temperature is 25.00 °C but the actual temperature is 25.16 °C when the TEMPERATURE SET control is set to 3670 (i.e. the TEMPERATURE SET resistance is 3670+200=3870 Ω), then adjust the TEMPERATURE SET control by +25 (i.e. (–0.16)×(-0.04)×3870) to 3695.

4. MAINTENANCE

4.1. PREVENTIVE MAINTENANCE

4.1.1. Cleaning

The instrument requires very little maintenance other than periodic dusting of the outside and inside of the enclosure. Remove accumulated dust from the air filter on the rear door.

4.1.2. Temperature Check

Insert a thermometer in through the side access hole and make a direct measurement of the air temperature within the chamber. Compare this temperature to the expected temperature for the TEMPERATURE SET control setting as indicated by the enclosed temperature setting table.

4.2. CORRECTIVE MAINTENANCE

Symptoms appear at the beginning of each of the following paragraphs as a guide to detailed fault location. Refer to Section 5 of this manual for the PRINCIPLES OF OPERATION.

4.2.1. Preliminary Checks

Check POWER – Either the HEATER ON or HEATER OFF lamp should be lit when the instrument is connected to the AC line and the POWER switch is set to "ON". If not, check that the circulation fans inside the chamber are running. If they are not, then a general loss of power is indicated. Check the line input fuse.

Check the HEATER ON/OFF indicators - They should indicate the cycling on and off of the heater.

4.2.2. Temperature Control

If the temperature is low and the HEATER indicator is lit, check the continuity and resistance of the heater circuit.

If the temperature is low and the HEATER indicator is not lit, check the operation of the control circuit as follows:

1) Short out between WT103 and WT104 and the HEATER indicator should light. If not, then check for a fault in the control circuit. If the indicator lights, then check the resistance of R2 (the TEMPERATURE SET resistance) and RT1 (the thermistor). RT1 is equal to Rl+R103 (200 Ω) at the control temperature, and is larger than R2+R103 if the temperature is lower. It has a temperature coefficient of approximately -4%/°C.

Control circuit board testing - Measure the voltage at the terminals as indicated in Table 4-1.

Between	And	Should Read	Components To Check
7	16	-12 V D.C	CR106, CR107
9	7	-3.2 V	see NOTE 1
10	7	-3.2 V	see NOTE 1
12	7	-3.2 V	see NOTE 1
14	7	≈ -0.3 V	when heater off
		-0.7 V	when heater on: see NOTE 2

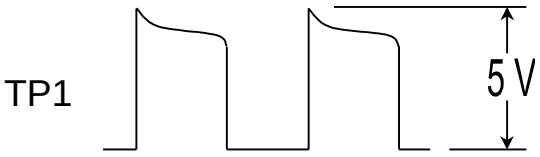
Table 4-1: Control Circuit Board Testing

NOTE 1: If this reading is incorrect, then check the voltage across C101, 500 pF capacitor. – It should read 8.2V ± 5%. If not, then check R107, CR101, CR102 and C101. If correct, then check R102, R105, C103 and Q101.

NOTE 2: If this reading is not obtained, check Q7.

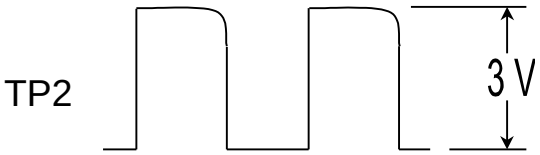
Check the operation of the temperature sensitive oscillator. If the resistance of RT1 is greater than the resistance of Rl, then the oscillator should be running. Check with an oscilloscope between TP1 (collector of Q102) and Jl-7. The waveform should be as shown. If not, then check the following components:

Q101, Q102, C104, T101, C102, R103, R125, R104, R110



If oscillation is observed, then check between TP2 (coil Q103) and Jl-7. The waveform should be as shown. If not, then check the following components:

Q103, C106, R117, R112, R106



If this waveform is observed, then measure the D.C. voltage between TP3 (CR104 anode) and Jl-7. It should read ≥-2.5 volts. If not, then check C105, C107, CR103 and CR104. If it is correct, then check Q104, Q105, R121, R122 and R114.

Note: Both of the above indicated waveforms are typical, if RT1 is at ambient temperature of about 25 °C.

As a further guide to trouble shooting, typical D.C. voltage at the transistor terminals are given in Table 4-2.

DEVICE	VOLTAGE READINGS (Jl-7 Common)					
	HEATER ON			HEATER OFF		
	E	B	C	E	B	C
Q101	-3.05	-3.2	-5.2	-3.05	-3.2	-5.2
Q102	-5.4	-5.2	-3.05	-5.4	-5.2	-3.05
Q103	-2.95	-3.05	-5.3	-2.95	-3.05	-5.3
Q104	-1.4	-2.0	-1.45	————--Variable-———-		
Q105	-75	-1.42	-1.45	————--Variable-———-		
Q7	0	-.75	-.25	0	≈-.25	-12.8

Table 4-2: Transistor Voltages

4.2.3. Over Temperature

If the temperature within the chamber exceeds 55 °C, then the thermal breaker will trip. Allow the enclosure to cool to less than 50 °C. Check that the temperature sensitive switch S2 is open. If this condition is satisfied, then reset the switch. The reset switch is located inside the back panel of the inner chamber. The switch may be accessed by opening the rear door and removing the back panel of the inner chamber. WARNING: Unplug main power cord before removing back panel.

If the HEATER lamps do not indicate heater cycling when the temperature approaches normal, then check the operation of the control circuit as follows:

- Locate pins A and B of P2.

- Short pin A to pin B. The HEATER indicator should go out. If it does, then check the resistances of RT1 and R2 as detailed in section 4.2.2. Replace them as a matched pair. If not, then check at TP1 and TP2 with an oscilloscope (common to J1-7). With P2-A and P2-B shorted, there should be no oscillation. Check the voltage at TP3. It should be zero. Refer to Table 4-2 for voltage measurements to aid in locating the fault in the heater driver.

5. PRINCIPLES OF OPERATION

5.1. INTRODUCTION

The heater control unit in the model 5031 enclosure consists of the following functional blocks:

a) Temperature Control - consisting of a sensor, oscillator, amplifier, detector and heater

b) Overtemperature Circuit

c) Power Supply

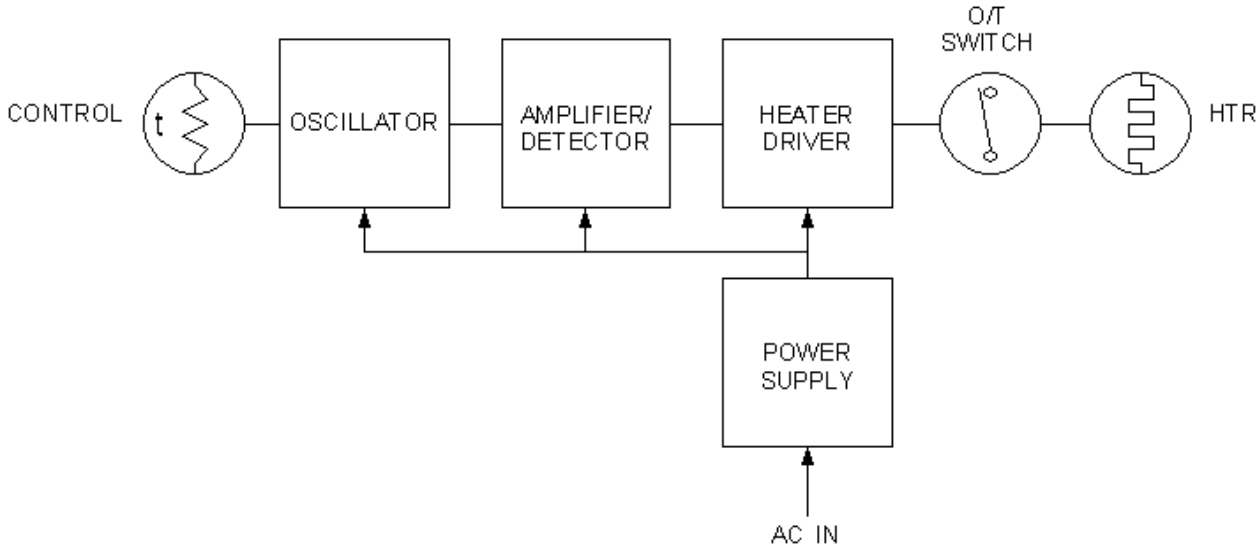


Figure 5-1: HEATER CONTROL UNIT

5.2. TEMPERATURE SENSITIVE OSCILLATOR

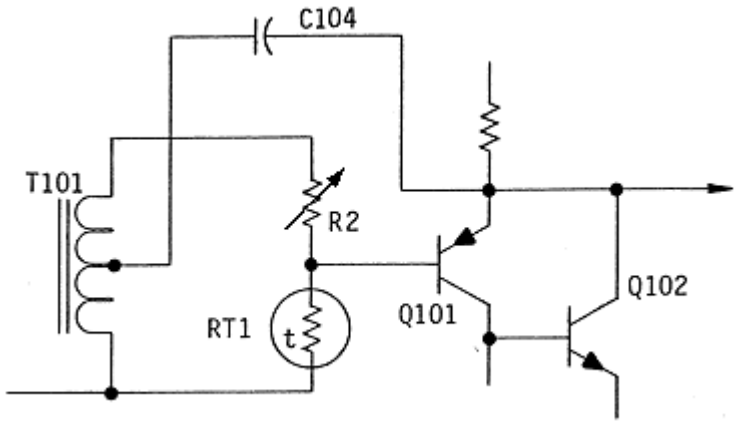


Figure 5-2: TEMPERATURE SENSITIVE OSCILLATOR

Temperature changes are sensed by the thermistor RT1 connected with variable R2 across the 1:2 ratio autotransformer T101. As the temperature decreases, the thermistor resistance increases and the voltage divider output to the base of Q101. As soon as this voltage exceeds half the transformer output, the circuit gain becomes greater than one and oscillation occurs.

5.3. AMPLIFIER AND DETECTOR

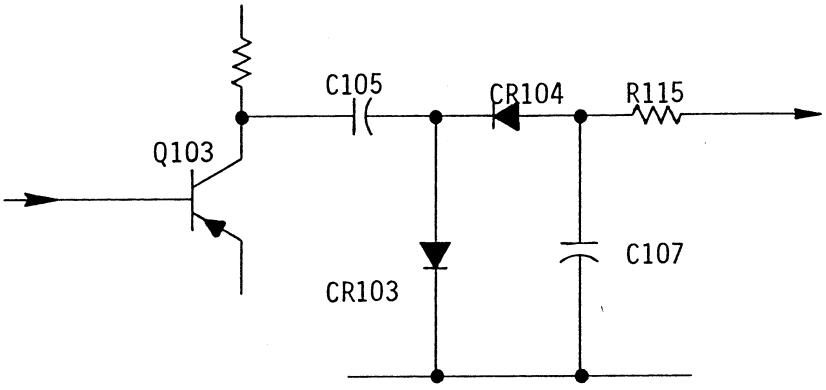


Figure 5-3: AMPLIFIER AND DETECTOR

The output of the oscillator is amplified by Q103 and rectified by a voltage doubler, consisting of C105, CR103, CR104 and C107. The resistor R115 gives current limiting protection for the next stage.

5.4. HEATER DRIVER

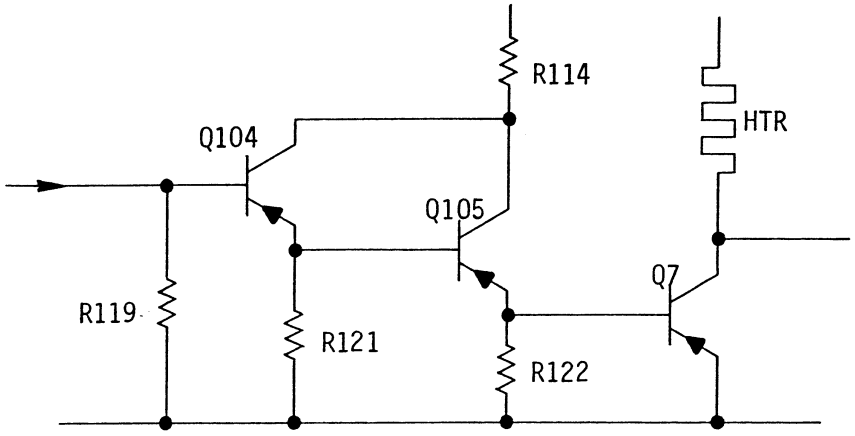


Figure 5-4: HEATER DRIVER

The voltage across C107 causes base current in the emitter follower Q104, which in turn drives another emitter follower Q105. This produces base current to switch on transistor Q7 which controls the heater current. The resistors R119, R121 and R122 ensure that Q7 is not conducting when there is no output from the oscillator.

5.5. OVER TEMPERATURE CIRCUIT

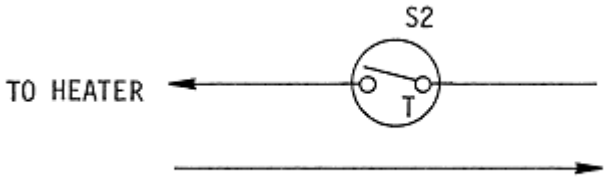


Figure 5-5: OVER TEMPERATURE CIRCUIT

If the temperature in the enclosure exceeds 55 °C, switch S2 opens. This disconnects all power to the heaters.

5.6. POWER SUPPLY

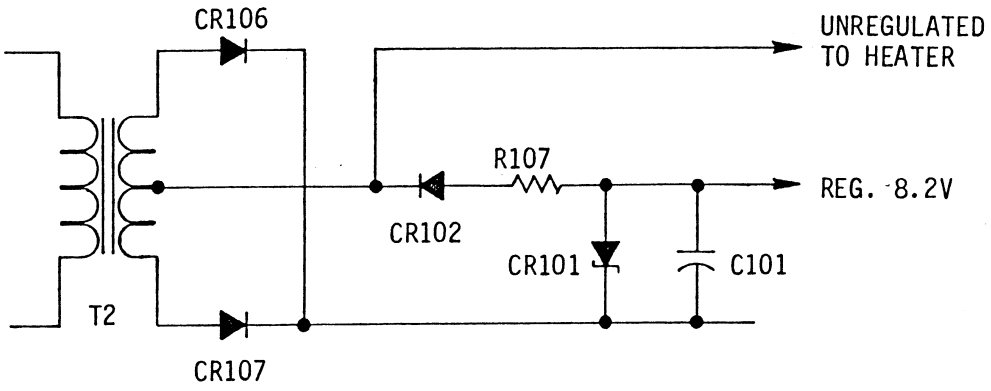


Figure 5-6: POWER SUPPLY

A universal power transformer T2 allows for operation of the instrument from 110/120 VAC or 220/240 VAC, 50 or 60 Hz, and feeds a full-wave rectifier. The heater is fed from the unregulated output and the control circuit is fed from a regulator consisting of R107, CR101 and C101.