BAM21

Bridge Amplifier

INSTRUCTION MANUAL

Serial No._____

051910

World Precision Instruments

CONTENTS

ABOUT THIS MANUAL

The following symbols are used in this guide:

This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.

This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

Fig. 1–*BAM21 Bridge Amplifier*

INTRODUCTION

The **BAM21** Bridge Amplifier is used in conjunction with the SI-H Muscle Bath system and the related line of SI-Heidelberg muscle physiology products. The **BAM21** powers the force transducer and outputs an analog voltage proportional to the force applied to the force transducer. The force feedback signal can be multiplied by a factor of 10 to provide better resolution for a minimal change in applied force. The **BAM21** includes a temperature control for the muscle bath. Temperature stabilization is provided by a PID (proportional-integral-derivative) controller, a control loop feedback mechanism.

Features

The **BAM21** is a bridge amplifier that:

- Provides temperature control for muscle tissue bath.
- Supplies an analog output (-10VDC to +10VDC) representing the force applied to the tissue sample.
- Delivers a DC voltage to the force transducer.

How the Amplifier Works

In a typical setup, a muscle is held by a force transducer and suspended in a tissue bath. Both the tissue bath and the force transducer are connected to the **BAM21**. As the muscle contracts or releases, the force transducer (using a photodiode array) converts the force into an electrical current signal which is proportional to the force applied to the force transducer.

Before initiating an experiment, the **BAM21** must first be zeroed. This sets the baseline for measurements to follow.

The output signal is buffered and multiplied by 1 or 10, depending on the front panel **Multiplier** switch setting. The X10 setting is useful when output signals are extremely small. Finally, the force proportional signal is sent through the output amplifier circuit.

The analog output has a range of -10V to +10V that drives a data acquisition system, multimeter or oscilloscope.

Notes and Warnings

NOTE: This system is designed for use with the SI-H line of KG force transducers. It is not configured for use with the SI-H MicroTweezer or other types of force transducers.

CAUTION: This unit measures the temperature of the cuvette chamber, however, the temperature of the liquid inside the cuvette itself might be slightly different. If exact temperature at the location of the muscle is required, use an additional thermometer in the tissue bath and adjust the setpoint of the **BAM21** to a temperature that yields the desired result.

Parts List

After unpacking, verify that there is no visible damage to the sensor. Verify that all items are included:

(1) **BAM21** Bridge Amplifier

(1) Universal input (100-120VAC to 200-240VAC) AC adapter

(1) Power cord with location specific plug

(1) **13661** Potentiometer Adjustment Tool

(1) Instruction Manual

Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled "Claims and Returns" on page 19 of this manual. Please contact WPI Customer Service if any parts are missing at 941.371.1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI's Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled "Claims and Returns" on page 19 of this manual.

INSTRUMENT DESCRIPTION

Front Panel

The front panel of the **BAM21** is shown in **Fig. 2**.

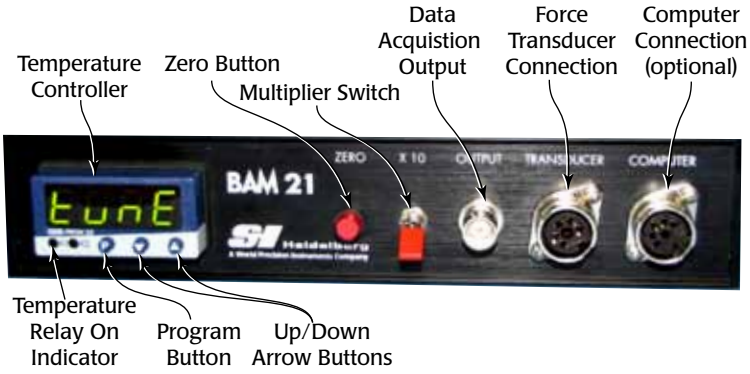

Fig. 2–*Front panel of the BAM21*

Temperature Controller Display–The temperature of the tissue bath cuvette is shown on the display. The temperature controller is programed using the three buttons (**Program**, **Up** arrow and **Down** arrow buttons). The **Program** button (**P**) lets you toggle through various parameters. (See "Programming the Temperature Controller" on page 9.) Use the up/down arrows to change the value of the parameters. When the temperature relay is on, the heating element is powered and the **Temperature Relay On Indicator** (K1) illuminates. During normal operations, this LED toggles on and off as the heating element goes on and off. The K2 indicator is not used.

Zero Switch–When pressed, the **Zero** button illuminates. Before any measurements are taken, the **BAM21** should be zeroed to establish a baseline value for the force transducer.

Multiplier Switch–Under normal conditions, the **Multiplier** switch is set to X1. The current output of the force transducer can be amplified by a factor of 10 when the **Multiplier** switch is set to X10. This is essential when working with extremely small forces.

Data Acquisition Output–Connect a data acquisition system like WPI's **Lab-Trax** to this BNC connector to record the **BAM21** voltage output. For test purposes, a multimeter or oscilloscope may be connected using a standard BNC cable (WPI #**2851**).

Force Transducer Connection–A SI-H KG series force transducer is plugged into this DIN connector. Align the pins, plug it in and then rotate the lock 30° clockwise to secure the plug.

Computer Connection–This connector is used when connecting a computer that is running the SI-H MUSCLEDATA software.

Back Panel

The back panel of the **BAM21** is shown in **Fig. 3**.

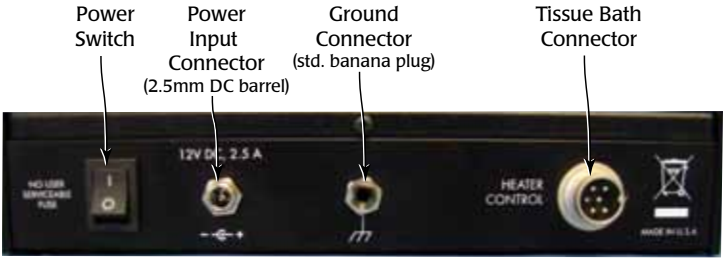

Fig. 3–*Back panel of the BAM21*

Power Switch–This toggle switch turns the power off (0) and on (I).

Power Input Connector–Plug the power cord into this connector.

Ground Connector–Use a ground wire with standard banana plug connector in this socket to ground the entire unit to the desired reference.

Tissue Bath Connector–To heat the tissue bath, connect the plug from the tissue bath to this port. Align the pins, push the plug in place and secure it by screwing the outer ring in place finger tight.

Side Panel

The side panel of the **BAM21** is shown in **Fig. 4**.

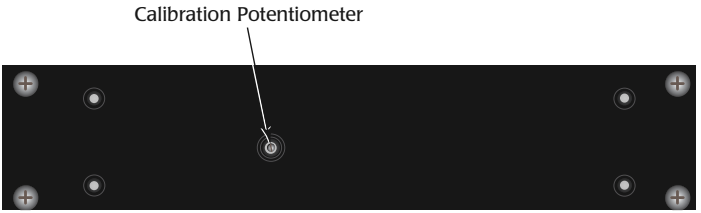

Fig. 4–*Side panel of the BAM21*

Calibration Potentiometer– Adjusting this potentiometer defines the gain applied. Use a potentiometer adjustment tool (WPI **#13661**) to calibrate the data acquisition output voltage by applying an appropriate scale factor to the force transducer current. See "Calibrating the **BAM21**" on page 7.

Setup

Once the instrument has been inspected and accessories accounted for, make the cable connections for system interfaces as shown in **Fig. 5**.

Fig. 5–*BAM21 Connections*

1. Connect the force transducer cable to the **Force Transducer** connection port (labeled **Transducer**) on the front of the **BAM21**. Align the pins and insert the connector. Then, rotate the outside ring 30º to lock the cable in place.
2. Insert the free end of the tissue bath cable into the **Tissue Bath** connector (labeled **Heater Control**) on the back of the **BAM21**. Align the pins, push the plug into place and secure it by screwing the outer ring finger tight.
3. If desired, connect a BNC cable from the data acquisition system input to the **Output** on the front panel of the **BAM21**. The analog output has a range of –10VDC to +10VDC.
4. Connect the AC power adapter to the **Power Input** (labeled **12V DC**, **2.5A**) on the back panel of the **BAM21**.
5. Turn the **Power** switch on the back panel on (I).

OPERATING INSTRUCTIONS

After completing the system setup, the temperature parameters may be modified depending on experimental requirements. Prior to recording measurements, zero the system.

Calibrating the BAM21

Before taking measurements, the **BAM21** must be calibrated. The SI-H KG force transducers shown in the table below respond linearly within their respective measurement ranges. Consequently, the **BAM21** can be calibrated using only two reference points.

Force Transducer	Force Range	Range (g)	Suggested Mass (g)	Noise (µN)	Compliance (nm/mN)	Resonance Frequency
KG2	0-2N	0-200	20	250	150	1.3kHz
KG2A	0-0.5N	0-50	5	300		
KG4	0-50mN	0-5	0.5	15	0.5	1.2kHz
KG4A	0-20mN	0-2	0.2	4	1	1.2kHz
KG7	0-5mN	0-0.5	0.05	0.2	10	250Hz
KG7A	0-5mN	0-0.5	0.05	0.4	5	500Hz
KG7B	0-10mN	0-1.0	0.1	1	1.5	550Hz

The basic procedure for calibrating the **BAM21** involves:

1. Setting a zero reference point with the force transducer un-loaded.
2. Applying a load to the transducer with a known mass.
3. Adjusting the amplifier's output to achieve a value that either:
   - Maximizes the resolution for the intended measurement range.
   - Numerically correlates the force with a voltage output.

Using the Calibration Potentiometer, the amplifier output may be adjusted to a desired value in a large range, allowing you to choose the calibration method that best serves your application.

- For the greatest precision, maximize the resolution of the **BAM21** by calibrating so that the 10.0V output is set a little above the maximum expected force (~5%). For example, if your maximum expected value is 4.75g, set the **BAM21** so that a 5g mass yields a 10.0V output. Your force should never exceed the top of the scale you set.
- On the other hand, for quick visualization, you might choose to establish a numerical correlation by calibrating the **BAM21** so that a force like 1.0g generates a 1.0V output.

Although each of the KG force transducers has a fixed load range, the design of the **BAM21** offers two levels of amplification using the **Multiplier** switch (X1 and X10). You can choose to use the full-load range of the transducer (X1) or (if higher resolution is desired) 1/10th the full-load range of the transducer (X10). Under ideal

conditions, the **Multiplier** switch is set to an amplification factor appropriate for the experiment, and the **BAM21** is calibrated for optimum use in that range. However, if it is necessary to use both ranges during an experiment, the **BAM21** should be calibrated so that a balance is achieved between the offsets in the two ranges.

The following calibration procedure may be used with any SI-H KG force transducer. For illustration purposes a KG4 force transducer is used in the example. Note that a 0.5g mass is about 10% of the total range of the KG4 force transducer, and a 5g mass is a the maximum force the KG4 can measure. If we intend to use the X10 mode, 0.5g is the largest mass we can use with this force transducer. If you use a different force transducer, choose a mass that ia appropriate for the force range of your transducer and **Multiplier** switch setting.

1. Attach the desired force transducer to the **Transducer** port on the front panel of the **BAM21**. For this example, use a KG4 force transducer.
2. Connect a data acquisition system or a digital multi-meter to the **Output** (BNC connection) on the front panel of the **BAM21**. The analog BNC output on the front panel can be connected to a multi-meter for DC voltage measurements between −10.0 and 10V DC. Alternatively, a data acquisition system with analog data tracking, recording and analysis can be connected to a PC to provide a record of the analog output (WPI #**LAB-TRAX-4**).
3. Set the **Multiplier** switch to the amplification factor you intend to use.
4. With no weight suspended from the transducer, press and release the **Zero** button and monitor the output. You should see a reading of 0.0V DC ±10mV.

   NOTE: When the **Zero** button is pressed, it illuminates to indicate that it is functioning properly.
5. From the transducer suspend a known mass that is close to the maximum range for the amplification factor and force transducer. For the KG4 force transducer, use a less than 5.0g for X1 or less than 0.5g for X10.

   NOTE: Mass in grams in not equal to force in newtons. Since force equals mass times acceleration (F = ma), a 0.5g weight is equal to 4.9mN. (0.0005kg * 9.8m/s^2 = 0.0049N) The mass you choose must exert a force that falls within the operating range of the force transducer and amplification factor you select.
6. Monitor the output while adjusting the calibration potentiometer. The output voltage may be set to almost any arbitrary value up to 10.0V. Use a potentiometer adjustment tool (WPI #**13661**) to adjust the **Calibration Potentiometer** screw on the right side panel. Turn the screw until you get the desired reading. The potentiometer is sensitive enough to get extremely close to the desired value. At this point, the **BAM21** is calibrated for the desired amplification factor.
   - When maximizing the resolution with a 5.0g mass in the X1, adjust the value as close as possible to 10.0V, because the chosen scale factor is 2.0V/g.
   - The reading for a 0.5g mass in X10 should also be near 10.0V, because the chosen scale factor is 20V/g.

8. If you intend to use both X1 and X10 amplification factors, set the **Multiplier** switch to X1 and verify that the output is one tenth of the value of the X10. If a 0.5g mass is used and the **BAM21** is calibrated as close as possible 10.0V in X10, then in X1, the monitor should display very close to 1.0V.

   NOTE: Depending on your configuration, it may be necessary to balance the offset readings between the two amplification factors until a suitable balance is reached. If so, toggle the **Multiplier** switch between X10 and X1 and adjust the **Calibration Potentiometer** screw in each mode until an acceptable balance is achieved between the two amplification factors.

Programming the Temperature Controller

The **BAM21** includes a temperature control for the muscle bath. Temperature stabilization is provided by a PID (proportional-integral-derivative) controller, a control loop feedback mechanism. All parameters are set at the factory, including:

- Setpoint: 37ºC
- Setpoint Low: 30ºC
- Setpoint High: 40ºC

Many parameters are available, but the setpoint range (high and low) and setpoint are the settings typically modified.

NOTE: For more information on all the parameters and configuration tables, see "Appendix A: Temperature Controller Parameters" on page 14.

1. Turn the **BAM21 Power** switch on (I). The **Temperature Controller** flashes for a second or two and then displays the current temperature of the tissue bath.

   NOTE: If the tissue bath is not connected to the **Tissue Bath** connector (**Heater Control**) on the **BAM21**, the **Temperature Controller** display will continue to flash 1999. The unit cannot be programmed until the tissue bath is properly connected.

2. To change the setpoint, press the **Program** button (**P**). *SP* appears on the display briefly, and then the actual setpoint displays. Use the up/down arrow keys to change the value. Press the **Program** button again to return to normal operation.

   NOTE: The **BAM21** will heat the tissue bath until it reaches the defined setpoint, then it will hold the tissue bath at that temperature. The **K1** LED on the **Temperature Controller** display will illuminate when the **BAM21** is heating. After the setpoint is reached, the **K1** LED toggles off and on as the heater kicks off and on. The **K2** LED is not used.

3. To enter the programming mode where you can access other parameters and configuration settings, press and hold the **Program** (P) button until the display changes to *Pb. 1*.

4. Press the **Program** (P) button several times (but do NOT hold it in) to toggle through the available parameters until you get to *Y.0*.

   NOTE: The configuration settings can be accessed from the *Y.0*, *Y.1* or *Y.2*

parameters using the method described in step 4.

5. To enter the configuration mode, press and hold the **Program** (P) button until *C111* displays. Now the configuration settings are available.
6. To change the Setpoint Low, press the **Program** (P) button several times (but do NOT hold it in) to toggle through the available configuration settings until you get to *SPL*. This is the lowest value at which the setpoint may be set. Use the up/down arrow keys to change the value. The factory setting is 30°C. Press the **Program** (P) button again to return to the configuration menu.
7. To change the Setpoint High, press the **Program** (P) button again to display *SPH*. This is the highest value at which the setpoint may be set. Use the up/down arrow keys to change the value. The factory setting is 40°C. Press the **Program** (P) button again to return to the configuration menu.
8. Press the **Program** (P) button several times (but do NOT hold it in) to toggle through the rest of configuration settings until the tissue bath temperature reading displays again.

Making Measurements

After the **BAM21** has been calibrated and the setpoint has been established, measurements may be taken.

1. Turn the **BAM21 Power** switch on (I). The **Temperature Controller** display flashes for a second or two and then displays the current temperature of the tissue bath.
2. Turn on the data acquisition system.
3. Press the **Zero** button to set the baseline value for the measurements.

   NOTE: When the **Zero** button is pressed, it illuminates to indicate that it is functioning properly.
4. Press and hold both the **Up** and **Down** arrows until *tunE* flashes on the display. This enables the auto-optimization feature for the tissue bath heater. Auto-tuning takes several minutes, and tunE will flash on the display until the tuning process is complete.

   NOTE: Auto-optimization automatically sets the *rt, dt, Pb .1, Pb .2, CY 1, CY 2* and dF parameters. See "Parameters" on page 14.
5. When the tissue bath reaches the setpoint temperature, the muscle that is attached to the force transducer may be suspended in the tissue bath, and measurements may be taken.

MAINTENANCE

The **BAM21** is maintenance free. However, to protect your **BAM21**, follow these guidelines:

- Place the **BAM21** in a clean, dry location.
- Use only a 12V DC, 3A power supply.
- Keep liquids away from the **BAM21** connections.

ACCESSORIES

Table 1: Accessories

Part Number	Description
13661	Potentiometer Adjustment Tool (Tweaker)
2851	BNC Cable
801513	Universal Input Power Supply AC Adapter
801514	Power Cord for AC Adapter, US plug
92740	Cuvette holder with RTD temperature sensor and heater
AOSC	Anti-oscillation Unit to eliminate resonance frequency from measurements
DAS	SI-H Data Acquisition/Analysis System
KG2	0-2N Force Transducer
KG2A	0-0.5N Force Transducer
KG4	0-50mN Force Transducer
KG4A	0-20mN Force Transducer
KG7	0-5mN Force Transducer
KG7A	0-5mN Force Transducer
KG7B	0-10mN Force Transducer
LAB-TRAX-4	4-Channel Data Acquisition System
MT-ORG-B	Muscle Tester
FS	Electrode for field stimulation

TROUBLESHOOTING

Issue	Possible Cause	Solution
No display	Wrong power supply	Verify that you are using the supplied 2.5mm DC Barrel, 12V DC, 3A power supply (WPI #**501513**).
	No AC power from the wall outlet	Verify that AC power is available from the wall outlet.
	AC adapter is defective	Using a DC volt meter, verify that +12V DC is present between the center conductor pin and outside sleeve of the AC adapter barrel connector. If not, replace the AC adapter.
No output Signal (0.0V DC)	Poor force transducer connection	Verify that the cables are securely connected.
	BNC cable is bad	Try substituting a different BNC cable to troubleshoot the cause.
	Transducer failed	Try substituting a different force transducer to troubleshoot the cause.
Tissue bath is not getting warm	Tissue bath cable improperly connected	Remove the Tissue Bath cable and plug it in again. Be sure to secure it by screwing the outer ring in place finger tight.
	PID controller factory settings have been modified	Refer to Appendix A (page 14) and re-configure the PID controller by resetting each parameter and configuration setting to the factory setting.
Display flashes 1999	Tissue bath cuvette is not connected with the BAM21	Verify that the tissue bath cable is securely connected to the **BAM21.**

NOTE: If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941.371.1003 or technicalsupport@wpiinc.com.

SPECIFICATIONS

The **BAM21** conforms to the following specifications:

Bridge Amplifier

Input Configuration	Current to voltage converter
Gain	1X, 10X - Switch slectable
Output Impedance	470Ω
Power Requirements	12V DC at 3A (wall adaptor included), 2.5mm DC barrel
Output Range	±10V DC

Temperature Controller

Sensor Type	1,000Ω Platinum Resistive Thermal Device (RTD)
Temperature Range	Ambient to 40ºC*
Accuracy	<0.1ºC
Element Current	0-2.4A

*This temperature range is a configurable. Specifications reflect the factory settings. See SPL and SPH in "Configuration Settings" on page 15.

APPENDIX A: TEMPERATURE CONTROLLER PARAMETERS

The PID loop temperature controller housed within the **BAM21** has a series of parameters and configuration settings that can be modified. These settings are set at the factory. With the exception of the setpoint, the setpoint range (high and low) it is highly recommended that you do not make changes to these settings. The tables below list the parameters and configuration settings and the values set at the factory. To make changes to these settings, see "Programming the Temperature Controller" on page 9.

Parameters

Not all parameters are visible from the display. The parameters displayed are dependent upon configuration settings. Some additional information for the various parameters is included below the table.

Display	Parameter	Factory Setting
SP 1	Setpoint 1	Not used
SP 2	Setpoint 2	Not used
HYSt	Limit Comparator Differential	Not used
AL	Limit Comparator Limit Value	Not used
Pb .1	Proportional Band 1	0.0
Pb .2	Proportional Band 2	Not used
dt	Derivative Time	0
rt	Reset Time	12
CY 1	Cycle Time 1	2.5
CY 2	Cycle Time 2	Not used
db	Contact Spacing	Not used
HYS.1	Differential 1 (hysteresis)	1.0
HYS.2	Differential 2 (hysteresis)	Not used
Y .0	Working Point (basic load)	0
Y .1	Output Limiting (max. output)	100
Y .2	Output Limiting (min. output)	0
df	Filter Time Constant (damping)	0.9
rASd	Ramp Slope (ºC/h or ºC/min)	Not used
SP	Setpoint	37.0

Pb .1 and **Pb .2**–These parameters influence the proportional action of the controller.

When set to 0, the controller structure isn't used.

dt–This affects the Derivative action of the controller. When set to 0, the controller has no "D" action.

rt–This affects the Integral action of the controller. When set to 0, the controller has no "I" action.

CY 1–The cycle time is selected so that the power to the process is nearly continuous to avoid wearing out the relay.

Y .0–This represents the output if the process value equals the setpoint.

Configuration Settings

Multiple options are available for the configuration settings. If you need customized settings for the following parameters, contact the WPI Technical Support team at technicalsupport@wpiinc.com.

Display	Configuration Setting	Factory Setting
C111	Temp Probe (process value input)	05
C112	°C/°F and Number of decimal places	1
C113	Controller Type	10
C114	Limit Comparator Function	0
C115	Ramp Function (on/off, time unit)	0
C116	Outputs in Fault Condition	0
C117	Function of the Logic Input (stop)	0
C118	Assignment of the Outputs	Not used
C120	Timer Function	0
C121	Start Condition of Timer	Not used
C122	Timer Signalling	Not used
C123	Unit of Time	Not used
SCL	Standard Signal Start Value	Not used
SCH	Standard Signal End Value	Not used
SPL	Setpoint Low	30
SPH	Setpoint High	40
OFFS	Offset	0
HYSt	Limit Comparator Switch Differential	Not used

Below, the factory setting is described for the configuration parameters the **BAM21** uses:

C111–05 defines the temperature probe as a Pt 1000 2-wire temperature probe.

C112–1 sets the controller to display °C, one decimal place (999.9°C). 4 sets the controller to display °F, one decimal point (999.9°F).

C113–10 defines a single setpoint (reversed).

C114–0 determines that the limit comparator function is not used.

C115–0 turns the ramp function off.

C116–0 turns the timer function off and sets the output to 0%.

C117–0 applies no function to the logic input.

C120–0 turns the timer function off.

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WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of 30 days* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

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