Series AR100
Recorder, Recorder-Controller

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>1-1</td>
</tr>
<tr>
<td>Operation</td>
<td>2-1</td>
</tr>
<tr>
<td>Technical Data</td>
<td>3-1</td>
</tr>
<tr>
<td>Troubleshooting</td>
<td>4-1</td>
</tr>
<tr>
<td>Parts List</td>
<td>5-1</td>
</tr>
<tr>
<td>Basic Characteristics of Proportional Controls</td>
<td>B-1</td>
</tr>
<tr>
<td>—Appendix B</td>
<td></td>
</tr>
<tr>
<td>Calculating Tuning Constants—Appendix C</td>
<td>C-1</td>
</tr>
<tr>
<td>Specification</td>
<td></td>
</tr>
</tbody>
</table>
## Series AR100
Recorder and Recorder-Controller

### Installation

#### Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspecting for shipping damage and checking for</td>
<td>1-2</td>
</tr>
<tr>
<td>accessories and kits</td>
<td></td>
</tr>
<tr>
<td>Assembling options ordered as kits</td>
<td>1-2</td>
</tr>
<tr>
<td>Reviewing data before installation</td>
<td>1-2</td>
</tr>
<tr>
<td>Guidelines for external wiring</td>
<td>1-3</td>
</tr>
<tr>
<td>Selecting wire for inputs</td>
<td>1-3</td>
</tr>
<tr>
<td>Thermocouple</td>
<td>1-3</td>
</tr>
<tr>
<td>Millivolt, volt, current and potentiometer/slidewire</td>
<td>1-3</td>
</tr>
<tr>
<td>Resistance temperature detector</td>
<td>1-3</td>
</tr>
<tr>
<td>Three wire</td>
<td>1-3</td>
</tr>
<tr>
<td>Two wire</td>
<td>1-3</td>
</tr>
<tr>
<td>Differential</td>
<td>1-3</td>
</tr>
<tr>
<td>Relative humidity—Honeywell Q457B</td>
<td>1-3</td>
</tr>
<tr>
<td>Shielding and bundling the wires</td>
<td>1-3</td>
</tr>
<tr>
<td>Using bushing to mount the conduit</td>
<td>1-3</td>
</tr>
<tr>
<td>Panel mounting the AR100</td>
<td>1-4</td>
</tr>
<tr>
<td>Surface mounting the AR100</td>
<td>1-5</td>
</tr>
<tr>
<td>Connecting the external wiring</td>
<td>1-6</td>
</tr>
<tr>
<td>Power and ground</td>
<td>1-6</td>
</tr>
<tr>
<td>Inputs</td>
<td>1-7</td>
</tr>
<tr>
<td>Controller type</td>
<td>1-8</td>
</tr>
<tr>
<td>Options</td>
<td>1-9</td>
</tr>
</tbody>
</table>
Inspecting for Shipping Damage and Checking for Accessories and Kits

Assembling Options Ordered as Kits

Reviewing Data Before Installation

If the AR100 hasn't been removed from its shipping carton, inspect the carton for damage; then remove the AR100. Inspect the AR100 for any obvious shipping damage and report any damage due to transit to the carrier. Check that bags containing panel mounting hardware, pen cartridges, and any kits you ordered, are included with the AR100.

Before installing the AR100, use the instructions furnished with the kits to assemble the options.

While the installation of the AR100 is not complicated, we recommend that you review the following data before the installation:

<table>
<thead>
<tr>
<th>Rated</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature</td>
<td>40 to 120°F</td>
</tr>
<tr>
<td></td>
<td>(5 to 49°C)</td>
</tr>
<tr>
<td>Relative humidity 5 to 90%</td>
<td>5 to 95%</td>
</tr>
<tr>
<td></td>
<td>(400 grains H₂O max)</td>
</tr>
<tr>
<td>Vibration</td>
<td>0.2g-0.05 to 60 cps</td>
</tr>
<tr>
<td>Power consumption</td>
<td>One pen: 16W max., Two pen: 20W max.</td>
</tr>
<tr>
<td>Common mode</td>
<td>12 Vac, 24 Vdc</td>
</tr>
<tr>
<td>Normal mode</td>
<td>2 x span</td>
</tr>
<tr>
<td>Weight (Approx)</td>
<td>14 lbs (6 kg)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>See Figure 1-1</td>
</tr>
</tbody>
</table>

![Figure 1-1—Dimensions](image-url)
Guidelines for External Wiring

Selecting Wire for Inputs
Thermocouple
Millivolt, Volt, Current, and Potentiometer/Slidewire
Resistance Temperature Detector

Three Wire
Use three copper wires of equal resistance. For lengths up to 150 feet (46 meters), 18 gage copper wire can be used. Longer lengths require larger gage wire.

Two Wire
Use copper wires with as low resistance as possible and connect a jumper between terminals 2 and 3. Each ohm of resistance causes approximately 0.1% error. If wire resistance cannot be reduced to a satisfactory amount, calibrate the AR100 with a signal source replacing the RTD at the end of the wires.

Differential
Make the resistance of the three copper wires less than one percent of the nominal RTD resistance.

Relative Humidity
Honeywell Q457B

Use a shielded cable (Example: Belden 9248) as follows:
NOTE: If length of cable exceeds the maximum specified, use a Honeywell SSP136 Signal Conditioner, and change the range and actuation of the AR100 to 0-10 or 0-100 mV dc.

<table>
<thead>
<tr>
<th>Cable connection to AR100</th>
<th>No Calib.</th>
<th>Calib.</th>
</tr>
</thead>
<tbody>
<tr>
<td>One cable with core on Terminal 1 and shield on Terminal 2</td>
<td>50 ft. (15 m)</td>
<td>100 ft. (30 m)</td>
</tr>
<tr>
<td>Two cables with cores on Terminals 1 and 2 and shields floating</td>
<td>125 ft. (38 m)</td>
<td>250 ft. (76 m)</td>
</tr>
</tbody>
</table>

Shielding and Bundling the Wires

Shield and combine the wires as follows to reduce the possibility of electrical noise (unwanted electrical signals) being superimposed on a valid input or output signal and causing inaccuracies in recording and controlling.

<table>
<thead>
<tr>
<th>Signal carried</th>
<th>Twist</th>
<th>Shield</th>
<th>Bundle number</th>
<th>Possible bundle combinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>No</td>
<td>No</td>
<td>1</td>
<td>3, 5</td>
</tr>
<tr>
<td>Input</td>
<td>Yes</td>
<td>Yes</td>
<td>2</td>
<td>None</td>
</tr>
<tr>
<td>Relay contact</td>
<td>No</td>
<td>No</td>
<td>3</td>
<td>1, 5</td>
</tr>
<tr>
<td>Current output</td>
<td>Yes</td>
<td>Yes</td>
<td>4</td>
<td>None</td>
</tr>
<tr>
<td>Ground</td>
<td>No</td>
<td>No</td>
<td>5</td>
<td>1, 3</td>
</tr>
</tbody>
</table>

Using Bushings to Mount the Conduit

Use grounding type bushings to connect metal conduit to the AR100 case; then connect the bushings together and to ground.
Panel Mounting the AR100

When planning the installation, consider the following:
- If replacing a Partlow or U.S. instrument, place the panel adaptor over the case before mounting (optional kit).
- To use the mounting screws supplied, the thickness of the panel plus adaptor cannot exceed 0.25 inch (approx 0.6 mm). For thicker panels, you must supply size 8 self-threading screws of the correct length.
- The hinge edge of the bezel is offset 0.35 inch (approx 9 mm) to the left of the case. The conduit openings are located on the bottom and sides of the case.

Use the instructions in Figure 1-2 to install the AR100.

1. Make the cutout in the panel to the dimensions shown.
2. Insert the case into the cutout until the bezel (adaptor) is against the panel.
3. Assemble, as shown, a mounting bracket in the slot on each side of the case.
4. Insert a screw through the hole in each mounting bracket; then tighten the screws until the bezel (adaptor) is tight against the panel.

Figure 1-2—Panel mounting instructions
Surface Mounting the AR100

You must supply four size 10 screws with a maximum head diameter of 0.38 inch (approx 9 mm) and a length sufficient to screw into the mounting surface and leave approx 0.30 inch (8 mm) of the length exposed.

Use the instructions in Figure 1-3 to surface mount the AR100.

1. Install the two upper screws in the pattern shown.
2. Make provisions for installing the two lower screws in the pattern shown.
3. Press the latch, open the door, loosen the two captive screws on the right edge of the front plate, swing the plate to the left; then lift the plate from its hinges.
   NOTE: If the plate is in the way of the next steps, remove it by disconnecting the cables at the board, and the ground wire at the screw on the plate.
4. Use a 0.38 inch (approx 9 mm) diameter punch and a 0.18 (approx 5 mm) diameter punch to remove the knockouts from the two keyholes on the back of the case.
5. Use a 0.18 inch (approx 5 mm) diameter punch to remove the knockouts from the lower two holes on the back of the case.
6. Using the two keyholes, hang the AR100 on the two installed screws.
7. Insert and tighten the screws in the two bottom holes, and tighten the two upper screws.
8. If necessary, replace the plate.
9. Tighten the two captive screws on the right edge of the plate, and close the door.

Figure 1-3—Surface mounting the AR100
Connecting the External Wiring

The knockouts for the conduit or cable clamps, and the terminals for the wiring connections are located behind the front plate. Use the following instructions to gain access to them and to remove the knockouts.

1. First press the latch and open the door; then loosen the two captive screws on the right edge of the plate and swing the plate to the left.
2. Hit the conduit knockout on its outside surface to remove it.

After installing conduit or cable clamps, bring the wires through them and into the case.

Select from Figures 1-4, 1-5, 1-6 and 1-7 the wiring diagrams that are applicable to your AR100.

Figure 1-4—Power and ground
Thermocouple

NOTE: Make sure the compensation resistor is installed on Terminals 2 and 3.

Millivolt, current, and volt.

RTD Three-wire

RTD Two wire

RTD Differential (Wet/Dry bulbs)

Humidity Honeywell Q457B

Potentiometer

NOTE: Terminal numbers are the same for Pins 1 and 2.

Figure 1-5—Inputs
**Time proportional**

The output relay condition shown is when the input is below the set point.

Load; Resistive = 5A at 120/240 Vac  
Pilot duty = 50 VA at 120/240 Vac

---

**Current proportional**

4 to 20 mA output  
600 ohms maximum load.

---

**Limit**

Position of the internal output relay contacts is shown for the condition where the input is below the set point.

Load-Pilot duty = 120/240 Vac, 50 VA  
Resistive = 120/240 Vac, 5A  
User supplied external switch for resetting the Output relay.

---

NOTES: 1. If the input is grounded, do not ground the output.  
2. Terminal numbers are the same for Pens 1 and 2.
Alarm

Position of the internal output relay contacts is shown for the condition where the input is below the set point.

Load-Pilot duty = 120 Vac, 50 VA
Resistive = 120 Vac, 2A

PV output

Output = 0 to 5 Vdc, 5mA max (+) (-)

Figure 1-7—Options
### Contents

**Introduction**
- Preparing for Start-up

<table>
<thead>
<tr>
<th>Operation</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All AR 100s</strong></td>
<td>2-2</td>
</tr>
<tr>
<td>Installing the Chart</td>
<td>2-2</td>
</tr>
<tr>
<td>Positioning the Chart Time Line</td>
<td>2-2</td>
</tr>
<tr>
<td>Installing a Pen Cartridge</td>
<td>2-2</td>
</tr>
<tr>
<td>Verifying the Recording Accuracy</td>
<td>2-3</td>
</tr>
<tr>
<td>Setting the Burnout Direction</td>
<td>2-4</td>
</tr>
<tr>
<td><strong>AR 100s with Options</strong></td>
<td>2-5</td>
</tr>
<tr>
<td>Setting the Alarm Output and Set Point</td>
<td>2-5</td>
</tr>
<tr>
<td><strong>AR 100s with Controllers</strong></td>
<td>2-6</td>
</tr>
<tr>
<td>Verifying the Output Relay Operation</td>
<td>2-6</td>
</tr>
<tr>
<td>Setting the Tuning Constants</td>
<td>2-7</td>
</tr>
<tr>
<td>Proportional Band</td>
<td>2-7</td>
</tr>
<tr>
<td>Reset</td>
<td>2-7</td>
</tr>
<tr>
<td>Rate</td>
<td>2-7</td>
</tr>
<tr>
<td>Setting the Output Relay Cycle Time</td>
<td>2-7</td>
</tr>
<tr>
<td>Setting the Limit Relay Control Action</td>
<td>2-8</td>
</tr>
<tr>
<td>Setting the Current Output Control Action</td>
<td>2-8</td>
</tr>
</tbody>
</table>

**Start-up**
- Recorders | 2-9 |
- All Recorder-Controllers | 2-9 |
- Limit Controllers with Manual Reset | 2-9 |

**Monitoring**
- All AR 100s | 2-10 |
- Recorder-Controller | 2-10 |
- All Proportioning Control | 2-10 |
- Proportioning Control with Manual Reset | 2-10 |
- Limit Control | 2-10 |
Introduction

Operating your AR100 requires the following:
- preparing for start-up
- start-up
- a minimum of monitoring after start-up.

Preparing for Start-up

The procedures required to prepare your AR100 depend on the options, type of input, and type of controller assembled on your AR100. (These are listed on the nameplate attached to the front plate.) To make it easy for you to select only needed procedures, we separated them into groups. The first group includes procedures required for all instruments, while subsequent groups include procedures required for specific instruments.

All AR 100s

Before each of the following procedures, open the door. After you have completed all of the procedures, close the door.

Installing the Chart

NOTE: If pen cartridges are installed, lift or cap the pens to prevent marking the chart. Leave the pens lifted or capped until the chart time line is positioned. Slide the chart under the pens and the set point pointers; then place the holes in the chart over the center and drive pins on the hub.

Positioning the Chart Time Line

NOTES: 1. You do not have to do this procedure until you apply power and are ready to start-up.

2. If the pen cartridges are installed, lift or cap pens to prevent marking chart.

Use the thumb and forefinger against the hub and the drive pin to rotate the chart clockwise until the correct time line is aligned with the mark (identified as TIME) on the right side of the front plate.

Installing a Pen Cartridge

NOTE: Leave the cap on the pen until the cartridge is installed and you are ready to start-up.

Based on whether you have a cartridge with a plastic or metal mounting clip, select one of the following procedures:

Plastic

Place the cartridge on the top surface of the pen arm with the pen against the sides of the vee, and bend the clip under the arm; then press the clip until it locks on the side of the cartridge.

Metal

Slide the end of the pen arm between the metal clip and the cartridge until the pen is against the sides of the vee; then press the clip until it locks on the side of the cartridge.

CAUTION: When making wire connections in the following procedures, remove the power; then keep it off until the connections are completed.

NOTES: 1. The following procedures require you to press the latch, open the door, loosen the screws on the right edge of the front plate, swing the plate open, and locate a connector or adjustment on a printed wiring board; then close everything when the procedure is completed.

2. On two-pen instruments, the settings are made for either pen.
**Verifying the Recording Accuracy**

Before the initial start-up, you can use the following procedures to verify the recording accuracy of the AR100:

**For All Input Types**
1. Obtain the input type and range from the nameplate located on the front plate, under the chart.
2. Disconnect the wires from the input terminals. (See the Installation Section for the terminal numbers).
3. Connect a signal generator (millivolt, volt or resistance depending on the input type) to the terminals with two, short, insulated, copper wires.
4. If the input type you are verifying is current, volt, millivolt or resistance, skip the following Special Procedures and proceed to Step 5. If the input type you are verifying is a thermocouple, complete the following Special Procedures for Thermocouple Type Inputs; then proceed to Step 5.

**Special Procedures for Thermocouple Type Inputs**
- **a.** Measure the temperature at the AR100 input terminals in either °F or °C.
- **b.** Use the IPTS 68 Conversion Table for the input type you are calibrating to convert from temperature units to millivolts, the upper range limit, the lower range limit and the input terminal temperature.
- **c.** Subtract the input terminal temperature in millivolts from the lower and upper range limits. Use these corrected limits in Steps 5 and 8.

5. Apply power, set the lower range limit on the signal generator, and note the position of the pen tip on the chart.
6. If the pen tip is within 1% of the lower range limit on the chart, go to Step 7, otherwise, swing the front plate open, and locate the ZERO potentiometer (see Figure 2-1); then adjust the potentiometer until the pen is within 1% of the lower range limit.
7. Set the upper range limit on the signal generator, and note the position of the pen tip on the chart.
8. If the pen tip is within 1% of the upper range limit on the chart, go to Step 9, otherwise, swing the front plate open, and locate the SPAN potentiometer (see Figure 2-1); then adjust the potentiometer until the pen is within 1% of the upper range limit.
9. Repeat the setting of the lower and upper range limits in Steps 5 through 8 until they remain constant. If your instrument has limit control, see the heading “Verifying the Limit Relay Operation,” otherwise the verification is complete.

![Figure 2-1—Location of the ZERO and SPAN potentiometers](image-url)
Setting the Burnout Direction
(thermocouple, millivolt, volt or potentiometer/slidewire input type)

Set the burnout direction (which way the pen goes when the input open circuits) by positioning the 100 megohm resistor on connector Sₐ (see Figure 2-2) as follows:

<table>
<thead>
<tr>
<th>Direction</th>
<th>Pin positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upscale</td>
<td>2 and 5 &lt;(Factory setting)</td>
</tr>
<tr>
<td>Downscale</td>
<td>2 and 3</td>
</tr>
</tbody>
</table>

Figure 2-2—Location of connector Sₐ
AR 100s with Options

Setting the Alarm Output Mode and Set Point

1. Set the alarm mode as HIGH (the alarm relay is actuated when the input is above the set point, or LOW (the alarm output relay is actuated when the input is below the set point.) by positioning wires JA and JB on connector A as shown in Figure 2-3.

2. Set the alarm set point as follows:
   a. Disconnect the input from the terminal block and replace with a signal generator; then disconnect the wires from the alarm output terminals and replace with an ohmmeter or similar device to recognize open and closed relay contacts. (See the INSTALLATION section for the terminals).
   b. Adjust the signal generator until the pen is at the alarm set point on the chart.
   c. Locate potentiometer P5 (see Figure 2-3) and rotate it (clockwise to increase the set point) until the alarm relay is actuated.
   d. Adjust the signal generator to drive the pen above and below the set point to make sure the relay actuates properly.
   e. Remove the instruments from the input and alarm terminals; then replace them with the proper wires.

Figure 2-3—Location of the alarm setting means
AR 100s with Controllers

The following are procedures for:
- verifying the output relay operation
- setting the tuning constants
- setting the output relay cycle time
- setting the limit relay control action
- setting the current output control action

Verifying the Output Relay Operation

On AR100s with limit control, before the first start-up but after you verified the accuracy you can use the following steps to verify the operation of the output relay:

1. After removing power, connect an ohmmeter, or other device capable of displaying the position of relay contacts, across Terminals 7 and 8.

2. Set the pen at approximately 40% span; then use the knob to set the control set point pointer at 50% span.

3. Slowly adjust the signal generator until the ohmmeter indicates a change in the relay contact position.

4. Check that the pen tip and the set point pointer are aligned within 1% of span.

5. If they are aligned, go to step 6. If they aren’t, first, adjust the signal source until the pen tip and pointer are aligned; next, open the front plate and locate the Manual Reset Switch (see Figure 2-4) and the potentiometer P301 (see Figure 2-5); finally, while pressing the Manual Reset Switch, adjust P301 until the ohmmeter indicates the position of the relay contact changed.

6. Install a new chart.

Figure 2-4—Location of the manual reset switches

Figure 2-5—Location of potentiometer P301
Setting the Tuning Constants

The following instructions define the proportional band, reset, and rate; locate the setting means; and give the limits of adjustment. (If you do not know what the tuning constant values should be for your process, use the procedures in Appendix C "Determining Tuning Constants" as a guide to establish them.)

Proportional Band

Proportional band regulates the controller output in proportion to the deviation of the input from the set point.

Single Mode
Set to 2, 5, or 10% of span by positioning wire JG to the corresponding pin on connector PB (see Figure 2-6).

Three Mode
Set from 1 to 100% of span by rotating potentiometer P401 as shown by the label on the capacitor just above it.

Reset
(Three mode)

Reset regulates the controller output at a rate in proportion to deviation of the input from the set point.

Set to 0, 0.1, 0.5, 1, or 2 repeats/minute by positioning wire JF to the corresponding pin on connector RESET (see Figure 2-6).

Set from 3 to 100 repeats/minute by first positioning wire JF on pin 3-100 of connector RESET, then rotate potentiometer P402 as shown by the label on the capacitor to the right of it.

Rate
(Three mode)

Rate regulates the controller output at a rate in proportion to the rate of change of the input.

Set to 0, 0.5, 1, 2, 5, or 10 minutes by positioning wire JE to the corresponding pin on connector RATE (see Figure 2-6).

Setting the Output Relay Cycle Time
(Time Proportioning)

Setting the output relay cycle time of the time proportioning controller establishes the cycle rate of the output relay, and thus that of the control element. Using the slowest time increases the life of both devices.

Set the time to either 10 or 20 second by positioning the wire JE on the corresponding pin of connector CT (see Figure 2-6).
Setting the Limit Relay Control Action
(Limit Controller)

Setting the limit relay control action HIGH causes the relay to actuate when the input is above the control set point. Setting it LOW causes the relay to actuate when the input is below the set point. See Figure 2-7 for the settings and locations of the setting means.

Figure 2-7—Location of the limit relay action setting means

Setting the Current Output Control Action
(Current Proportioning)

Setting the current output control action to REVERSE causes the output to decrease when the input goes above the set point. Setting the action to DIRECT causes the output to increase when the input goes above the set point. See Figure 2-8 for the settings and location of the setting means.

Figure 2-8—Location of the current output control action setting means
Start-up

The procedures below assume the AR100 has been installed in accordance with instructions in the Installation Section and prepared for start-up in accordance with earlier information in this section.

Recorder

Apply power.

Recorder-Controller

1. Use the knobs (see Figure 2-9) to adjust the control set point for each controller.
2. Apply power.

Limit Control with Manual Reset

Press the manual reset switch for each pen (see Figure 2-10) to reset the output relay (turns off the red indicator that appears behind the chart).

Figure 2-9—Locations of the set point knobs
Operation 2-10

Monitoring

All AR 100s

Observe the pen trace. If it becomes too fine to be legible, replace the cartridge. (See page 2-2.)
If you stop the chart, lift the pen, or remove the pen cartridge for more than an hour, put a cap on the pen tip to prevent drying of the ink.

Recorder-Controller

All Proportioning Control

Observe the pen trace to make sure controller action is suitable for your process. (If you are unfamiliar with the types of traces that appear with various tuning constant settings, see Appendix C for examples.)

Proportioning Control with Manual Reset

After the pen trace becomes stable, if there is a continuing difference between a pen trace and the control set point, use one of the following procedures to eliminate the difference:

Procedures

1. If the pen trace is below the set point, turn the manual reset adjustment (see Figure 2-10) clockwise (in the direction of the +) a small amount. Wait for the trace to stabilize after each adjustment.

2. If the pen trace is above the set point, turn the manual reset adjustment (see Figure 2-10) counterclockwise (in the direction of the -) a small amount. Wait for the trace to stabilize after each adjustment.

Limit Control

A red indicator appears behind the chart when the control output relay is activated. After you determine the cause for the indicator, press the manual reset switch to deactivate the relay. Figure 2-10 shows the location of the indicator and the manual reset switch for each controller.

Figure 2-10—Locations of the limit relay indicators and reset switches
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary</td>
<td>3-2</td>
</tr>
<tr>
<td>Power Supply</td>
<td></td>
</tr>
<tr>
<td>Recorder-Controller</td>
<td>3-2</td>
</tr>
<tr>
<td>Recorder</td>
<td>3-3</td>
</tr>
<tr>
<td>Chart Drive</td>
<td>3-4</td>
</tr>
<tr>
<td>Measuring Circuit</td>
<td></td>
</tr>
<tr>
<td>DC Millivolt, DC Volt, and DC Milliampere</td>
<td>3-4</td>
</tr>
<tr>
<td>Thermocouple</td>
<td>3-5</td>
</tr>
<tr>
<td>Resistance Temperature Detector</td>
<td>3-5</td>
</tr>
<tr>
<td>Differential Resistance Temperature Detector</td>
<td>3-6</td>
</tr>
<tr>
<td>Potentiometer/slidewire</td>
<td>3-6</td>
</tr>
<tr>
<td>Honeywell Q457B, Relative Humidity Sensor</td>
<td>3-7</td>
</tr>
<tr>
<td>Preamplifier</td>
<td>3-8</td>
</tr>
<tr>
<td>Pen-Position Servo</td>
<td>3-9</td>
</tr>
<tr>
<td>Automatic Control</td>
<td></td>
</tr>
<tr>
<td>Two-Position (On-Off) Control</td>
<td>3-10</td>
</tr>
<tr>
<td>Time Proportioning with Manual Reset</td>
<td>3-11</td>
</tr>
<tr>
<td>Time Proportioning-plus Reset plus Rate</td>
<td>3-11</td>
</tr>
<tr>
<td>Current Proportioning with Manual Reset</td>
<td>3-12</td>
</tr>
<tr>
<td>Current Proportioning-plus Reset plus Rate</td>
<td>3-12</td>
</tr>
<tr>
<td>Three-Mode Circuit</td>
<td></td>
</tr>
<tr>
<td>Proportional band</td>
<td>3-12</td>
</tr>
<tr>
<td>Reset</td>
<td>3-12</td>
</tr>
<tr>
<td>Rate</td>
<td>3-12</td>
</tr>
<tr>
<td>Reset lockout</td>
<td>3-12</td>
</tr>
<tr>
<td>Limit Control with Manual Reset</td>
<td>3-14</td>
</tr>
<tr>
<td>Auto-Reset</td>
<td>3-15</td>
</tr>
<tr>
<td>Process Variable Output</td>
<td>3-15</td>
</tr>
<tr>
<td>Alarm</td>
<td>3-16</td>
</tr>
</tbody>
</table>
Summary

Honeywell’s AR100 Recorder-Controller is structured on a through control concept—独立 parallel recording, automatic control, and alarm functions. The block diagram (Figure 3-1) shows these functions as well as the common measuring circuit and preamplifier, the power supply outputs, and the optional process variable output and event switching functions. The following describes how the individual functions work.

![Block Diagram](image)

**Figure 3-1—Operational block diagram**

**Power Supply Recorder-Controller**

This power supply (Figure 3-2) accepts the ac line voltage and transforms it to 37 Vac (center tapped) and 24 Vac. Different transformers are used for 120 and 230 Vac line voltages. The 24 Vac powers the chart drive motor, the servo motor, the optional illumination, and the Q457B relative humidity sensor. The 37 Vac winding feeds a full wave rectifier and filter which results in a ±24Vdc unregulated voltage. The ±24Vdc drives (a) output relays for control or alarm functions, and the ±20 mA power transistor (and the external load) for current proportioning control output, and (b) the precision ±12 Vdc stages of the power supply. A three-terminal integrated circuit voltage generator in the +24 Vdc line generates the precision ±12 Vdc. A tracking regulator (operational amplifier plus power transistor) in the −24 Vdc line references the +12 Vdc and produces the −12 Vdc. The ±12 Vdc is used by the thermocouple input circuit for automatic cold junction compensation and for burnout signals. The ±12 Vdc also supplies voltages for the RTD, the zero adjust, the integrated circuit supply, the measuring slidewire, and the alarm set point slidewire.
Recorder

This power supply (Figure 3-4) accepts the ac line voltage and transforms it to 24 Vac. Different transformers are used for 120 and 230 Vac line voltages. The 24 Vac powers the chart drive motor, the pen motor, the optional illumination, and the Honeywell Q457B relative humidity sensor. The 24 Vac also feeds a half-wave rectifier and filter which produce a ±30 Vdc unregulated voltage. The ±30 Vdc drives the optional alarm relay, and the precision ±12 Vdc stages of the power supply. Two, four-terminal, integrated-circuit, voltage regulators in the ±30 Vdc lines generate a precision ±12 Vdc for the thermocouple input circuit, the RTD input circuit, the zero adjust, the integrated circuit supply, the measuring slidewire, and the alarm set point slidewire.
Chart Drive
The chart drive mechanism consists of a 24 Vac synchronous motor driving a precision hub on which is mounted a drive pin. The motor is powered from a plug-in connection on the printed circuit board. The taper of the hub and pin ensures accurate chart mounting and prevents chart slippage. The hub is rotated on its clutch to set the chart time line. Timing accuracy is dependent on the accuracy of the power frequency. Different motors are used for 50 and 60 Hz power and for different chart speeds.

Measuring circuit
The measuring circuit incorporates the preamplifier as part of its operation, not merely as a separate following stage. The preamplifier operates in conjunction with other elements of the measuring circuit to perform input signal conditioning and scaling of the input signal level. Seven input signal conditioning circuits are available to match the input types listed below:

DC Millivots, DC Volts, and DC Milliamperes
The millivolt input signal (Figure 3-4) is introduced on Terminals 1(+) and 3(−); then routed directly to the preamplifier. Burnout protection is provided.

The volt signal (Figure 3-4) is introduced on Terminals 1(+) and 3(−) which are bridged by a 1M and a 4.99K resistor. The fraction of the signal appearing across the 4.99K resistor is routed directly to the preamplifier.

The milliampere signal (Figure 3-4) is introduced on Terminals 1(+) and 3(−) which are bridged by a 2.49 ohm resistor. The IxR voltage developed across the 2.49 ohm resistor is routed directly to the preamplifier.

Burnout protection is achieved by inserting a small positive (upscale) or negative (downscale) dc current into the positive side of the input signal. To minimize the effect of this signal on the input signal, the current is obtained from the 12 Vdc passing through a 100 megohm resistor. However, if the input circuit opens, the full 12 Vdc is routed to the preamplifier. This causes the controls, alarms, and pens to drive to an extreme position.

Figure 3-4—Measuring circuit for dc millivolt, dc volt, and dc milliampere input types

<table>
<thead>
<tr>
<th>Ranges</th>
<th>R**</th>
<th>R***</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-200mV</td>
<td>17.4K*</td>
<td>7.50K*</td>
</tr>
<tr>
<td>200-800mV</td>
<td>93.1K*</td>
<td>7.50K*</td>
</tr>
<tr>
<td>800mV-3.2V</td>
<td>392K*</td>
<td>7.50K*</td>
</tr>
<tr>
<td>3.2-12.8V</td>
<td>523K*</td>
<td>2.49K*</td>
</tr>
</tbody>
</table>

* ± 1% tolerance
Thermocouple

The thermocouple input (Figure 3-5) is introduced on Terminals 1(+) and 2(−). These are the cold junction of the thermocouple and must be referenced to 0°C (32°F). (The thermocouple principle is based on the voltage produced by the temperature difference between the hot and cold junctions of the two dissimilar metals making up the thermocouple.) The terminal temperature varies as the case temperature varies and, if uncompensated, causes an error in the input signal. For compensation, a 10 ohm resistor with a high positive coefficient of resistance is mounted between Terminals 2 and 3. A controlled dc current is passed through this resistor to create a voltage which is algebraically added to the input signal. This voltage sum is routed directly to the preamplifier.

Because the amount of compensating voltage needed is a characteristic of the thermocouple type, the current through the compensation resistor is set to a different value for each thermocouple type. A resistor, R1, and potentiometer P1 connected in series with +12 Vdc and the compensation resistor are used to establish the current setting.

Burnout protection is provided in the same manner as for the millivolt input.

Resistance Temperature Detector

The resistance temperature detector (Figure 3-6), produces a resistance change when the temperature changes. The 12 Vdc supply powers the RTD through current limiting resistors. This keeps the current through the RTD at a nominal 250 microamps.

The power to the RTD is provided at Terminals 1 and 3. To achieve compensation for leadwire resistance, a 3-wire installation is made, with the third wire connected at Terminal 2. With the 3-wire system, and all three wires of equal resistance, the effective wire resistance added to the resistance of the RTD is reduced to less than one seventh the wire resistance.
**Differential Resistance Temperature Detector**

A differential RTD (Figure 3-7) normally measures a small temperature difference, such as the depression between wet and dry bulbs, rather than absolute temperature. Hence, one RTD is viewed as measuring the reference temperature (dry bulb temperature) and the other RTD is viewed as measuring the changing temperature (wet bulb temperature). The RTD measuring reference temperature (dry bulb) is connected across Terminals 1 and 3, and the RTD measuring the changing temperature (wet bulb) is connected across Terminals 2 and 3. The input signal is the difference between the signals from the two RTDs. The input signal is routed through a low level amplifier to be raised to a millivolt level, then to the preamplifier.

Figure 3-7—Measuring circuit for differential RTD input type

**Potentiometer/Slidewire**

The potentiometer/slidewire (Figure 3-8) receives a fixed millivoltage from Terminals 2 and 3. The wiper is connected to Terminal 1. The wiper is mechanically positioned by the process variable, which causes a portion of the potentiometer/slidewire millivoltage to appear across Terminals 1 and 3. The input signal is treated the same as the millivolt, and like the millivolt, has burnout protection.

Figure 3-8—Measuring circuit for potentiometer/slidewire input type
Honeywell Q457B, Relative Humidity Sensor

The Q457B relative humidity sensor is a gold grid composite which is powered by an ac voltage through half of A300 across Terminals 1 and 3 (Figure 3-9.) The sensor's resistance change with a change in %RH modifies this voltage to an ac signal. The ac signal is converted in the other half of A300 to a dc millivolt signal which is routed to the preamplifier. No ambient temperature compensation is provided. If temperature compensation is required, a Honeywell SSP145A signal conditioner is used with the sensor and an AR100 with 0 to 10 mV dc range is used to record the output of the signal conditioner.

Figure 3-9—Measuring circuit for Honeywell Q457B sensor

NOTE: R6 DELETED ON MAIN PWB
All resistors are 1/4 watt, ±5%
unless otherwise specified
* ±1% tolerance
The preamplifier circuit (Figure 3-10) provides:
- input signal conditioning (resistor capacitor networks)
- protection (diodes) from over-range input signals
- offset (zero suppression or elevation) calibration and adjustment
- gain (span) calibration and adjustment.

The preamplifier is a Type 714C low-temperature drift integrated-circuit operational amplifier. Its output is the high level input signal used by the automatic control, alarm and pen servo systems. Measuring circuit resistor R3, in conjunction with the zero potentiometer, P2, sets the low end of the calibrated range of the system by establishing a precise reference voltage equal to 0% of scale. The chosen span of the calibrated range determines the operational amplifier gain. Gain is set by the feedback around the operational amplifier. Measuring circuit resistor R4, in conjunction with the span adjust potentiometer, P3, determines the span. The span value added to the zero reference voltage produces the full scale level of the system’s calibrated range.

P3 is a 15-turn potentiometer that, with R4, covers the entire range of required span settings. This high resolution allows easy and accurate field calibration.

The input resistance of the measuring circuit/preamplifier combination is very high (0.8 megohms or more), except for the low resistance shunt used for the milliamperie input. Hence, the circuit combination has a minimal loading effect on the input sensor. Further, this type of front end circuitry does not produce a feedback voltage to the sensor. Therefore, an AR100 can work in parallel with other devices, such as the Honeywell DiaLatrol and Dialapak controllers, from a thermocouple or other voltage generating sensor, but cannot work in parallel with other devices from a sensor type which must be powered, such as RTD, potentiometer/slidewire, or Q457B.)

The high level signal output from the preamplifier is used by the recording, the automatic control, and the alarm functions. All three functions operate independently, but use a similar concept: a differential amplifier compares the high level input signal to a reference signal, and the output of the differential amplifier drives a power control network.

Figure 3-10—Measuring circuit and preamplifier
Pen-Position Servo

The pen-position servo (Figure 3-11) uses a differential amplifier (A50, Type 1458) to compare the high level input signal with the slidewire wiper signal. Any voltage difference (the servo error voltage) operates either the clockwise or the counterclockwise winding of the ac servo motor to drive the slidewire wiper to the zero error position. The pen is mechanically linked to the slidewire wiper. The recorder deadband is 0.5% of span maximum. To minimize “hunting,” the servo error voltage is fed to polarity sensitive, biased comparators (one-half of quad operational amplifier A51, Type LM224) so that in fact, the error signal must reach a factory set level before actuating the triac (Type HI23SS) that switches 24 Vac to the servo motor winding.

This design concept, called a “bang-bang” servo has the advantage of high reliability and high torque output. Since the servo motor and slidewire wiper can be driven to their limits by a burnout or other over-range signal, the circuit also uses the other half of the A51, Type LM224 quad operational amplifier as two comparators to serve as high and low limits, and to prevent motor drive beyond the limits established by resistors R58, R59, and R60.

![Diagram of Pen-Position Servo](image)
Automatic Control

Control is obtained by using a differential amplifier (Type 1458) to compare the high level input signal with the slidewire wiper position. Any difference initiates control action. Note that the slidewire has two independent wipers: the pen wiper and the control set point wiper. This arrangement ensures that the recording system and the control system are operating from the same electrical reference. Further, since the pen wiper is mechanically attached to the pen, and the SP wiper is mechanically attached to the set point pointer, the calibrated chart can be the reference for both systems. When the pen and the control set point pointer are at the same point on the chart, the contacts on the slidewire are mechanically within one convolution of each other.

The slidewire voltage is set for a range of 0.575 to 5.575 Vdc, which is the same as the high level input signal from the preamplifier.

Two position (On-Off) Control

For two-position control (Figure 3-12) a differential amplifier (A101) with built-in hysteresis of approximately 0.5% span is used. This hysteresis helps to minimize relay chatter at the null position.

The control error voltage drives a power transistor (Q101, Type 2N5816) which, in turn drives a 24 Vdc SPDT electromechanical relay. A "balance" potentiometer (P6) provides an adjustable offset voltage to the the amplifier to shift the operating point of the relay slightly. The effect is comparable to manual reset on proportional controllers. The normally open relay contacts make (close) when the input signal is below the set point. These contacts are available at Terminals 7 (Hot) and 8 (Load). The normally closed contacts open when the input signal is below the set point. These contacts are available on Terminals 7 (Hot) and 9 (Load). Contact rating is 5A at 120/230 Vac resistive, and 50 VA at 120/230 Vac pilot duty.

An electromechanical relay is used because these devices are more tolerant of misapplication and contact overload than are triacs and SCRs (though these conditions will shorten the life of the relay).

Relay contact arc-suppression is a function of the characteristics of the load, and is applied across the load to enhance the relay's life. Therefore, a 100 ohm resistor and a 0.022 microfarad capacitor are installed in series across Terminals 7 and 8. The user has to install these devices if Terminals 7 and 9 are used.
Time Proportioning with Manual Reset

The time proportioning control (Figure 3-13) is like the two-position control, in that it has the same differential amplifier input, and the same electromechanical amplifier is fed to a comparator stage (A101) where the control error voltage is compared to the output of a free-running sawtooth voltage generator (A102). The output of this comparator stage is the percent of time the error voltage is greater than the sawtooth voltage. The amplitude of the sawtooth voltage is selectable by printed circuit board jumper positions corresponding to proportional bands of 2, 5 and 10% of span. The period of the sawtooth voltage is selectable by another jumper as a cycle time of 10 or 20 seconds. Also included is a manual reset circuit which adds or subtracts voltage to the control error voltage signal, thus enabling the percent on-time of the relay to be greater or less than 50% when the input signal equals the control set point. The manual reset adjustment (Potentiometer P6) overcomes continuing input offset from the set point (droop or overshoot). It is accessible on the right side of the front plate with the door open.

This type of control, commonly called three-mode control, operates exactly as the proportioning with manual reset to generate the initial error signal. However, before the error voltage is compared to the sawtooth voltage, it is modified by the Three-mode Circuit (Figure 3-15). The single-mode functions of proportional band and manual reset (dotted outlined circuit portion of Figure 3-15) are replaced by similar functions in the Three-mode Circuit, and the Three-mode Circuit output is fed back to compare the modified error voltage with the sawtooth voltage in A101. The amplitude of the sawtooth voltage is a fixed value, and a potentiometer adjustment in the Three-mode Circuit adjusts the error signal voltage. The A101 comparator stage output corresponds to the percent of time the modified error voltage is greater than the sawtooth voltage, as in the single mode control.

Figure 3-13—Time proportioning control

Figure 3-15—Modified error signal (output from 3-mode circuit)
Current Proportioning with Manual Reset

This type of control (Figure 3-14) generates a control error voltage signal from a differential amplifier in the same manner as in the two-position and time-proportioning control. The control error voltage and a voltage proportional to the 4 to 20 mA output are fed to an amplifier stage (A101) whose output is proportional to their difference and drives a Darlington transistor (Q101, Type D40C4.) The Darlington transistor regulates the 4 to 20 mA current to the external 0 to 600 ohm load, using the +24 Vdc supply. The load is connected to Terminals 7(+) and 8(−). By means of a jumper on the printed circuit board, portions of the control error voltage can be selected corresponding to proportional bands of 2, 5, and 10%. To allow field conversion from the reverse-acting control mode to the direct-acting control mode, a pair of jumpers (JC and JD) on the printed circuit board are repositioned to reverse the input and set point signals to the differential amplifier. The Manual Reset enables the operator to adjust the output current to be greater or less than 12 mA when the input equals the set point so as to overcome control offset (droop or overshoot).

Current Proportioning plus Reset plus Rate

This control, commonly called three-mode control, operates exactly as the current-proportioning control with manual reset to generate the initial error signal. However, before the error voltage is compared to the current output feedback voltage, it is modified by the Three-mode Circuit (Figure 3-15). The single mode functions of proportional band and manual reset (dotted outlined circuit portions of Figure 3-14) are replaced by similar functions in the Three-mode Circuit, and the Three-mode Circuit output is fed back to compare the modified error voltage with the current output feedback voltage in A101. The comparator stage output drives the output-regulating Darlington transistor, as in the single-mode control.

Three-mode Circuit

The Three-mode Circuit (Figure 3-15) modifies the error signal in accordance with chosen settings of proportional band, reset (repeats/minute) and rate. The modified error output is fed to the A101 amplifier stage of the time- or current-proportioning circuit (Figures 3-13 or 3-14) to complete the control action circuit.

Proportional Band

Amplifier A402 accepts the modified error output from amplifier A401, and multiplies it by a gain factor. The gain of A402 is set by feedback from its output through the proportional band potentiometer P401. The gain varies with the resistance ratio of the portion of P401 in the feedback loop to the remainder of P401 and resistor R418. Proportional band is the inverse of gain. The output from A402 is the total modified error signal.

Reset

The amount of reset action (repeats per minute) is determined by the plug-on jumper selection of resistances in parallel with capacitor C408. When a reset value above zero is selected, C408 charges with the output feedback voltage from amplifier A401. A voltage divider scales the changing voltage level for C408 to be comparable to the error signal from the rate portion of the circuit. The error voltage and the capacitor voltage are added in A401, increasing the amplifier output steadily as C408 continues to charge.

Rate

A voltage divider (R401 and R402) sets the steady-state voltage level at the input of amplifier A401 as a percentage of the error voltage. The amplifier input voltage at any given moment is determined by the error voltage minus the voltage on capacitor C402. Since the voltage of a capacitor cannot change instantaneously, the amplifier input voltage will charge directly with the error voltage and decay to its steady-state value as C402 charges or discharges. The amount of time required to reach steady-state is determined by the plug-on jumper selection of resistances in parallel with C402.

Reset lockout

If reset action continued without stop, the output could exceed the control limits. This effect, called "reset wind-up," increases the time required for the reset effect to decay, due to the over charging of C408. The discharge time becomes excessively long and prevents proper control action. To prevent this, the three mode proportioned error output from A402 is compared in A403 with fixed voltage levels corresponding to the upper and lower error limits. An excessive error causes an output from A403 which turns off FET Q401, removing the reference ground from the reset circuit to prevent additional charging of C408. This stops reset build-up whenever the error output is outside the chosen proportional band.
Figure 3-14—Current proportioning control

Figure 3-15—Three-mode circuit
**Limit Control with Manual Reset**

The output circuit (Figure 3-16) accepts the amplified error signal \( E_o \), and drives the control relay. This circuit consists of a modulator, ac amplifier, trigger, and a power amplifier including the demodulator.

The signal \( E_o \) is chopped at line frequency by FET, Q309 driven directly from the secondary of the transformer. R313 and C305 act as a filter to eliminate spikes from the preamplifier. The zener, CR305, shorts the negative wave and cuts the positive wave at about 8 volts. The chopped input signal \( E_o \) is then amplified. The ac amplifier is a two-stage amplifier (Q308, Q307). The bias (by CR304) is such that the signal phase cannot be changed by a failure of one of the amplifier components. The amplifier gain, when loaded by Q306, is about 20. The signal is then fed to a trigger circuit.

The trigger circuit, Q306 and Q305, is designed so that if one component fails, it can never work as an amplifier and change the signal phase. As soon as the threshold is reached by the amplifier output, the circuit is triggered and the output is a square-wave constant magnitude signal, the phase of which depends on the \( E_o \) polarity.

The square wave signal from the trigger circuit is fed into a power amplifier, which is supplied by a half-wave voltage in phase with the modulator drive signal. Q304 drives a push-pull circuit (Q302, R3012, and CR301), and the relay with C301 in parallel. The relay is not fed directly from the power supply, but only from the discharge of C302.

The power supply of the trigger circuit is half-wave (CR303), and demodulation is done by Q304. When the output signal of the trigger is in phase with the half-wave of the power supply, the collector of Q304 is clamped to zero. Therefore, C302 cannot be charged and the relay drops out. When the output signal of the trigger circuit is in opposition phase with the half-wave of the power supply, Q304 is alternately turned on and off. C302 can be charged and discharged and the relay pulled in.

The power supply of the circuit is cut off as soon as the relay drops out. A manual reset pushbutton, connected in parallel with the relay contact, re-energizes the circuit. However, the relay will not pull in again unless the input is of the correct polarity.
Auto-reset
(limit control)

An optional plug-in card, (Figure 3-17) is available to automatically reset the relay after a power failure, providing the input signal is below the set point (High Limit). A decreasing power supply discharges capacitor C322 on the gate of the FET, Q322. When the power is restored, relay K321 is closed. The contacts in parallel with the reset switch allow the load relay to close and lock-in if the input is below the set point. The reset relay is closed for about 5 seconds to allow the circuit to stabilize. The timing is a function of the charging rate of capacitor C322 in the FET Q322 gate circuit.

Process Variable Output

The input signal passes through one-half of A402, which as a buffer, isolates the control circuit (Figure 3-18). The voltage is then divided in half by resistors R440 and R441 and fed to one input of the other half of A405 (difference amplifier) for reamplification to a level between 0 and 5 Vdc. Potentiometer P406 adjusts the span of the output by changing the gain of A405. At the same time, P405 establishes an offset voltage at the other difference amplifier input to shift the zero point by approximately ±0.2 Vdc to eliminate any zero offset. The amplifier input voltages are algebraically added to produce the 0 to 5 Vdc output voltage at Terminals 1(+) and 2(−).

All resistors are 1/4 watt, ±5% unless otherwise specified

* ±1% tolerance
The alarm circuit (Figure 3-19) is separate from automatic control and is available on Recorder-Controllers and Recorders. The alarm circuit provides a High or Low alarm. The alarm set point is adjusted by the 4.5-turn screwdriver-type potentiometer P5. With the exception of the manner of adjusting the set point, the alarm circuit operates in much the same manner as the Two-Position control circuit. A differential amplifier compares the high level input signal with the alarm set point signal to produce an alarm error voltage. The alarm error voltage drives a power transistor (Q201, Type 2N5366) which in turn drives a 24 Vdc SPDT electromechanical relay. The alarm contacts are on Terminals 4 (Hot) and 5 (alarm load), and are made (closed) when the power transistor is turned “ON” by the alarm error voltage. Instruments are usually set to the HIGH alarm mode (Jumper A to Post B and Jumper B to Post A) so that when the input signal is above the alarm set point, the relay is activated. By reversing the positions of the jumpers, the alarm is set in the LOW alarm mode. Even though the alarm relay is soldered to the printed circuit board, it is replaceable.

The alarm relay contact ratings are 2A at 120/230 Vac, resistive, and 50 VA, 120/230 Vac, pilot duty. As in Two-Position and Time Proportioning control, arc suppression should be sized and applied across the load. An internal 100 ohm resistor, in series with an 0.022 microfarad capacitor, is mounted between Terminals 4 and 5. No suppression is supplied between terminals 4 and 6.

![Diagram of Alarm Circuit](image-url)

**Table 3-19 — Alarm**

<table>
<thead>
<tr>
<th>RELAY ENERGIZED FOR</th>
<th>CONNECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>JUMPER B</td>
<td>JUMPER A</td>
</tr>
<tr>
<td>F.V. ABOVE ALARM S.P.</td>
<td>A</td>
</tr>
<tr>
<td>F.V. BELOW ALARM S.P.</td>
<td>B</td>
</tr>
</tbody>
</table>

*± 1% tolerance*

A98-172-1-A
Series AR 100
Recorder, Recorder-Controller, and Limit Controller

Contents

Summary

1—Controller will not operate .................................................. 4-6
2—Recorder operation normal, but pen trace incorrect ................. 4-8
3—Chart rotates at wrong speed or not rotation
   (pen indication correct) .................................................... 4-11
4—Pen remains at high end of range when the
   input signal is low ....................................................... 4-12
5—Pen does not move when the input signal changes ................. 4-13
6—Limit relay does not operate ............................................. 4-16
7—Process Variable output incorrect or missing ...................... 4-17

Flowchart

Failed Component Replacement .................................................. 4-18
<table>
<thead>
<tr>
<th>Problem</th>
<th>Flowchart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller will not operate</td>
<td>1</td>
</tr>
<tr>
<td>Recorder operation normal, but pen trace incorrect</td>
<td>2</td>
</tr>
<tr>
<td>Chart rotates at wrong speed or not rotating (pen indication is correct)</td>
<td>3</td>
</tr>
<tr>
<td>Pen remains at high end of range when the input signal is low</td>
<td>4</td>
</tr>
<tr>
<td>Pen does not move with a change in the input signal</td>
<td>5</td>
</tr>
<tr>
<td>Limit relay does not operate</td>
<td>6</td>
</tr>
<tr>
<td>Process Variable output incorrect or missing</td>
<td>7</td>
</tr>
</tbody>
</table>
Figure 4-1—Location of test points and major components on p.c. board for recorder
Figure 4-2 — Location of test points and major components on p.c. board for proportional controller
Flowchart 1—Controller will not operate

- **ENTER**
  - Does instrument have proper rated power? **YES**
    - Provide appropriate voltage and frequency.
    - Controller operates OK? **YES** END
    - Controller operates OK? **NO**
      - Current proportioning controller unit? **YES**
        - Adjust set point. Check voltage across CR101 as control relay operates.
        - Replace control relay.
        - Controller operates OK? **YES** END
        - Controller operates Ok? **NO**
          - Check voltage from connector SB-7 to TP-5.
          - Clean slidewire and set point wiper. Check continuity between set point wiper and SB-7.
          - Voltage present? **NO**
            - Replace open set point wiper.
            - Controller operates OK? **YES** END
          - Voltage changes smoothly as set point varies? **YES**
            - Check recorder portion of unit.
              - Is recorder operating normally? **NO**
                - Replace circuit boards.
                - Controller operates OK? **YES** END
              - **YES**
                - Check preamplifier as follows:
                  - Connect SD-4 to TP-5, and Terminal 1 to Terminal 3.
                  - Check that the voltage between TP-4 and TP5 is 0 mV ± 2000/span in mV.
                  - Remove connections between SD-4 and TP-5, and Terminal 1 and Terminal 3.
                  - Apply a signal equal to the 100% range value across Terminals 1 and 3.
                  - Check that the voltage between TP-4 and TP-5 is 5.57 Vdc ± 0.6 Vdc.
                - Volatges correct? **NO**
                  - Replace circuit boards.
                  - Controller operates OK? **YES** END
                - **NO**
                  - TA

***Contact***
Honeywell
1885 Douglas Drive North
Minneapolis, Minnesota 55422
Flowchart 1—Controller will not operate (continued)

1A

Two-position controller unit?

NO

YES

Measure SP voltage at pin 1 of A101 (same as at SB-7 to TP-5).

Measure SP voltage at pin 7 of A102 (same as at SB-7 to TP-5).

Voltage correct?

NO

YES

Replace circuit board (A102 failure).

Problem solved?

NO

YES

END

Adjust SP (with PV constant) and measure voltage at pin 7 of A101.

Replace circuit board (A101 failure).

Voltage change with SP?

NO

YES

Problem solved?

NO

YES

END

Replace Q101 or circuit board.

Problem solved?

NO

3 Mode controller unit?

NO

YES

Adjust SP (with PV constant) and measure voltages at pin 6 of A401 and pin 6 of A402.

Voltage change with SP?

NO

YES

Problem solved?

NO

YES

Replace circuit board (A401 or A402 failure).

***Contact
Honeywell
1885 Douglas Drive North
Minneapolis, Minnesota 55422
Flowchart 2—Recorder operation normal, but pen trace incorrect

ENTER

Check pen cartridge for proper installation, pen nub centered in V-notch of pen arm, and clasp closed.

Pen cartridge OK?

NO  Reposition or replace cartridge. If pen arm is severely warped to prevent proper installation, replace pen arm.

YES

Check chart that it agrees with sensor type and instrument range.

Correct chart?

NO  Replace wrong chart with correct chart.

YES

Check sensor for proper type and ability to function.

Sensor OK?

NO  Replace sensor.

YES

Check supply voltage to instrument that it agrees with the instrument rating. Measure voltage at terminals L1 and L2.

Voltage OK?

NO  Provide correct supply voltage.

YES

Measure slidewire excitation voltage between TP-6 and TP-5 (6.15 Vdc).

Voltage correct?

NO  Adjust P7 to correct voltage.

YES

Check calibration at 0%, 50%, and 100% of scale points.

2A
Flowchart 2—Recorder operation normal, but pen trace incorrect (continued)

2A

Calibration correct?

YES

Check instrument power supply circuit. Measure voltages between J1 and TP-5 (+12 ±0.6 Vdc), and J1A and TP-5 (-12 ±0.6 Vdc).

NO

Recalibrate at 0% and 100% using zero and span adjustments.

Problem solved?

YES

END

NO

Problem solved?

YES

END

NO

Replace circuit board.

Voltages OK?

YES

Check preamplifier as follows:
- Connect SD-4 to TP-5, and Terminal 1 to Terminal 3.
- Check that the voltage between TP-4 and TP5 is 0 mV ± 2000/span in mV.
- Remove connections between SD-4 and TP-5, and Terminal 1 and Terminal 3.
- Apply a signal equal to the 100% range value across Terminals 1 and 3.
- Check that the voltage between TP-4 and TP-5 is 5.57 Vdc ± 0.6 Vdc.

NO

Voltages correct?

YES

Replace circuit board.

Problem solved?

YES

END

NO

2B

NO
flowchart 2—Recorder operation normal, but pen trace incorrect (continued)

Is sensor a T/C?

Measure voltage across compensator. Measure temperature at compensator. Compare the voltage and temperature values with the values in Table 4.

Values agree with table?

Readjust compensator voltage using P1. If voltage cannot be corrected, replace circuit board.

Servo wiper at midpoint?

Repair servo amplifier or replace circuit board.

Adjust manual reset (on proportional control models).

Problem solved?

Loosen pen arm setscrews. Reposition pen arm. Tighten setscrews.

Problem solved?

*Remove chart paper to compare position with 50% marking on chart plate.

**Contact Honeywell 1885 Douglas Drive North Minneapolis, Minnesota 55422
Flowchart 3—Chart rotates at wrong speed or not rotating (pen indication correct)

1. ENTER
2. Check chart installation. Be sure drive pin on hub is in drive hole in chart.
   - Chart installed correctly?
     - YES: Problem solved? YES END
     - NO: Check that chart is not binding. Turn chart hub clockwise manually. Chart should be under set point indexes; flat against chart plate.
       - Problem solved? YES END
       - NO: Check that power is getting to chart motor through plug-in connector SC, posts 3 and 4 (24 Vac)*
         - Problem solved? YES END
         - NO: Voltage OK?
           - YES: Check supply voltage
             - Supply voltage OK?
               - YES: Problem solved? YES END
               - NO: Correct supply voltage
                 - Problem solved? YES END
                 - NO: Replace transformer T1 or circuit board.
                   - Problem solved? YES END
                   - NO: Replace chart drive assembly.
                     - Problem solved? YES END
                     - NO: ***

*Check for jumper on motor terminals of optical event switch board (where applicable). Also, check for 24 Vac at SF connector.

***Contact Honeywell 1885 Douglas Drive North Minneapolis, Minnesota 55422
Flowchart 4—Pen remains at high end of range when the input signal is low

**Enter**
- Check servo wiper for proper contact with slidewire.
  - Wiper contact open? YES → Clean slidewire: Check for continuity between servo wiper and TP-1.
  - Continuity OK? NO → Replace slidewire and/or servo wiper.
  - Continuity OK? YES → Go to next step.
  - Continuity OK? NO → Replace sensor or leadwires as needed. Tighten connections.
  - Is sensor a thermocouple? YES → Check compensator resistance \( R = 100 \)Ω. Note: Disconnect compensator from terminal #2 to measure its resistance.
  - Make sure that SB connector is plugged in correctly. Check slidewire excitation voltage at connector from SB-8 to SB-6 (6.15 Vdc).
  - Voltage correct? NO → Adjust P7 until slidewire excitation voltage at SB connector (SB-8 to SB-6) equals 6.15 Vdc.
  - Voltage correct? YES → Check for servomotor binding-up. Remove 2 motor mount screws and rotate body of motor by hand to move servo.
  - Servo binding up? YES → Replace servo assembly.
  - Problem solved? YES → END
  - Problem solved? NO → Replace circuit board.
  - Problem solved? YES → END

- Replace compensator.
- Problem solved? YES → END
- Problem solved? NO → Replace compensator.
- Problem solved? YES → END

***Contact Honeywell 1865 Douglas Drive North Minneapolis, Minnesota 55422***
Flowchart 5—Pen does not move when the input signal changes

ENTER

Check power supply to instrument that voltage agrees with rating. Measure voltage at terminals L1 and L2.

Power OK?

NO

Provide correct supply

YES

Check voltages between J1 and TP-5 (+12 ±0.6 Vdc), J1A and TP-5 (-12 ±0.6 Vdc), and between connector posts SC-1 and SC-2 (24 Vac). (Optional chart light will be on if the 24 Vac is present).

Voltage OK?

NO

Replace circuit board. *

YES

Check sensor and leadwires for continuity. Check connections.

Continuity OK?

NO

Replace sensor or leadwires as needed. Tighten connections.

YES

Unplug connector SB. Check slidewire resistance between plug receptacles 6 and 8 (3.3kΩ ±10%).

Slidewire OK?

NO

Replace slidewire or servo assembly

YES

Check pen arm for secure mechanical attachment to servo shaft.

END

* (Or isolate and replace failed components). Refer to "Failed Component Replacement" paragraph.
Flowchart 5—Pen does not move when the input signal changes (continued)

5A

Pen arm secure to shaft? NO

Adjust an input signal until a voltage of 3.075 Vdc is at TP-4 to TP-5. Servo wiper should move to slidewire midpoint. Reposition pen arm to 50% position* and tighten setscrews.

Pen arm tight? NO

Replace pen arm assembly.

YES

Servo wiper at midpoint? NO

Replace servo or circuit board

YES

Problem solved?

YES END

NO

Check preamplifier as follows:
- Connect SD-4 to TP-5, and Terminal 1 to Terminal 3.
- Check that the voltage between TP-4 and TP-5 is 0 mV ± 2000/span in mV.
- Remove connections between SD-4 and TP-5, and Terminal 1 and Terminal 3.
- Apply a signal equal to the 100% range value across Terminals 1 and 3.
- Check that the voltage between TP-4 and TP-5 is 5.57 Vdc ± 0.6 Vdc.

Voltagess correct? NO

Replace circuit board

YES END

Problem solved?

YES END

NO

Servo binding up? NO

Replace servo assembly

YES END

*Remove chart paper to compare position with 50% marking on chart plate.

Check for servomotor binding-up. Remove 2 motor mount screws and rotate body of motor by hand to move servo.
Flowchart 5—Pen does not move when the input signal changes (continued)

Adjust an input signal for 100% of range. Connect a jumper from SC-1 to SB-3. Pen should drive upscale. Adjust input signal to 0%. Connect jumper from SC-1 to SB-4. Pen should drive downscale.

Plug-in SB connector.

NO

Connector SB plugged in correctly?

YES

Replace servo motor.

NO

Problem solved?

YES

END

Adjust an input signal until the voltage measured between TP-4 and TP-5 is 6.0 Vdc or greater. Measure voltage from SB-3 to terminal 3 (0.8 ±0.4 Vac).

Voltage correct?

NO

Replace circuit board

YES

Problem solved?

YES

END

NO

*** Contact
Honeywell
1885 Douglas Drive North
Minneapolis, Minnesota 55422
Flowchart 6—Limit Controller output relay does not operate

1. **ENTER**
2. **Does instrument have proper rated power?**
   - **YES**
     - **Adjust set point. Check voltage across CR101 as Control Relay operates.**
     - **NO**
     - **Provide appropriate voltage and frequency. Press Manual reset button.**
     - **Controller operates OK?**
       - **YES**
         - **END**
       - **NO**
         - **Replace control relay.**
3. **Check voltage from connector SB-7 to TP-5.**
   - **NO**
     - **Voltage present?**
       - **YES**
         - **Check continuity between set point wiper and SB-7.**
         - **Clean slidewire and set point wiper.**
       - **NO**
         - **Voltage changes smoothly as set point varies?**
           - **YES**
             - **Check preamplifier as follows:**
               - Connect SD-4 to TP-5, and Terminal 1 to Terminal 3.
               - Check that the voltage between TP-4 and TP5 is 0 mV ± 2000/0.8V in mV.
               - Apply a signal equal to the 100% range value across Terminals 1 and Terminal 3.
               - Check that the voltage between TP-4 and TP-5 is 5.57 Vdc ± 0.6 Vdc.
             - **END**
           - **NO**
             - **Continue.**
               - **Controller operates OK?**
                 - **YES**
                   - **Replace circuit board(s).**
                 - **NO**
                   - **Is recorder operating normally?**
                     - **YES**
                       - **Replace open set point wiper.**
                     - **NO**
                       - **Clean slidewire.**
4. **END**

**Contact**
Honeywell
1885 Douglas Drive North
Minneapolis, Minnesota 55422
Flowchart 7—Process variable output signal incorrect or missing

**ENTER**

Measure voltage (0 to 5 Vdc) between points G (+) and C (−) on upper printed circuit board level.

**Voltage present?**

- **YES**
  - Repair/replace leadwires from printed circuit board to PV output terminal strip.
  - Problem solved?
    - **YES**
      - END
    - **NO**
      - Consult factory.

- **NO**
  - Measure PV output voltage with 0% PV input. Adjust P405 to set PV output to 0 Vdc.
  - Measure PV output voltage with 100% PV input. Adjust P405 to set PV output to 5 Vdc.

**Adjustments set correct PV output voltages?**

- **YES**
  - END
- **NO**
  - Measure voltage between points E (+) and C (−) on upper printed circuit board level for:
    - 0% PV input (measure 0.575 ±0.01 Vdc)
    - 100% PV input (measure 5.575 ±0.01 Vdc)

**Replace controller printed circuit board (probable A405 failure).**

**Problem solved?**

- **YES**
  - END
- **NO**
  - *****

***Check preamplifier as follows:***

- Connect SD-4 to TP-5, and Terminal 1 to Terminal 3.
- Check that the voltage between TP-4 and TP5 is 0 mV ± 2000 span in mV.
- Remove connections between SD-4 and TP-5, and Terminal 1 and Terminal 3.
- Apply a signal equal to the 100% range value across Terminals 1 and 3.
- Check that the voltage between TP-4 and TP-5 is 5.57 Vdc ± 0.6 Vdc.

***Contact***

Honeywell
1885 Douglas Drive North
Minneapolis, Minnesota 55422

44-01-13-02, Page 17
Failed Component Replacement

Board replacement is generally preferable to component replacement because of possible damage to a board, and because of variations in the replacement components. However, it is not always possible to obtain the replacement board immediately, so that following procedures are provided to replace components.

CAUTION: Use a low power soldering iron (30 watts maximum) and a solder suction tool or solder wick material to remove solder. Be careful not to "bridge" between pads or circuits on the board.

Procedures
1. Isolate failed components by using the flowcharts, standard troubleshooting procedures, and the circuit descriptions and schematics provided in the Technical Data section.
2. Remove the p.c. board assembly by disconnecting connectors, and removing the wires from the terminal block; then removing the screws that mount the board to the case.
3. Based on the results obtained from the troubleshooting, replace components as follows:
   ■ If the voltage between SC-1 and SC-2 is incorrect, replace Transformer T1.
   ■ If the unregulated voltage between the plus end of C30 and TP-5 isn't +24 Vdc, and between the minus end of C33 and TP-5 isn't -24 Vdc, check each of the following components in the order listed, and replace if failed: CR30, CR31, CR32, CR33, CR40, CR41, C30, C33, C40 and C41.
   ■ If ac voltage isn't present at the rectifier diodes, replace T2.
   ■ If the regulated voltage between J1 and TP-5, and the regulated voltage between J1A and TP-5 differ from 12 Vdc ±0.6 by the same amount, replace components as follows: A40 if the AR 100 is a recorder only; A30 if the AR 100 is a recorder-controller.
   ■ If the regulated voltage between J1 and TP-5 is +12 Vdc ±0.6, but the regulated voltage between J1A and TP-5 isn't -12 Vdc ±0.6, replace components as follows: A41 if the AR 100 is a recorder only; A31 and Q30 if the AR 100 is a recorder-controller.

By using the Honeywell part numbers, the components listed below can be ordered from Honeywell, 1885 Douglas Drive North, Minneapolis, Minnesota 55422 or, by using the commercial part numbers, purchased locally:

<table>
<thead>
<tr>
<th>Component</th>
<th>Part Number Honeywell</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (100/24 Vac)</td>
<td>24001861-008</td>
<td>1N4004</td>
</tr>
<tr>
<td>(120/24 Vac)</td>
<td>24001861-003</td>
<td></td>
</tr>
<tr>
<td>(230/24 Vac)</td>
<td>24001861-004</td>
<td></td>
</tr>
<tr>
<td>T2 (100/37 Vac)</td>
<td>24001861-009</td>
<td></td>
</tr>
<tr>
<td>(120/37 Vac)</td>
<td>24001861-005</td>
<td></td>
</tr>
<tr>
<td>(230/37 Vac)</td>
<td>24001861-006</td>
<td></td>
</tr>
<tr>
<td>CR30, CR31, CR32, CR33</td>
<td>192265</td>
<td></td>
</tr>
<tr>
<td>CR40, CR41</td>
<td>2001191-001</td>
<td>100 μF, 50V</td>
</tr>
<tr>
<td>C30, C33, C40, C41</td>
<td>2001184-451</td>
<td></td>
</tr>
<tr>
<td>A30</td>
<td>2001482-451</td>
<td></td>
</tr>
<tr>
<td>A31</td>
<td>193889</td>
<td></td>
</tr>
<tr>
<td>A40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A41</td>
<td>193888</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

44-01-13-02, Page 18
### Parts List

#### Spares for 100 instruments

<table>
<thead>
<tr>
<th>Key No.</th>
<th>Part No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>see Table 2</td>
<td>Printed Wiring Board Assembly</td>
<td>1 per pen</td>
</tr>
<tr>
<td>2</td>
<td>24110266-001</td>
<td>Replacement Case Assembly</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>24400124-001</td>
<td>Panel Mounting Bezel Kit (not illustrated)</td>
<td>1</td>
</tr>
<tr>
<td>3-1</td>
<td>Note A</td>
<td>Range Resistors</td>
<td>1</td>
</tr>
<tr>
<td>3-2</td>
<td>24001179-001</td>
<td>Alarm Relay (soldered)</td>
<td>1 per pen</td>
</tr>
<tr>
<td>3-3</td>
<td>134378</td>
<td>Control Relay (plug-in type for 2-position and Time Proportioning Controllers)</td>
<td>1 per pen</td>
</tr>
<tr>
<td></td>
<td>135300</td>
<td>Control Relay (plug-in type for Limit Control)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>24400131-001</td>
<td>Auto Reset Assembly Kit (Limit Control)</td>
<td>1 per pen</td>
</tr>
<tr>
<td>5</td>
<td>24001627-001</td>
<td>Hinge Pin</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>24110261-001</td>
<td>Door Assembly (includes window)</td>
<td>1</td>
</tr>
<tr>
<td>6-1</td>
<td>24001622-001</td>
<td>Window (glass)</td>
<td>1</td>
</tr>
<tr>
<td>6-2</td>
<td>24400125-001</td>
<td>Window Kit (clear acrylic plastic)</td>
<td>1</td>
</tr>
<tr>
<td>6-3</td>
<td>24400132-001</td>
<td>Door Latch Assembly</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>24400142-001</td>
<td>Door Lock Kit (not illustrated)</td>
<td></td>
</tr>
</tbody>
</table>

#### Spares for 10 instruments

<table>
<thead>
<tr>
<th>Key No.</th>
<th>Part No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE A:** Part Numbers explained in "Changing Range or Actuation" in the Product Manual.

---

Figure 1 — Case and door — chart plate removed
Figure 2—Chart plate — recorder-controller

<table>
<thead>
<tr>
<th>Key No.</th>
<th>Part No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>see Tables 4 &amp; 5</td>
<td>Chart paper</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>24110269-001</td>
<td>Pen 2 set point lever/index/link assembly</td>
<td>1</td>
</tr>
<tr>
<td>2-1</td>
<td>24001828-001</td>
<td>Pen 1 set point knob (plain, beige color)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>24001610-001</td>
<td>Pen 1 set point index</td>
<td>1</td>
</tr>
<tr>
<td>3-1</td>
<td>24001613-001</td>
<td>Pen 2 set point knob (purple marking)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>24400128-001</td>
<td>Set point mechanical stop kit (Pen 1 SP only)</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>24110260-001</td>
<td>Pen 1 arm assembly</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>24110270-001</td>
<td>Pen 2 arm/linkage</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>see Table 2</td>
<td>Pen 2 cartridge</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>see Table 2</td>
<td>Pen 1 cartridge</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>123298</td>
<td>Lamp (1829)</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>24400120-001</td>
<td>Illumination kit</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>24110265-001</td>
<td>Servo assembly—complete with motor—no set point</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>24110265-002</td>
<td>Servo assembly—complete with motor and set point</td>
<td>1</td>
</tr>
<tr>
<td>11-1</td>
<td>24110274-001</td>
<td>Servo motor assembly</td>
<td>1</td>
</tr>
<tr>
<td>11-2</td>
<td>24400122-001</td>
<td>Slidewire</td>
<td>1</td>
</tr>
<tr>
<td>11-3</td>
<td>24110264-001</td>
<td>Slidewire wiper arm—set point assembly</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>24110263-001</td>
<td>Slidewire wiper arm—pen assembly</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>see Table 3</td>
<td>Chart drive assembly</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>24110310-001</td>
<td>Lamp and pushbutton assembly (includes connector block) not shown</td>
<td>1</td>
</tr>
<tr>
<td>13-1</td>
<td>24001826-001</td>
<td>Lamp</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>24400142-001</td>
<td>Pen lifter kit (not illustrated)</td>
<td>1</td>
</tr>
</tbody>
</table>
### TABLE 1—Printed Wiring Board Assemblies

<table>
<thead>
<tr>
<th>Operation</th>
<th>100V</th>
<th>120V</th>
<th>230V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record only</td>
<td>24110334-005</td>
<td>24110334-001</td>
<td>24110334-002</td>
</tr>
<tr>
<td>Record with Alarm</td>
<td>24110334-006</td>
<td>24110334-003</td>
<td>24110334-004</td>
</tr>
<tr>
<td>Record with On-Off</td>
<td>24110262-127</td>
<td>24110262-105</td>
<td>24110262-106</td>
</tr>
<tr>
<td>Record with On-Off and Alarm</td>
<td>24110262-128</td>
<td>24110262-107</td>
<td>24110262-108</td>
</tr>
<tr>
<td>Record with Time Prop. (1-mode)</td>
<td>24110262-129</td>
<td>24110262-109</td>
<td>24110262-110</td>
</tr>
<tr>
<td>Record with Time Prop. (1-mode) and Alarm</td>
<td>24110262-130</td>
<td>24110262-111</td>
<td>24110262-112</td>
</tr>
<tr>
<td>Record with Current Prop. (1-mode)</td>
<td>24110262-131</td>
<td>24110262-113</td>
<td>24110262-114</td>
</tr>
<tr>
<td>Record with Current Prop. (1-mode) and Alarm</td>
<td>24110262-132</td>
<td>24110262-115</td>
<td>24110262-116</td>
</tr>
<tr>
<td>Record with Manual Reset Limiter (no separate alarm)</td>
<td>24110308-103</td>
<td>24110308-101</td>
<td>24110308-102</td>
</tr>
<tr>
<td>Record with Time Prop. (3-mode)</td>
<td>24110313-117</td>
<td>24110313-101</td>
<td>24110313-102</td>
</tr>
<tr>
<td>Record with Time Prop. (3-mode) and Alarm</td>
<td>24110313-118</td>
<td>24110313-103</td>
<td>24110313-104</td>
</tr>
<tr>
<td>Record with Current Prop. (3-mode)</td>
<td>24110313-119</td>
<td>24110313-105</td>
<td>24110313-106</td>
</tr>
<tr>
<td>Record with Current Prop. (3-mode) and Alarm</td>
<td>24110313-120</td>
<td>24110313-107</td>
<td>24110313-108</td>
</tr>
</tbody>
</table>

### TABLE 2—Pen Cartridges (Kit of 6)

<table>
<thead>
<tr>
<th>Pen</th>
<th>Part No.</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30735489-002</td>
<td>red</td>
</tr>
<tr>
<td></td>
<td>30735489-001</td>
<td>purple</td>
</tr>
<tr>
<td></td>
<td>30735489-003</td>
<td>green</td>
</tr>
<tr>
<td></td>
<td>30735489-008</td>
<td>black</td>
</tr>
<tr>
<td>2</td>
<td>30735489-007</td>
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<td>30735489-006</td>
<td>green</td>
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### TABLE 3—Chart Drive Assembly

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<td>24110273-003</td>
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### TABLE 4—Single Range Charts

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<tr>
<th>Sensor Type J</th>
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<tr>
<td></td>
<td>- 50 to + 300°F</td>
<td>24001660-019</td>
<td>24001661-019</td>
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<tr>
<td></td>
<td>0 to 300°F</td>
<td>24001660-002</td>
<td>24001661-002</td>
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<tr>
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<td>0 to 400°F</td>
<td>24001660-012</td>
<td>24001661-006</td>
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<tr>
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<td>0 to 500°F</td>
<td>24001660-013</td>
<td>24001661-007</td>
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<td>0 to 600°F</td>
<td>24001660-003</td>
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<td>0 to 800°F</td>
<td>24001660-014</td>
<td>24001661-009</td>
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<tr>
<td></td>
<td>0 to 1000°F</td>
<td>24001660-015</td>
<td>24001661-010</td>
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<tr>
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<td>0 to 1200°F</td>
<td>24001660-004</td>
<td>24001661-011</td>
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<tr>
<td></td>
<td>0 to 1600°F</td>
<td>24001660-018</td>
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<td>50 to 650°F</td>
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<td>50 to 1400°F</td>
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<td>- 45 to + 150°C</td>
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<td>- 18 to + 425°C</td>
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<td></td>
<td>0 to 150°C</td>
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<td>0 to 250°C</td>
<td>24001660-024</td>
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<td>0 to 300°C</td>
<td>24001660-062</td>
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<td>0 to 400°C</td>
<td>24001660-063</td>
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<td>10 to 340°C</td>
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<td>10 to 760°C</td>
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<td>100 to 260°C</td>
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<td>- 250 to + 150°F</td>
<td>24001660-042</td>
<td>24001661-042</td>
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<td>- 130 to + 410°F</td>
<td>24001660-033</td>
<td>24001661-033</td>
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<td></td>
<td>- 100 to + 100°C</td>
<td>24001660-069</td>
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<tr>
<td></td>
<td>- 90 to + 210°C</td>
<td>24001660-034</td>
<td>24001661-034</td>
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<td></td>
<td>+ 75 to - 200°C</td>
<td>24001661-058</td>
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<td></td>
<td>0 to 300°C</td>
<td>24001661-079</td>
<td>24001661-079</td>
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<tr>
<td></td>
<td>- 105 to 105°C</td>
<td>24001660-098</td>
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<table>
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<tbody>
<tr>
<td></td>
<td>0 to 400°F</td>
<td>24001660-053</td>
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<td></td>
<td>0 to 1000°F</td>
<td>24001660-007</td>
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<td>0 to 1200°F</td>
<td>24001660-006</td>
<td>24001661-012</td>
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<td>0 to 1600°F</td>
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<td>24001661-013</td>
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<td>0 to 2000°F</td>
<td>24001660-005</td>
<td>24001661-014</td>
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<td>0 to 2400°F</td>
<td>24001660-009</td>
<td>24001661-015</td>
</tr>
<tr>
<td></td>
<td>- 18 to 1320°C</td>
<td>24001660-031</td>
<td>24001661-031</td>
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<tr>
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<td>0 to 400°C</td>
<td>24001660-064</td>
<td>24001661-064</td>
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<tr>
<td></td>
<td>0 to 600°C</td>
<td>24001660-059</td>
<td>24001661-059</td>
</tr>
<tr>
<td></td>
<td>0 to 800°C</td>
<td>24001660-060</td>
<td>24001661-060</td>
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<td></td>
<td>0 to 1000°C</td>
<td>24001660-049</td>
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<td></td>
<td>0 to 1200°C</td>
<td>24001660-065</td>
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<table>
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<th>Chart Numbers</th>
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<td></td>
<td>700 to 1450°C</td>
<td>24001660-118</td>
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### TABLE 4 (Continued)

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<tr>
<td>0 to 2500°F</td>
<td>24001660-025</td>
<td>24001661-025</td>
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<tr>
<td>30 to 2900°F</td>
<td>24001660-032</td>
<td>24001661-032</td>
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<tr>
<td>0 to 1600°C</td>
<td>24001660-017</td>
<td>24001661-017</td>
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<tr>
<td>800 to 1600°C</td>
<td>24001660-089</td>
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### Linear (or RTD)

- 200 to +100°F | 24001660-044 | 24001661-044 |
- 125 to +375°F | 24001660-020 | 24001661-020 |
- 100 to +100°C | 24001660-080 | 24001661-080 |
- 100 to +200°C | 24001660-021 | 24001661-021 |
- 85 to +190°C | 24001660-047 |                     |
- 75 to +260°C | 24001660-055 | 24001661-055 |
- 50 to +25°C | 24001660-048 |                     |
- 40 to +60°C | 24001660-067 | 24001661-067 |
- 35 to +75 | 24001660-023 | 24001661-023 |
- 30 to +170°F | 24001660-087 | 24001661-087 |
- 25 to +125 | 24001660-045 | 24001661-045 |
- 18 to +94 | 24001660-035 | 24001661-035 |
- 5 to +50 | 24001660-022 | 24001661-022 |
- 0 to −100°C | 24001660-084 |                     |
- 0 to 5 | 24001660-072 |                     |
- 0 to 5 (%) | 24001660-074 | 24001661-074 |
- 0 to 10 | 24001660-076 |                     |
- 0 to 14 | 24001660-036 | 24001661-036 |
- 0 to 14 (pH) | 24001660-073 |                     |
- 0 to 15 | 24001660-085 |                     |
- 0 to 20 | 24001660-071 |                     |
- 0 to 40 | 24001660-041 |                     |
- 0 to 45 | 24001660-078 |                     |
- 0 to 50 | 24001660-051 |                     |
- 0 to 70 | 24001660-075 |                     |
- 0 to 100 | 24001660-001 | 24001661-001 |
- 0 to 120 | 24001660-054 |                     |
- 0 to 200 | 24001660-010 | 24001661-004 |
- 0 to 250°C | 24001660-068 |                     |
- 0 to 300 | 24001660-037 | 24001661-037 |
- 0 to 350 | 24001660-050 |                     |
- 0 to 400 | 24001660-011 | 24001661-005 |
- 0 to 400°C | 24001660-081 | 24001661-081 |
- 0 to 600 | 24001660-052 |                     |
- 20 to 120 | 24001660-039 | 24001661-039 |
- +49 to −95°C | 24001660-083 |                     |
- +50 to −85°C | 24001661-046 |                     |
- 50 to 250 | 24001660-008 | 24001661-003 |
- 70 to 140 | 24001660-038 | 24001661-038 |
- +120 to −140°F | 24001660-082 |                     |

### TABLE 5—Dual Range Charts

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<tr>
<th>Ranges</th>
<th>Chart Numbers 1 Day</th>
<th>Chart Numbers 7 Day</th>
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<tr>
<td>−100 to +200 Linear or RTD</td>
<td>24001660-600</td>
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<tr>
<td>35 to 0 Linear or RTD</td>
<td>24001660-601</td>
<td>24001661-601</td>
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<tr>
<td>0 to 100 Linear or RTD</td>
<td>24001660-602</td>
<td>24001661-602</td>
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<tr>
<td>−30 to +70 Linear or RTD</td>
<td>24001660-603</td>
<td>24001661-603</td>
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<tr>
<td>0 to 200 Linear or RTD</td>
<td>24001660-604</td>
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<tr>
<td>35 to 0 Linear or RTD</td>
<td>24001660-605</td>
<td></td>
</tr>
<tr>
<td>0 to 600°F, Type J</td>
<td>24001660-606</td>
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</tr>
<tr>
<td>0 to 2400°F, Type K</td>
<td>24001660-607</td>
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</tr>
<tr>
<td>0 to 50 Linear or RTD</td>
<td>24001660-608</td>
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</tr>
<tr>
<td>0 to 50 Linear or RTD</td>
<td>24001660-609</td>
<td></td>
</tr>
<tr>
<td>0 to 100 Linear (RH, Q457B)</td>
<td>24001660-610</td>
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<tr>
<td>−76 to +100 RTD</td>
<td>24001660-611</td>
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<td>35 to 0 Linear or RTD</td>
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<td>−75 to +180°C RTD</td>
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<td>35 to 0 Linear or RTD</td>
<td>24001660-614</td>
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<tr>
<td>50 to 150 Linear or RTD</td>
<td>24001660-615</td>
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<td>20 to 0 Linear or RTD</td>
<td>24001660-616</td>
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<td>0 to 100 Linear</td>
<td>24001660-618</td>
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<tr>
<td>−10 to +50°C RTD (DIN)</td>
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<td>40 to 100°C RTD (DIN)</td>
<td>24001660-620</td>
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<tr>
<td>0 to 250°F Type E T/C</td>
<td>24001660-621</td>
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<tr>
<td>0 to 10 Square Root</td>
<td>24001660-622</td>
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<tr>
<td>14 to 122°F RTD (DIN)</td>
<td>24001660-623</td>
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<tr>
<td>104 to 212°F RTD (DIN)</td>
<td>24001660-624</td>
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<tr>
<td>0 to 300°F RTD</td>
<td>24001660-625</td>
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<tr>
<td>0 to 100 Linear</td>
<td>24001660-626</td>
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<tr>
<td>54 to 200°F RTD 100Ω</td>
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<td>0 to 146 psi MS2428C</td>
<td>24001660-628</td>
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<tr>
<td>−125 to +375°F Pt100Ω</td>
<td>24001660-629</td>
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<td>63 to 0°F A RTD</td>
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<td>−50 to +100°C Pt 100Ω</td>
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<td>24001660-632</td>
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<tr>
<td>0 to 400°F Type J T/C</td>
<td>24001660-633</td>
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</tr>
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<td>0 to 800 Linear</td>
<td>24001660-634</td>
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<td>−100 to +900°F Type K T/C</td>
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<td>0 to 10 Linear</td>
<td>24001660-636</td>
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<td>0 to 300°F Type J T/C</td>
<td>24001660-637</td>
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<tr>
<td>0 to 500 Linear</td>
<td>24001660-638</td>
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<tr>
<td>−10 to +60 RTD (DIN)</td>
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<tr>
<td>0 to 100 Q457B</td>
<td>24001660-640</td>
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<tr>
<td>50 to 150 Balco</td>
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<tr>
<td>0 to 100 Q457B</td>
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### Special Range

- Machine Uptime/Downtime (1) 24001829-001
- Machine Uptime/Downtime (2)
# Basic Characteristics of Automatic Controllers

## Contents

<table>
<thead>
<tr>
<th>Modes of Control</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Position (On/Off)</td>
<td>B-1</td>
</tr>
<tr>
<td>Proportional</td>
<td>B-2</td>
</tr>
<tr>
<td>Current Proportioning</td>
<td>B-3</td>
</tr>
<tr>
<td>Time Proportioning</td>
<td>B-3</td>
</tr>
<tr>
<td>Proportional plus Reset</td>
<td>B-4</td>
</tr>
<tr>
<td>Proportional plus Rate</td>
<td>B-5</td>
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</table>

| Using the Modes of Control |     |
|-----------------------------|     |
|                             | B-5  |
Modes of Control

The basic characteristic of an automatic controller is the manner in which it acts to restore the controlled variable to the desired value: this is called the mode of control. The modes of control are:
- Two Position (On/Off)
- Proportional
- Proportional plus reset
- Proportional plus rate
- Proportional plus rate plus rate

Two Position (On/Off)

In Two-Position Control, whenever the controlled variable deviates from the set point, the controller output relay is either activated or deactivated. Figure B-1 shows the action graphically for a REVERSE acting controller where the relay is activated above the set point and deactivated below the set point. (The reverse of this is called a DIRECT acting controller). This causes the controlled element to supply full energy or no energy to the process regardless of the size or rate of the deviation. This in turn causes the controlled variable to cycle.

A neutral zone is usually included between relay activation and deactivation to prevent relay “chattering.”

Two-Position Control will not accommodate large or rapid load changes because the controlled variable will start to cycle at a higher rate and magnitude or develop a permanent offset from the set point.

In general, Two-Position Control is satisfactory for processes which have a slow reaction rate, minimum transfer lag or dead time, and the two extreme positions of the controlled element are adjusted to permit an input just slightly above and slightly below requirements for normal operation.

![Figure B-1—Controlled variable action with two-position control](image_url)
**Proportional**

In proportional control, there is a fixed linear relationship between the value of the controlled variable (PV), and the value of the controller output (CO). The proportional controller changes CO a preset amount for a change in PV. The portion of the PV span within which the control action takes place is called the proportional band (PB). The PB is usually expressed as a percentage of the PV span. The three curves in Figure B-2 graphically portray the action of a controller output within a proportional band. Curve A is based on the following:

Given
1. Input range = 50 to 250°F
2. Proportional band range = 100 to 200°F
3. Control set point (SP) = 50%
4. CO at which PV equals SP is 50%

Then
5. \[ PB = \frac{200 - 100}{250 - 50} \times 100 = 50\% \]

6. A change in the PV of +10% causes a change in CO = \((SP - PV)/PB = (50 - 60)/50 = -10/50 \times 100 = -20\%\)
7. A change in the PV of -10% causes a change in CO = \((SP - PV)/PB = (50 - 40)/50 = +10/50 \times 100 = +20\%\)

Curves B and C assume the same PB and SP as Curve A, but Curve B assumes the CO at which the PV equals the SP is 25%, while Curve C assumes the CO at which the PV equals the set point is 75%. You can see that the change in CO per change in PV (slope of the curve) is the same for the three curves.

On most controllers, the proportional band is adjustable from some minimum value up to 100%. The larger the proportional band, the smaller the change in the controller output will be for a given change in the PV.

Electric proportional controllers have two types of output. One type, called a current proportioning controller, has a current output, usually 4 to 20 mA. The other type, called a time proportioning controller, has a relay output.

---

**Figure B-2**—Controller output action with proportional action
Current Proportioning

The current proportioning controller action is the same as that for the example shown in Figure B-2. The controller output is in milliamperes.

Time Proportioning

In time proportioning control, the output is a relay which is cycled on and off at a constant rate. However, the ratio of the on-time to the off-time varies in proportion to the amount the PV deviates from the SP. Figure B-2 shows how the relay position is controlled under the same process conditions and controller settings as used for the current proportional controller. Notice that CO is the percentages of the output relay on-time and off-time, and that these percentages change in proportion to the change of the PV from the SP.

In Figure B-2, the CO at which the PV equals the set point is 50% (50% off-50% on). If the PV increases 25%, the proportions become 75% off-25% on. If the PV decreases 25%, the proportions become 25% off-75% on.

Proportional plus Reset

Proportional control reduces the PV cycling rate and amplitude below that of two position control, even with moderate load changes. However, sometimes the change in the output with proportional control is not enough to make the PV equal the set point. This continuing difference between the PV and the SP is called "offset." How to eliminate offset is discussed here.

The offset present with proportional control only is due to the fact that, under the new load conditions, the controlled element is not positioned to supply the proper amount of energy or other medium to cause the PV to equal SP. Curve B in Figure B-2 illustrates the Proportional control action line when the load is too large and the energy or medium is insufficient, and Curve C illustrates the Proportional Control action line when the load is too small and the energy or medium is too great.

To correct these conditions it is necessary to "reset" the controller output so that it will move the controlled element to the proper position. The reset can be done manually or automatically. If done manually, the operator controls when the reset is made, the amount of the reset, and the time it takes to make the reset. If done automatically, the operator has to predetermine the time for the reset and set the value in the controller; then the controller will automatically make the reset.

In the proportional plus reset mode, as soon as there is a difference between the SP and the PV, the reset action starts to change the output beyond that made by the proportional action, and at a rate proportional to the difference between the SP and the PV. For example, a four percent difference between the SP and the PV causes a change in controller output to be added to that caused by the proportional action at twice the rate as that for a two percent difference. Reset action causes an additional change in output as long as a difference exists.

The amount of change for each minute the difference between the SP and PV exists is equal to that made by the proportional action, and is called the Reset Rate in repeats per minute. For example, if you set a Reset Rate of 2, the reset action adds a change in controller output equal to 200% of the proportional action every minute the difference between the SP and the PV exists.

Figure B-3 illustrates reset action. $T_i$ is the time per repeat, $E$ is the difference between the SP and PV, $CO_p$ is the change in output due to proportional action, and $CO_r$ is the change in output due to reset action.

With proportional control, even with the reset action added, the length of time it takes to make the output change is sometimes too great. To correct this condition, a control action called "rate" can be added to a proportional controller. The effect of the rate action on the controller output is discussed next under the next heading "Proportional plus Rate."
Proportional plus Rate

Rate action provides an immediate change in the controller output when the SP and PV start to deviate from one another. This change causes the output change being made by the proportional action to be reached sooner. In Figure B-4, Curve A illustrates the time for CO to change with proportional action with or without reset, and Curve B the time when rate action is added.

Proportional controllers are usually provided with a “Rate Time” adjustment. Rate Time is the decrease in the time it takes the proportional control action to change the controller output when Rate Action is added. Rate Time is shown in Figure B-5 as the difference in time between Curves A and B at the Final Controller Output Position.

The amount of the immediate change in controller output due to Rate Action depends on the amount of Rate Time, and the rate of change of the output. Figure B-5 shows how proportional plus rate action with the same Rate Time setting causes a different immediate output change when the rate of change of CO is different. In B-5A, CO is changing slowly, so the immediate output change is smaller than that in B-5B, where CO is changing rapidly.
Using the Modes

Each mode of control is applicable to processes having combinations of certain basic characteristics. It is important to remember that the simplest mode which will do the job is the best one to use, both for economy and for best results. Considerable experience is required in the selection of the mode best suited to the process. Table B-1 summarizes the principle process characteristics each of the control modes discussed here is best suited for.

<table>
<thead>
<tr>
<th>Control Mode</th>
<th>Rate of PV Change</th>
<th>Transfer Lag (Lead Time)</th>
<th>Process Load Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Position</td>
<td>Slow</td>
<td>Slight</td>
<td>Small and slow</td>
</tr>
<tr>
<td>Proportional</td>
<td>Slow or Moderate</td>
<td>Small or Moderate</td>
<td>Small</td>
</tr>
<tr>
<td>Proportional plus Reset</td>
<td>Fast</td>
<td>Small or Moderate</td>
<td>Slow but any amount</td>
</tr>
<tr>
<td>Proportional plus Rate</td>
<td>Slow or Moderate</td>
<td>Moderate</td>
<td>Small</td>
</tr>
<tr>
<td>Proportional plus Reset plus Rate</td>
<td>Fast</td>
<td>Moderate</td>
<td>Fast</td>
</tr>
<tr>
<td>Contents</td>
<td>Page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>C-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculating the Tuning Constants</td>
<td>C-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine-Tuning the Process</td>
<td>C-2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary
You can approximate the proper tuning constants for your process by first using assumed values to establish response curves for the process; then using data from these curves to calculate values closer to those the process needs.

Calculating the Tuning Constants
Use the procedures in Figure C-1 to calculate the tuning constants for your process.

Fine-tuning the Process
After the values are calculated and set in your controller, and you have made the first start-up, you will probably have to change the settings to fine-tune the controller to the process.
- If you are using a proportional controller with manual reset, compare the pen trace with those in Figure C-3 to determine if any further fine-tuning is required.
- If you are using a proportional controller plus reset, and/or plus rate, compare the pen traces to those in Figure C-4 to determine if any further fine-tuning is required.
ENTER

1. Position wire JE on Pin 0 of the RATE connector.
2. Position wire JF on Pin 0 of the RESET connector.
3. Adjust P401 to its maximum setting (approximately 100).
4. Adjust the set point to a nominal operating value.
5. Wait for the pen trace to stabilize.

Is the pen trace stabilized?

NO

6. Adjust P401 to one-half its present setting (approximately 50).
7. Change the set point approximately 5% of chart span.

YES

Is the pen trace cycling?

NO

YES

8. Compare pen trace with those in Figure C-1.

Matches Pattern C?

NO

9a. Adjust P401 to decrease PB by 20% of its present setting.

YES

9b. Measure the period in minutes. This is the ultimate Reset Time, $T_r$. Note the setting on P401. This is the ultimate proportional band, $PB_u$.

9c. Adjust P401 to increase PB by 50% of its present setting.

Matches Pattern A?

NO

Matches Pattern B?

YES

10. Test for Rate action:
- Adjust P401 to set $PB = 2 \times (PB_u)$.
- Move the wire in the Rate connector to the 0.5 pin.
- Change the set point approximately 5% of the full-scale value.

PV cycles per Pattern C near the set-point?

NO

YES

11. Position wire JF on Pin 0 of the RATE connector.
12. Select a controller response in Table C-1; then use the formulas under "Using only PB and Reset" to calculate PB and Reset values.
13. Adjust P401 to approximate the calculated PB value.
14. Position wire JE on the pin of the RESET connector closest to the calculated Reset value.

11a. Select a controller response in Table C-1; then use the formulas under the heading using PB, Reset and Rate to calculate PB, Reset and rate values.
12a. Adjust P401 to approximate the calculated PB value.
13a. Position wire JF on the RESET connector pin closest to the calculated RESET value.
14a. Position wire JE on the RATE connector pin closest to the calculated rate value.
Figure C.2—Pen trace patterns after a set point step change

<table>
<thead>
<tr>
<th>Controller Response</th>
<th>Tuning Constant</th>
<th>Using PB, Rate and Reset</th>
<th>Using only PB and Reset</th>
<th>Using only PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>No overshoot after a set point step change</td>
<td>Proportional band</td>
<td>5 x PBu</td>
<td>3.7 x PBu</td>
<td>3 x PBu</td>
</tr>
<tr>
<td></td>
<td>Reset (repeats/min.)</td>
<td>3/Tu</td>
<td>0.8/Tu</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Rate (minutes)</td>
<td>Tu/2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fastest recovery after a set point step-change</td>
<td>Proportional band</td>
<td>3 x PBu</td>
<td>2.2 x PBu</td>
<td>2 x PBu</td>
</tr>
<tr>
<td></td>
<td>Reset (repeats/min.)</td>
<td>2/Tu</td>
<td>1.2/Tu</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Rate (minutes)</td>
<td>Tu/3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Extremely tight control and min-recovery cycling</td>
<td>Proportional band</td>
<td>1.8 x PBu</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reset (repeats/min.)</td>
<td>6/Tu(a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rate (minutes)</td>
<td>Tu/6(a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compromise response</td>
<td>Proportional band</td>
<td>4 x PBu</td>
<td>3.0 x PBu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reset (repeats/min.)</td>
<td>2.5/Tu</td>
<td>1.0/Tu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rate (minutes)</td>
<td>Tu/2.5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

(a) To have a stable process, (Reset) x (Rate) must be equal to or less than 1.5.
Figure C-3—Pen traces identifying need for tuning constant adjustment (proportional plus manual reset)

Figure C-4—Pen traces identifying need for tuning constant adjustment (proportional plus reset and/or plus rate)
Series AR 100 Recorder-Controller
Recorder, Proportional Controller,
and Limit Controller

Function
Honeywell’s Series AR 100 Recorder-Controllers are designed for reliable operation, accurate measurement, and precise recording and controlling of any process variable that can be translated into a voltage or resistance signal in industrial processes.

Two models are available: single-pen (Figure 1) and two-pen (Figure 2). Both models can be equipped with independent controllers and alarm functions.

Integral cam programmed set point models are available for single-pen recorders with independent control forms and alarm functions as well as auxiliary cam functions. See Specification 58-01-03-01.

The AR 100 recorder-controller is ideally suited for applications involving the recording and controlling of environmental chambers, food processing machines, furnaces and ovens, and packaging machinery.

Honeywell offers a full-line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller. These devices measure:

- Temperature (thermocouple or RTD)
- Pressure
- Flow 
  (4 to 20 mA or 1 to 5 Vdc)
- Liquid Level (process transmitter)
- Humidity (gold grid sensor)

Description

Enclosure
The AR 100 case is designed for surface or panel mounting.

The case is of durable foamed Noryl® resin construction with a gasketed, glass-windowed door. Knockouts for wiring are provided in the bottom and sides of the case.

*Registered Trademark
Components
With the door open (Figure 3), the hinged chart plate swings out 90 degrees for convenient component access (Figure 4). The display components, as well as some parts of the instrument's servo balance system, are located on the chart plate. Display components include the 10-inch diameter chart, chart drive assembly, disposable fiber-tip pen cartridge, and index setting mechanism (on controller models only). The chart plate has an access hole for each manual reset adjustment on proportional controllers, a manual reset switch (and a signal light) for each limit controller, and a time index mark for chart time alignment. Synchronous chart drive motors provide two different chart speeds. Tapered hub and locating pin on the chart drive assembly assure correct alignment when chart is renewed. Assembly has a clutch for initial time alignment, or resetting in case of power interruption. Pen arm carries disposable fiber-tip, snap-on pen cartridge.

The servo balance system consists of solid state circuitry located on the main board assembly, and a servo assembly. The system converts electrical signals from process variable sensors into precise mechanical positions. Basically, this system measures an unknown emf by balancing the unknown emf against a known or calibrated emf established by the position of a contactor or a slidewire.

Solid state circuitry integrates power supply, measuring circuit, preamplifier and pen positioning servo functions. Plug-in range resistors make full range changes possible. The servo assembly includes an ac servo motor and a precision wound rebalancing slidewire. Also included is the set point wiper on models with a controller. The servo motor directly drives the wiper and the pen arm for accurate input signal tracking and reliable pen motion.

Field wiring connects to the screw terminals on the barrier connector strip at the bottom of the printed circuit board.

Two-pen models have two independent servo balance systems with or without independent controllers. See Control Selections for controller description. The separate ac servo motors drive their respective pens through a common pivot point with mechanical linkages. Color coded pens make traces easy to identify.

LEGEND
1. Control Index Knobs
2. Control Index Pointers
3. Chart Plate Latching Screws
5. Disposable Fiber-Tip Pen Cartridges — Red and Purple
6. Chart Locating Pin
7. Tapered Hub

Figure 3 — Components in front of the Chart Plate

LEGEND
1. Servo Assemblies — No. 1 and No. 2 Pens
2. Typical Main Board Assemblies
3. Manual Rest Adjustment — Proportional Control
4. Screw Terminals for Field Wiring
5. Chart Drive Assembly

Figure 4 — Components in back of the Chart Plate
Control Selections
Controller output signals activate remote final control devices (valves, motors, relays, SCR’s etc.) to keep the process at the desired set point. Six types of controllers are offered:
- Two position (on/off, high/low)
- One mode time proportioning with manual reset (offset adjust)
- Three mode time proportioning with auto-reset (offset adjust) and rate
- One mode current proportioning with manual reset (offset adjust)
- Three mode current proportioning with auto-reset (offset adjust) and rate
- High or low limit with manual reset

Solid state control circuitry is located on the main board with the recording servo balance system circuitry and optional alarm circuitry, but each is an independent parallel function. This “thru control” concept assures optimal control sensitivity and speed of response, independent of the recording servo system response.

Two Position (On/Off or High/Low) control is used in general control applications, usually with slow-changing processes. Typical controlled elements include triacs, SCR’s, relays, contactors, solenoid valves, and two-position (Modutol) motors.

Controller output is a relay whose condition depends on whether the process variable is above or below the set point.

Time Proportioning control is useful in heating/cooling, moisture controllers, or controllers plus alarm applications. Typical controlled elements include triacs, SCR’s, relays, and contactors.

Controller output is a relay that cycles on and off in proportion to the difference between the process variable and the set point. Single mode control (proportional band only) is used for processes with little or no load change. Three mode control (proportional band, rate, and auto-reset) is used for processes with frequent load changes.

Current Proportioning control is especially useful in applications using SCR power packs, saturable core reactors, proportioning Modutol motors, current to pneumatic (I/P) transducers or control plus alarm functions.

Controller output is a direct current which is proportional to the difference between the process variable input and the set point.

Limit control is designed for high or low limit cutoff control function. It immediately shuts down the process when the process variable reaches a preset critical point. Manual resetting is required after any shutdown, safety shutoff, or power interruption as well as on initial start-up. Automatic reset on startup and after power interruption is available as an optional kit for user installation.

A self-checking circuit cycles sixty times a second and shuts down the process on most major component failures. A SPDT electromechanical relay is used for output switching action, and a red signal light, visible through the chart, indicates when the relay is de-energized. The manual reset switch is accessible with the case door open.

Limit controllers are ideally suited for applications requiring a preselected alarm or control override.

- High Limit
  Relay energized and red light off, when process variable is below set point; de-energized and on when above set point. Upscale thermocouple burnout is standard.

- Low Limit
  Relay energized and red light off, when process variable is above set point; and de-energized and on when below set point. Upscale thermocouple burnout can be converted to downside.

*Requires repositioning a wire on & connector on the main board assembly.

Specifications
Operating Conditions and Design Limits

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reference Conditions</th>
<th>Rated Conditions</th>
<th>Extreme Conditions</th>
<th>Transportation and Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature Range</td>
<td>67 to 77°F</td>
<td>40 to 120°F</td>
<td>30 to 140°F</td>
<td>−40 to 151°F</td>
</tr>
<tr>
<td>Relative Humidity (% RH)</td>
<td>19 to 25°C</td>
<td>4.5 to 49°C</td>
<td>−1 to 60°C</td>
<td>−40 to 66°F</td>
</tr>
<tr>
<td>Vibration</td>
<td>10 to 55</td>
<td>5 to 90°F</td>
<td>5 to 95°F</td>
<td>5 to 98</td>
</tr>
<tr>
<td>Mechanical Shock</td>
<td>0</td>
<td>0.05 to 60</td>
<td>0.05 to 200</td>
<td></td>
</tr>
<tr>
<td>Acceleration (g)</td>
<td>0.2</td>
<td></td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Acceleration (ms)</td>
<td>0</td>
<td>0.5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Mounting Position from Vertical</td>
<td>0</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Tilted Forward</td>
<td>5°</td>
<td>30°</td>
<td>45°</td>
<td>any</td>
</tr>
<tr>
<td>Tilted Backward</td>
<td>5°</td>
<td>30°</td>
<td>90°</td>
<td>any</td>
</tr>
<tr>
<td>Tilted to Side (±)</td>
<td>5°</td>
<td>10°</td>
<td>20°</td>
<td>any</td>
</tr>
<tr>
<td>Power Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage (Vac)</td>
<td>100</td>
<td>95 to 105</td>
<td>96 to 110</td>
<td></td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>50</td>
<td>49 to 51</td>
<td>48 to 52</td>
<td></td>
</tr>
<tr>
<td>Interference (Stray) Rejection</td>
<td>Normal Mode: 50 or 60 Hz: 20 times span.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commens Mode: 50 or 60 Hz: 30 volt; DC: 42 volts.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic Fields</td>
<td>0.5 oersted (approximately 99.8 amperes/meter).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Consumption (Maximum)</td>
<td>Recorder-Controller: Single-pen: 16VA; Two-pen: 26 VA.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opened Input Circuit (Burnout)</td>
<td>Available with all thermocouple and potentiometer actuations and millivolts actuations from 8 to 600V span. Set at factory to drive pen upscale; User can change to drive pen downside.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Specifications (continued)

#### Performance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Accuracy</td>
<td>$\pm 1.0%$ of span</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>0.5 percent of span</td>
</tr>
<tr>
<td>Deadband</td>
<td>0.5 percent of span maximum</td>
</tr>
<tr>
<td>Span Step Response Time</td>
<td>10 seconds maximum; 9 seconds minimum (60Hz).</td>
</tr>
</tbody>
</table>

#### Inputs

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermocouple</strong></td>
<td>Types: J, K, R, and T. Span: 8.5 mV minimum, 55 mV maximum. Maximum Source Resistance: 500 ohms @ rated conditions; 2500 ohms @ extreme conditions.</td>
</tr>
<tr>
<td><strong>Resistance Temperature Detector (RTD)</strong></td>
<td>Type: Platinum two- or three-wire 100 ohm 200 ohm (Alpha = 0.003902 ohm/ohm/°C) 500 ohm Platinum (Din) 100 ohm (Alpha = 0.003850 ohm/ohm/°C) Honeywell Nickel A Balco Span: 20 ohms minimum. Leadwire resistance compensation is provided for three-wire sensors having equal resistance in the three leads. Compensation reduces leadwire resistance effect by a factor of at least seven.</td>
</tr>
<tr>
<td><strong>Differential RTD (Wet/Dry Bulb)</strong></td>
<td>Type: Platinum 100 ohm 200 ohm (Alpha = 0.003902 ohm/ohm/°C) 500 ohm Two, 2-wire sensors combined to form 3-wire unit. Span: 12.5 ohms minimum.</td>
</tr>
<tr>
<td><strong>Potentiometer/Slidewire</strong></td>
<td>Range: 0 to 1000 ohms.</td>
</tr>
<tr>
<td><strong>dc Milliamperes</strong></td>
<td>Ranges: 4 to 20 ma and 0 to 10 ma Input resistance: 2.50 ohms</td>
</tr>
<tr>
<td><strong>dc Millivolts</strong></td>
<td>Range: 0 to 10, 0 to 100, 0 to 200 and 0 to 500 mvdc Input impedance: 0.8 megohms minimum</td>
</tr>
<tr>
<td><strong>dc Volts</strong></td>
<td>Ranges: 0 to 1, 0 to 5 and 1 to 5 Input impedance: 0.8 megohms minimum</td>
</tr>
<tr>
<td><strong>Relative Humidity</strong></td>
<td>Type: Composite gold grid sensor (Honeywell Q457B). Range: 5% to 95% RH (used with a 0 to 100% chart).</td>
</tr>
</tbody>
</table>

#### Controller Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time Proportioning</strong></td>
<td>Output spdt relay contact rating: Resistive load: 5A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac.</td>
</tr>
<tr>
<td><strong>Two Position (On/Off)</strong></td>
<td>Output spdt relay contact rating: Resistive load: 5A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac.</td>
</tr>
<tr>
<td><strong>Current Proportioning</strong></td>
<td>Output current: 4 to 20 ma (0 to 600 ohm load) shipped reverse acting. User can change to direct acting.</td>
</tr>
<tr>
<td><strong>Limit Control</strong></td>
<td>Output spdt Contact rating: Resistive load: 5A @ 120/240 Vac. Pilot duty: 50 Va @ 120/240 Vac.</td>
</tr>
</tbody>
</table>
Specifications (continued)

**Design**

- **Pen**: Disposable fiber-tip pen cartridge on stainless steel pen arm. Two red ink cartridges (plus two purple ink cartridges for a two-pen) shipped with instruments. See Options for special colors and kit for spare cartridges.

- **Circular Chart**: 10.34 inches (260 mm) diameter; 4 inches (100 mm) calibrated width. Package of 100 shipped with the instrument.

- **Chart Speeds**: 24 hours/revolution (15 min./div.) or 168 hours (7 days)/revolution (2 hr./div.)

- **Chart Plate**: Opens on hinges to beyond 90 degrees for access to printed circuit board and wiring terminals and is removable.

- **Case**: Gray, foamed-Noryl®. 1/2-inch conduit knockouts for field wiring in bottom and right and left sides.

- **Door**: Beige Noryl® with a glass window for chart viewing. Opens to 105 degrees and is gasketed and latched. See Options for plastic window and door lock kit.

- **Rebalancing Element (Measuring Slidewire)**: Precision wirewound slidewire with two precious metal contacts, serves both the pen positioning servo and the control set point reference (cam follower arm).

- **Cam**: One 0.1 inch thick plastic blank furnished. Specify part number 24001814-002 and quantity for additional blanks.

- **Set Point Indication**: Pointer (one for each controller on two-pen) indicates the set position on the chart.

### Adjustments

<table>
<thead>
<tr>
<th>Non Control</th>
<th>Two-Position</th>
<th>Time Proportion</th>
<th>Current Proportion</th>
<th>Limit</th>
<th>Adjustment</th>
<th>Means of Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Span and Zero</td>
<td>Potentiometers</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Opened Input Circuit (Burnout indications)</td>
<td>Wire positioned on a connector to drive the pen either upscale or downscale.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>Alarm Set Point</td>
<td>Adjustable 0 to 100% span by using a potentiometer.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Control Set Point</td>
<td>Knurled knobs on the front of the chart plate.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Manual Reset of Pen to the Set Point (1-mode only)</td>
<td>Potentiometer allows readjustment of offset within the proportional band.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Auto Reset (3-mode only)</td>
<td>0, 0.1, 0.5, 1, 2, repeats per minute; selectable by positioning a wire on a connector or 3 to 300 repeats per minute by adjusting a potentiometer.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Rate Time (3-mode only)</td>
<td>0, 0.05, 1, 2, 5 and 10 minutes selectable by positioning a wire on a connector.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Proportional Band</td>
<td>Single mode: 2, 5, or 10 percent of span selectable by positioning a wire on connector. Three mode: 1% to 100% of span by adjusting a potentiometer.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Cycle Time</td>
<td>10 or 20 seconds selectable by positioning a wire on a connector.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Output Action</td>
<td>Direct or reverse selectable by positioning a wire on a connector.</td>
</tr>
<tr>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td>Output Relay Reset</td>
<td>Button on switch accessible through a hole in the chart plate.</td>
</tr>
</tbody>
</table>

*Registered Trademark*
Specifications (continued)

Design

Mounting  
Panel: Brackets supplied for clamping case to vertical panel. (See Options for panel cutout adaptor kit)  
Surface: Knockouts in back of case for four size 10 screws. Upper knockouts are keyhole-shaped for ease of installation.

Weight (maximum)  
13.8 lbs. (6.27 kg).

Dimensions  
See Figure 6. (NOTE: Door is off-center to left of panel cutout.)

Approval Bodies  
CSA Listing: all models  
FM Approval: all models  
UL Listing: all models

Wiring Connections  
Barrier terminal blocks with size 6 screws. Wiring diagram in Figure 5 is attached on inside surface of the chart plate.

Controller circuit board

CAUTION: NON METALLIC ENCLOSURE DOES NOT PROVIDE GROUNDING BETWEEN CONDUIT CONNECTIONS. USE GROUNDING TYPE BUSHINGS AND JUMPER WIRES TO MAINTAIN RACEWAY GROUND CONTINUITY.

NOTE: All relays shown in coil de-energized condition.

Output terminals must not be grounded when using grounded inputs.

Optical Event Switching and Programming Output (remote set point) board

NOTE: Relay shown in coil de-energized condition (reflective surface).
Specifications (continued)

Options Installed at the Factory

**Alarm Output**
Output spdt relay contact rating: Resistive load - 2A @ 120/240 Vac
Pilot duty - 50 VA @ 120/240 Vac
Set point adjusted by means of a potentiometer on main board assembly. Shipped with high alarm action. User can change to low alarm action.

Options Available in Kits for User Installation

**Chart Illumination**
An incandescent bulb mounted on the lower right corner of the chart plate.
Part number: 24400120-001.

**Window for Door**
0.1 thick acrylic to replace glass.
Part number: 24400125-001

**Panel Cutout Adaptor**
Covers hole in panel if replacing a Partlow or U.E. instrument.
Part number: 24400124-007

**Ink Cartridges (6)**

<table>
<thead>
<tr>
<th>Ink Color</th>
<th>Pen 1</th>
<th>Pen 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>30735489-002</td>
<td>Not avail.</td>
</tr>
<tr>
<td>Purple</td>
<td>30735489-001</td>
<td>30735489-007</td>
</tr>
<tr>
<td>Green</td>
<td>30735489-003</td>
<td>30735489-006</td>
</tr>
<tr>
<td>Black</td>
<td>30735489-008</td>
<td>Not avail.</td>
</tr>
</tbody>
</table>

**Door Lock**
Prevents operation of latch until a hidden screw is turned.
Part number: 24400134-001

**Auto-Reset (for output relay on Limit Controller)**
Output relay automatically reset at start-up.
Part Number 24400134-001

**Mechanical Stop for Set Point on Pen 1**
Limits travel of the set point at outer edge of chart.
Part Number 2440128-001
Ordering Data

**Specify for the AR100**

- Number of pens
- Input Actuation and Range for each pen
- Type of Controller with each pen
- Voltage and Frequency
- Alarm with each pen
- Chart Speed
- Factory Installed Options
- User Installed Options
- Sensors or Transmitters (see below)

**Order from one of the following:**

1. Local Honeywell Branch Office

2. Honeywell
   1885 Douglas Drive North
   Minneapolis, Minnesota 55422

3. Honeywell Inc.
   Process Control Division
   1100 Virginia Drive
   Fort Washington, PA 19034

4. In Canada –
   Honeywell Limited
   155 Gordon Baker Road
   Willowdale, Ontario M2H3N7

**Sensors and Transmitters**

Honeywell offers a full line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller.

Contact the Honeywell installations listed above for copies of catalogs and specifications listed below with the measured variable and sensors.

- Temperature (thermocouple or RTD)
  Catalog No. C100 and Specification S920.
  - Pressure
  - Flow
  - Liquid Level
    
    (4 to 20 mA or 1 to 5 Vdc process transmitter)

  Specifications 31-41-03-01 through 31-41-03-07.

- Humidity (gold grid sensor)
  Specifiation 95-5158.

**Specifications are subject to change without notice.**