PROCESS CONTROL SYSTEMS

7

LEARNING ACTIVITY PACKET

LIQUID LEVEL CONTROL

IST™

AMATROL

INTEGRATED SYSTEMS TECHNOLOGY

B270-XD

LIQUID LEVEL CONTROL

INTRODUCTION

Liquid level control methods range from relatively simple and inexpensive on/off control methods to more complex closed loop systems. The on/off control methods can use discrete devices like relays and have discrete inputs and outputs or they can use an analog input from a sensor and provide a discrete output. However, these methods can only control the level between a high and low limit. The more complex closed loop systems use analog inputs and outputs so that they can control the level at any point.

This LAP covers how to perform on/off liquid level control using control relays and a process meter's discrete outputs. It also covers how to control the liquid level in a closed loop system that uses analog inputs and outputs. In addition, this LAP presents how to add auxiliary functions such as alarms using the discrete inputs and outputs on an electronic controller and a process meter.

ITEMS NEEDED

Amatrol Supplied

1 T5552 Process Control Learning System

School Supplied

1 Water (10 Gallons)
1 Compressed Air Supply
1 Needle Nose Pliers

FIRST EDITION, LAP 7, REV. B

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TABLE OF CONTENTS

SEGMENT 1

RELAY BASED ON/OFF CONTROL

OBJECTIVE 1 DESCRIBE THE OPERATION OF AN ON/OFF PROCESS CONTROL SYSTEM AND GIVE AN APPLICATION

Read This

On/off control is a type of control method commonly applied to process control applications such as liquid level control. It is the simplest and often least expensive type of automatic process control. On/off control, or *two-position* control, examines the value of a process variable and gives an output that is either fully on (100%) or fully off (0%). There are no intermediate settings with on/off control.

As an example, figure 1 shows an on/off control system for liquid level. A solenoid-operated valve controls the output flow from the tank. Two level switches are positioned at a high and low level limits. The control circuit maintains the level between the level limits.

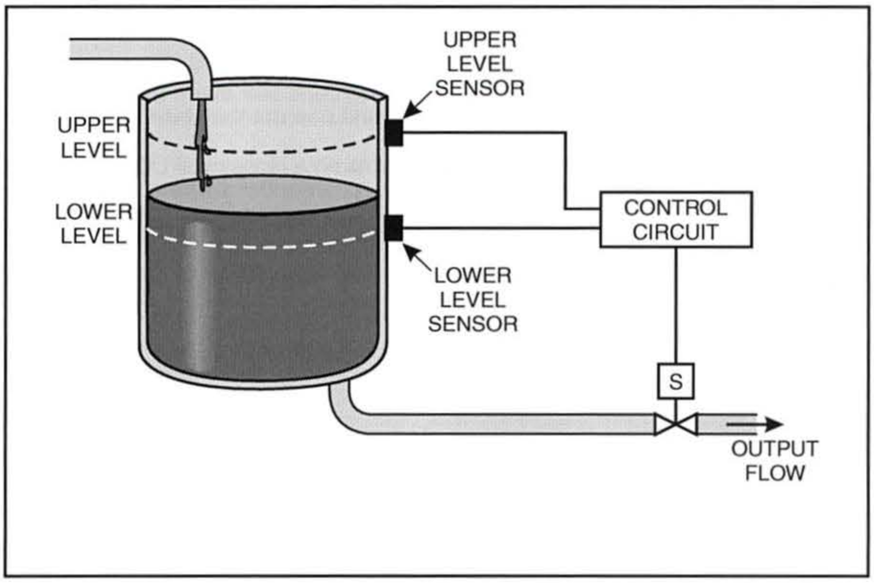

Figure 1. Two-Position Level Control

When the level falls below the low level limit, the low level switch sends a signal to the control circuit, causing the control circuit to close the solenoid valve. The tank level then rises until it reaches the high level limit. At that point, the high level switch sends a signal to the control circuit, causing it to open the solenoid valve and allow the tank level to fall. The tank level then drops until it reaches the low level limit, and the cycle repeats.

When the level is between the upper and lower level sensors, there is no change in the control circuit's output. Since there is no change in the output, there is no change in the position of the final control element (valve). For this reason, the area between the high level and low level is called the dead band, or neutral zone, as shown in figure 2.

If the dead band is too narrow, the control element turns off frequently, causing reduced life. Therefore, an on/off control system should be set up so that the dead band is wide enough to prevent frequent oscillation and still control the process variable within acceptable limits. As you can see, on/off control systems cannot achieve a specific setpoint but instead provide an output range between a high and low level limit.

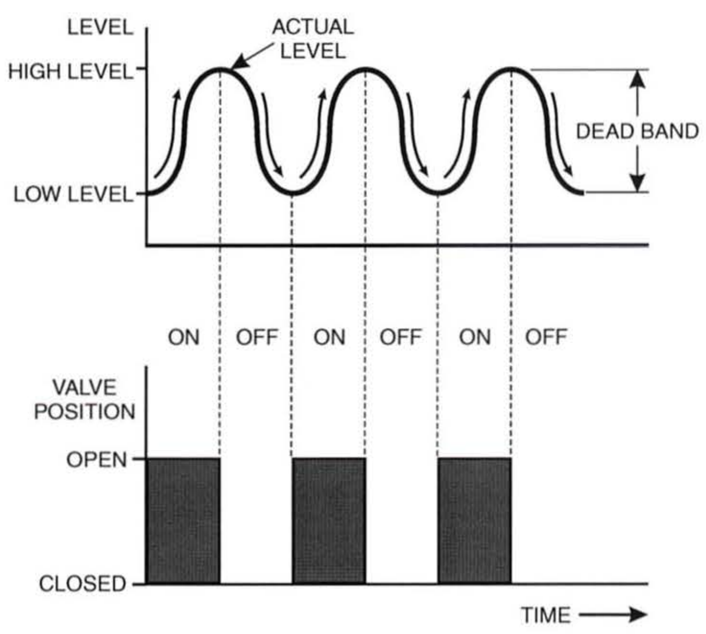

Figure 2. Process Response vs. Final Control Element Position

NOTE

The bars are spaced at equal intervals for clarity. However, the time intervals between valve openings in an industrial application are determined by the process under control.

OBJECTIVE 2 DESCRIBE THE OPERATION OF RELAY-BASED ON/OFF PROCESS CONTROL SYSTEMS

Electromechanical relay control systems were one of the first types of control systems used in the process control industry to perform on/off control. These systems are still used for some simple level control systems because they are inexpensive, although programmable controllers and other computer-based control systems have replaced them in more complex applications.

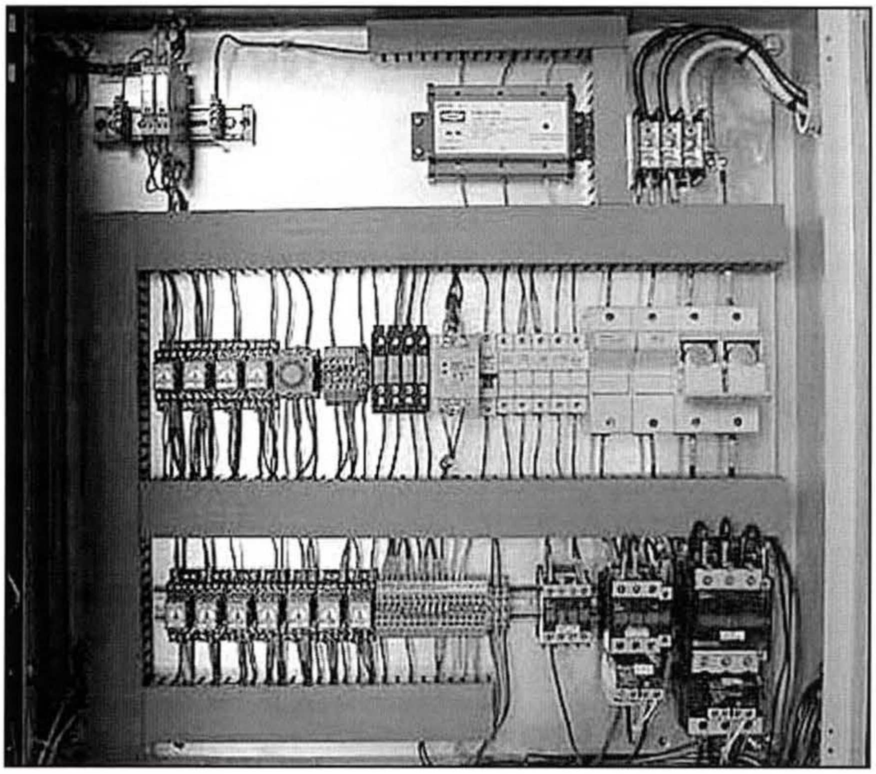

Figure 3. Industrial Relay Panel

Figure 4 shows a ladder diagram of a typical relay-based control system that could be used to control liquid level in the tank shown in figure 5. This circuit uses two level switches to maintain the level within a given range.

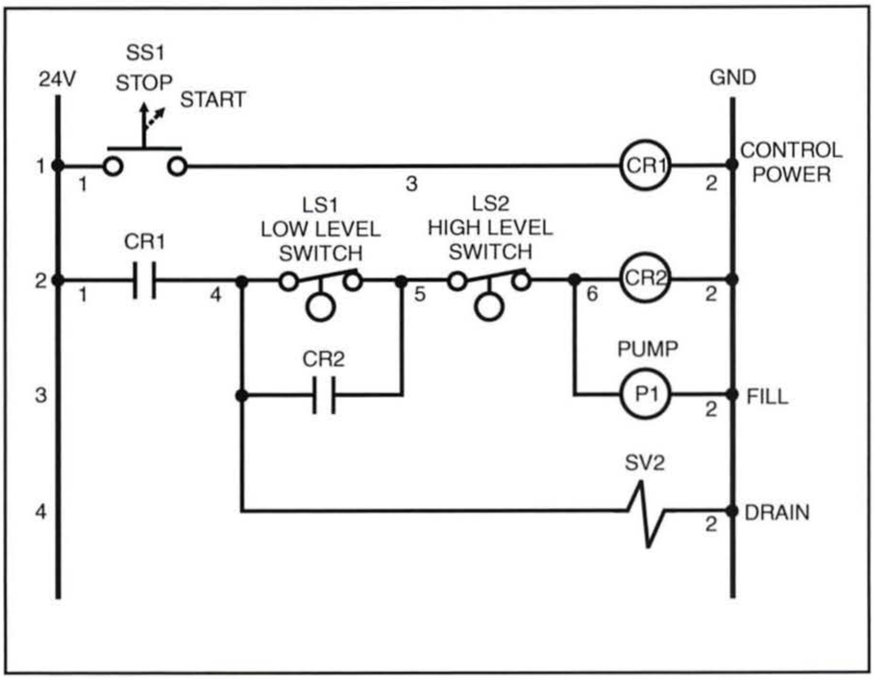

Figure 4. On/Off Control Circuit Ladder Diagram

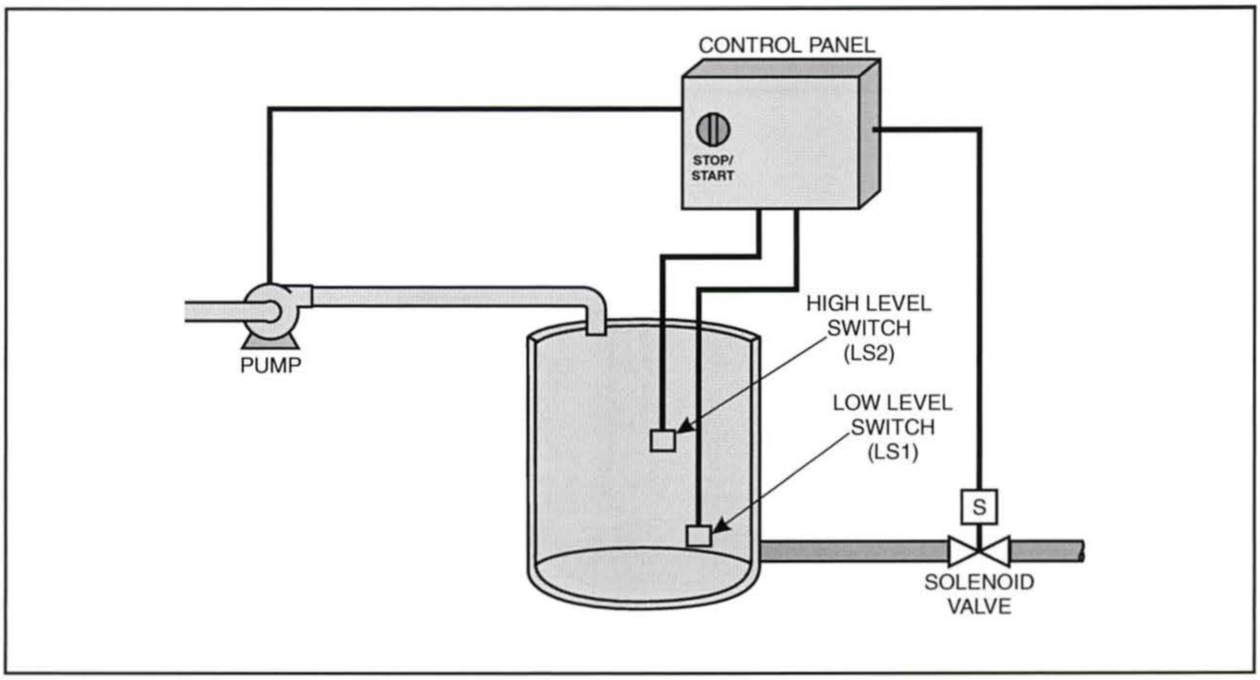

Figure 5. Pictorial of On/Off Control Circuit

To understand how the circuit of figure 4 works, first examine figure 6. When control power is applied (SS1 on), as shown in figure 6, the pump motor is energized. This causes the tank to begin to fill, as figure 7 shows.

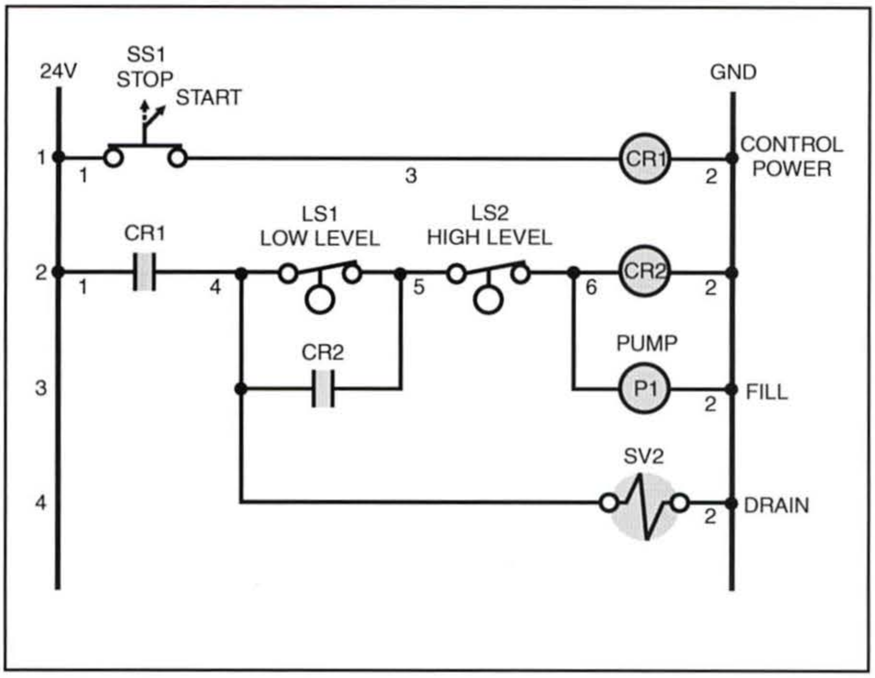

Figure 6. On/Off Control Ladder Diagram - SS1 On

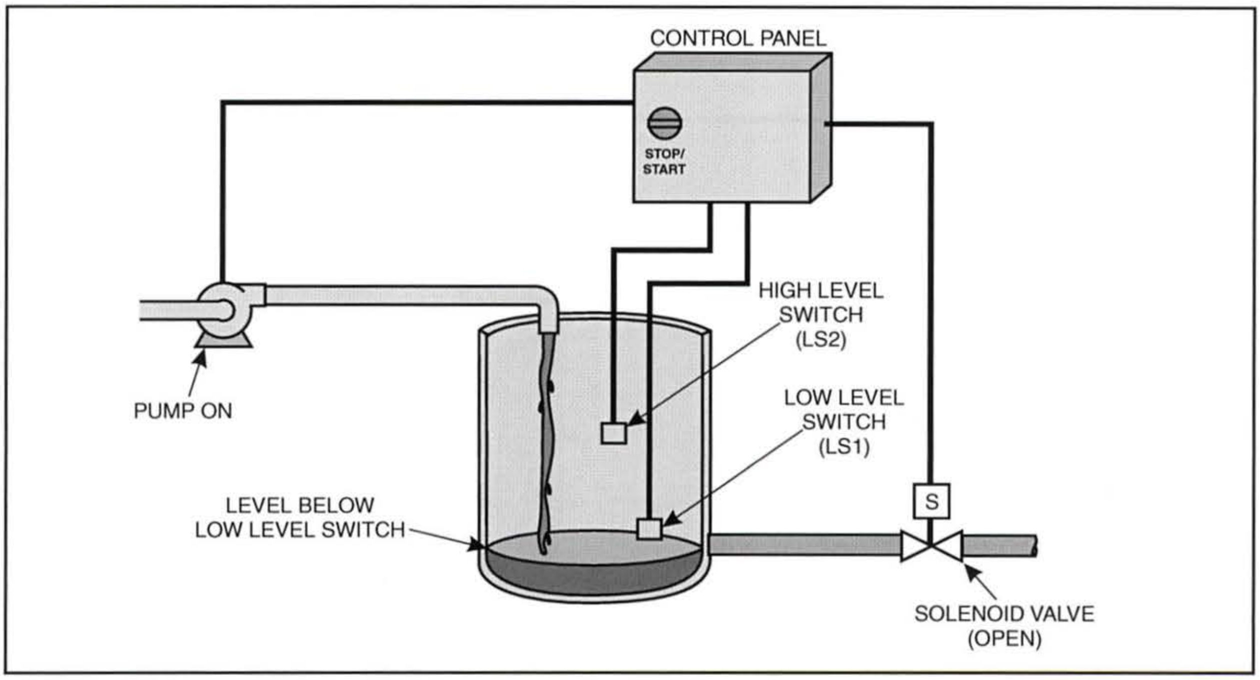

Figure 7. Pictorial - SS1 On

When the water level reaches the low level switch (LS1), the switch opens. However, the pump continues to fill the tank because the current to coil CR2 is sealed in by the CR2 N.O. contacts on rung 3, as shown in figure 8.

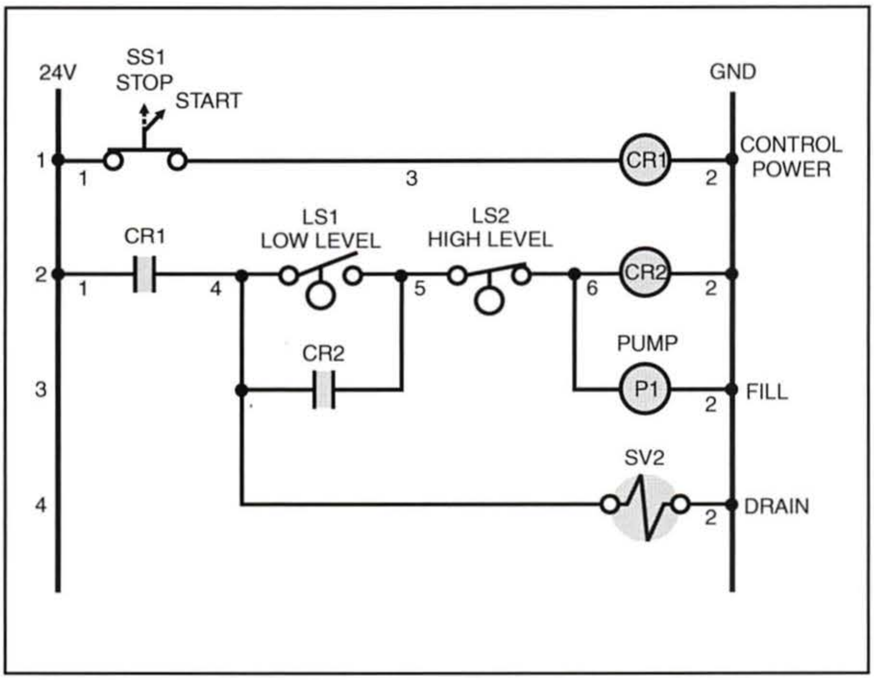

Figure 8. Circuit State at Low Level Limit

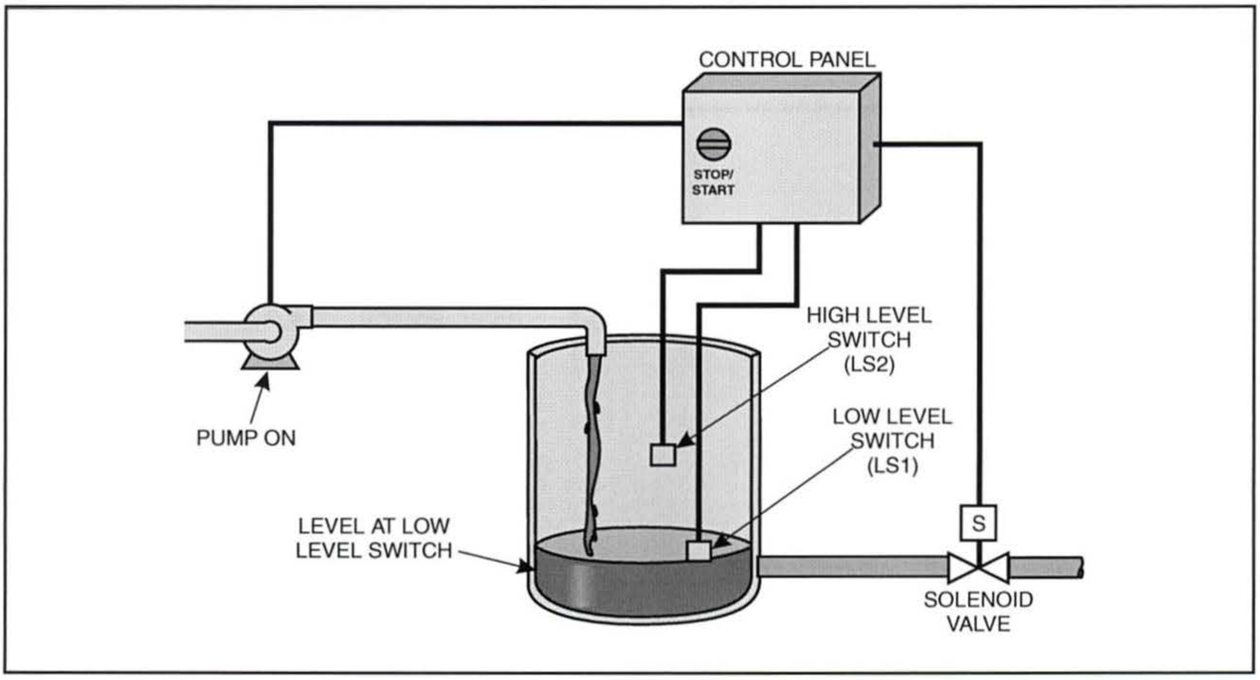

Figure 9. Pictorial of Circuit at Low Level Limit

When the water reaches the high level, the N.C. contacts of switch LS2 open causing the coil CR2 to de-energize and the pump to turn off, as figure 10 shows. The pump stays off until the water drains below the low level switch.

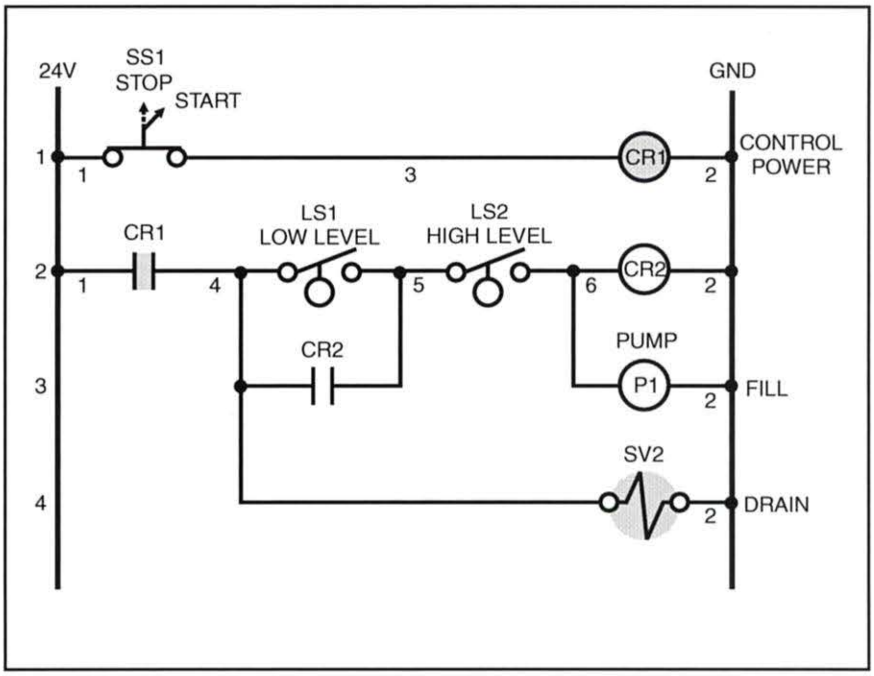

Figure 10. Circuit State at High Level Limit

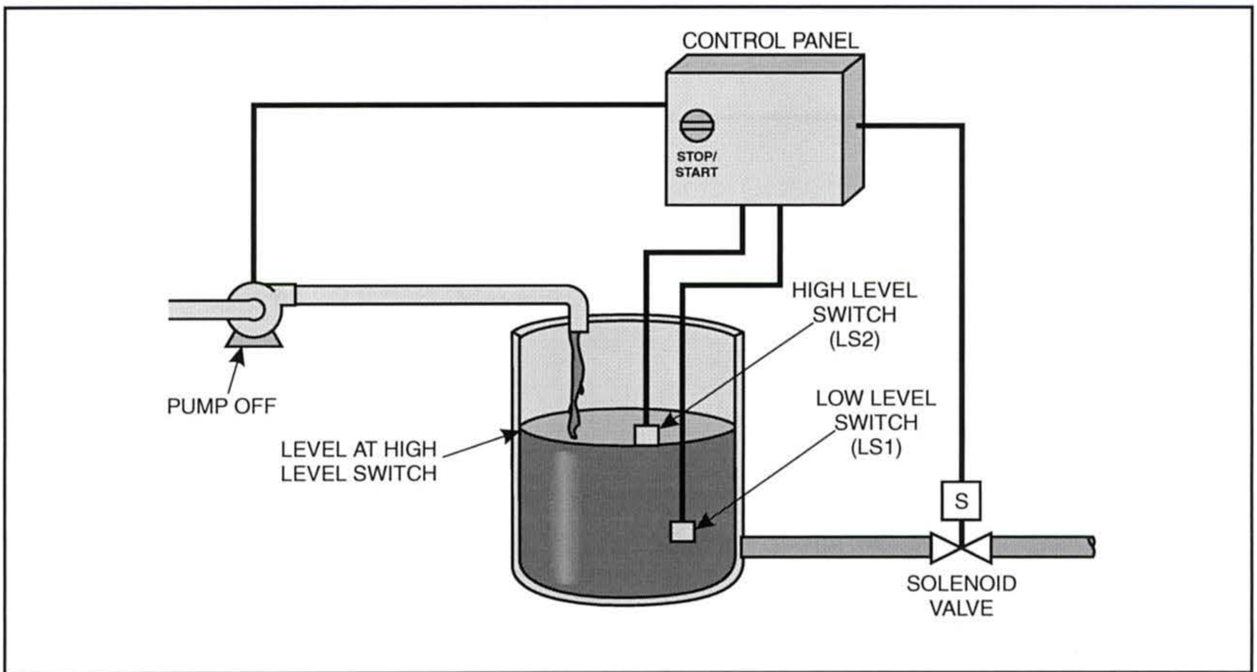

Figure 11. Pictorial of Circuit at High Level Limit

When the water in the process tank drains below the low level switch (LS1), the switch closes, the pump is again energized, and the tank fills. The process continues until the control power is removed (SS1 off). Notice that the solenoid valve (SV2) that drains the tank is always energized as long as there is control power.

An alternative method to control the level would be to allow the pump to run continually when the control power is on and use the solenoid valve to control the level. The solenoid valve opens when the level reaches the high level switch and closes when the level reaches the low level switch.

SKILL 1 CONTROL THE LEVEL IN A TANK USING ON/OFF CONTROL

Procedure Overview

In this procedure, you will use the control relays on the T5552 to control the level in the process tank using on/off control.

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5552, as shown in figure 12.

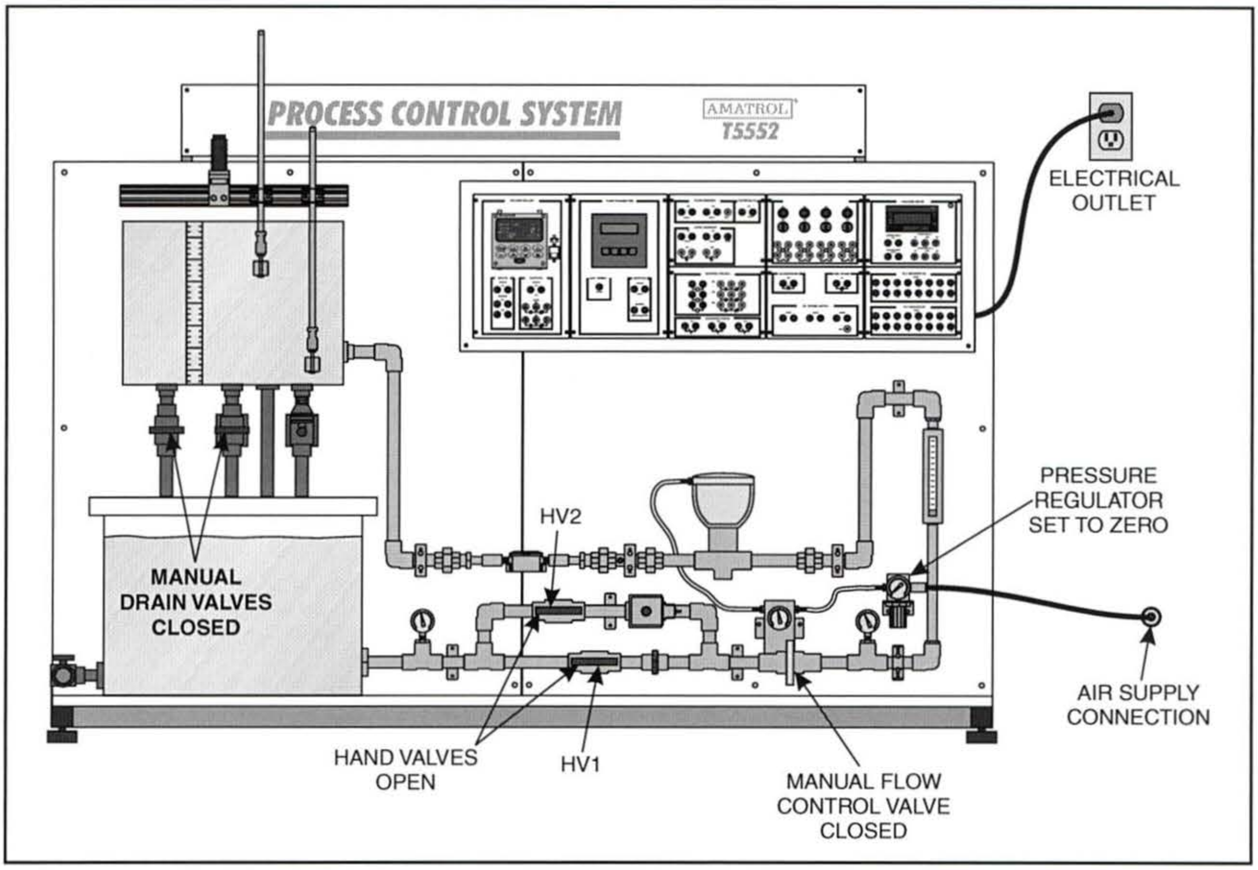

Figure 12. T5552 Setup

A. Plug the power cord into an electrical outlet.

B. Connect the air supply line to the T5552.

C. Set the pressure regulator to 0 psi.

You will not control flow with the diaphragm-actuated control valve in this skill.

D. Fill the reservoir tank with water.

E. Close the two manual process tank drain valves (fully clockwise).

F. Open flow hand valves HV1 and HV2.

G. Fully close the manual flow control valve.

❑ 3. Connect the on/off control circuit according to the ladder diagram in figure 13. Figure 14 shows a pictorial diagram.

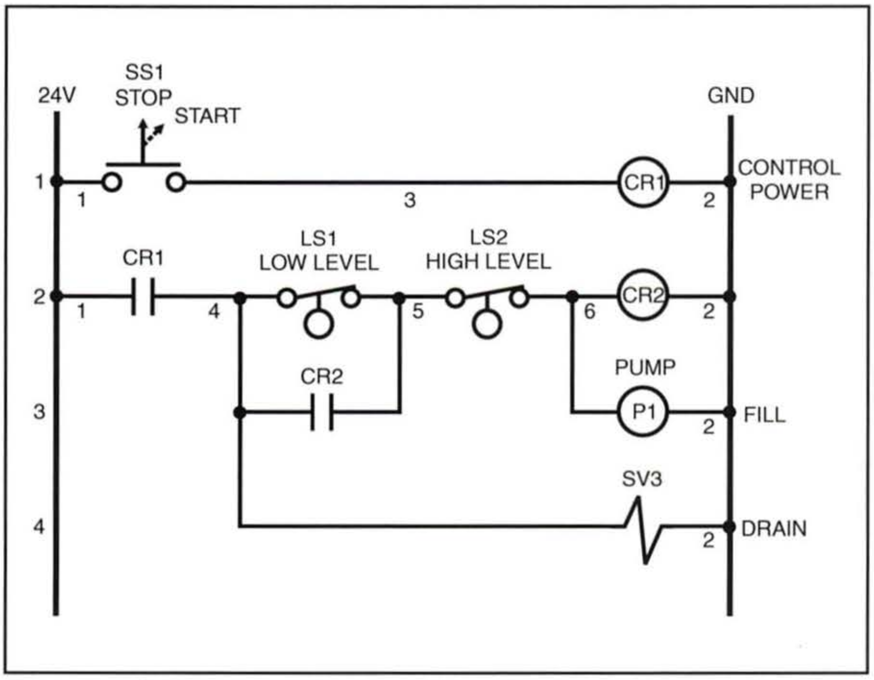

Figure 13. On/Off Control Ladder Diagram

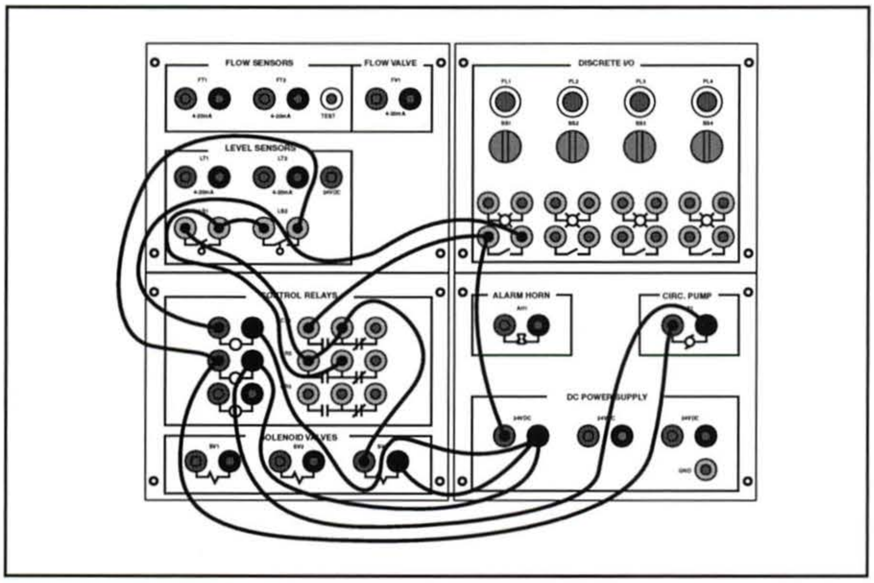

Figure 14. On/Off Control Circuit Pictorial

❑ 4. Determine if the float switches are in the normally closed or normally open position.

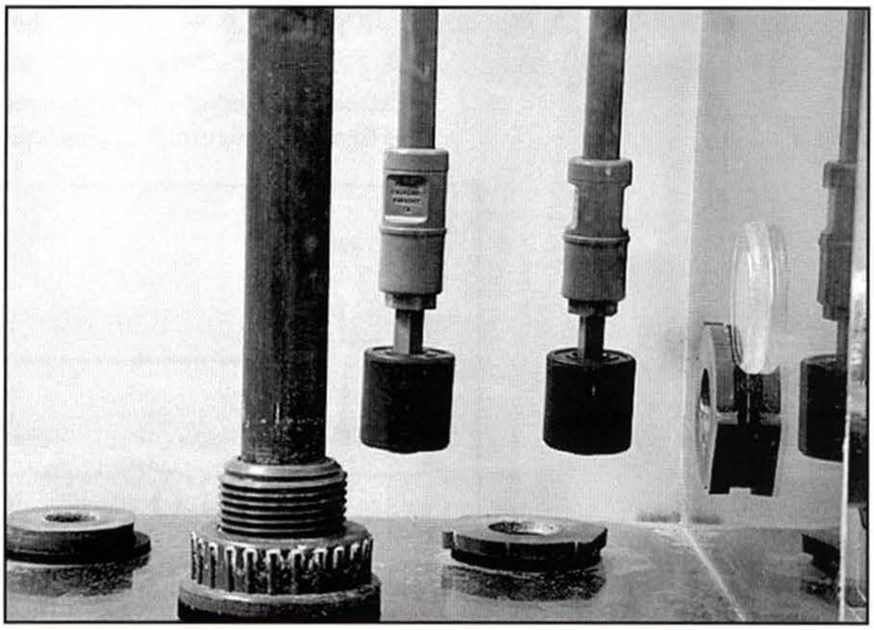

Figure 15. Float Switches in the Process Tank

Amatrol supplies the float switches on the T5552 in the normally open configuration. However, for this circuit, the float switches must be normally closed. You can quickly determine which state the float device is in by looking at it from the top. If you look down on the float device and see writing (e.g. manufacturer's name), as shown in figure 16, the float device is in the normally open state.

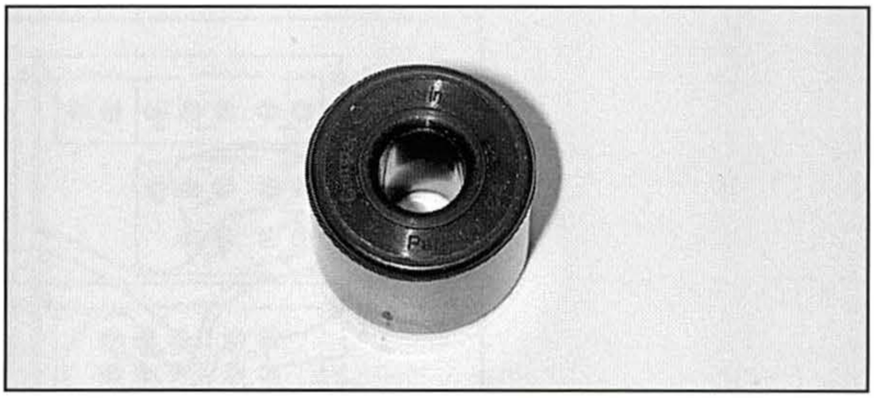

Figure 16. Float Device with Writing Side Up

NOTE

Another method used to quickly check the configuration of a level switch is to place an ohmmeter across the contacts. The meter will read a small resistance if the switch is normally closed and an infinite resistance if it is normally open.

❑ 5. Perform the following substeps to change the float switches on the T5552 from normally open to normally closed if they are normally open. If they are already in the normally closed state, skip to step 6.

A. Locate and remove the retaining clip by pulling it off, as shown in figure 17, with needle nose pliers.

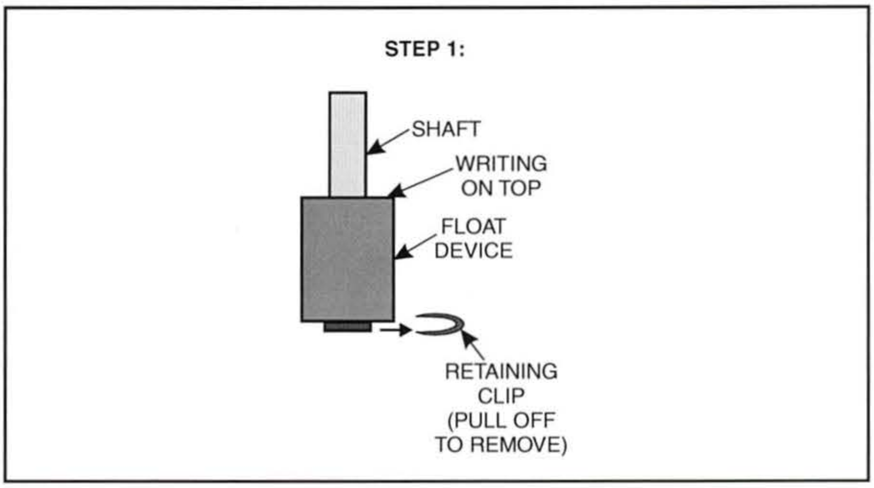

Figure 17. Location of Retaining Clip

B. Slide the float device off the shaft, as shown in figure 18.

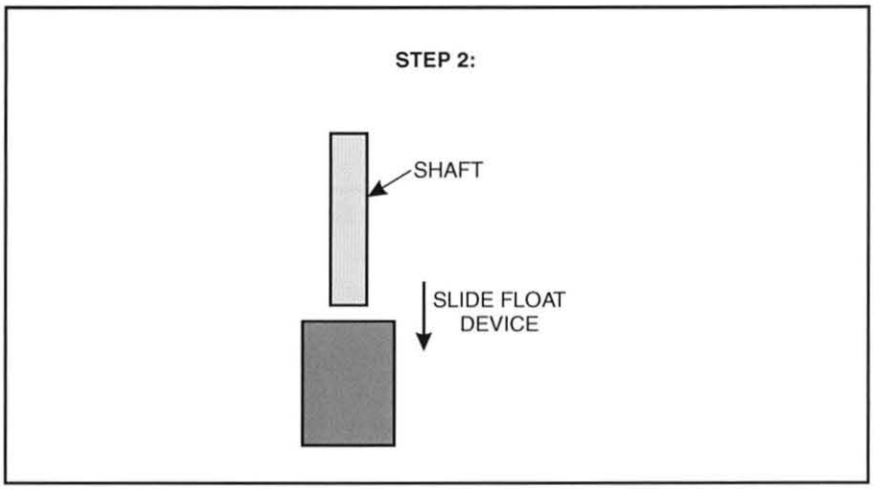

Figure 18. Remove Float Device

C. Rotate the float device 180° (end over end), as shown in figure 19.

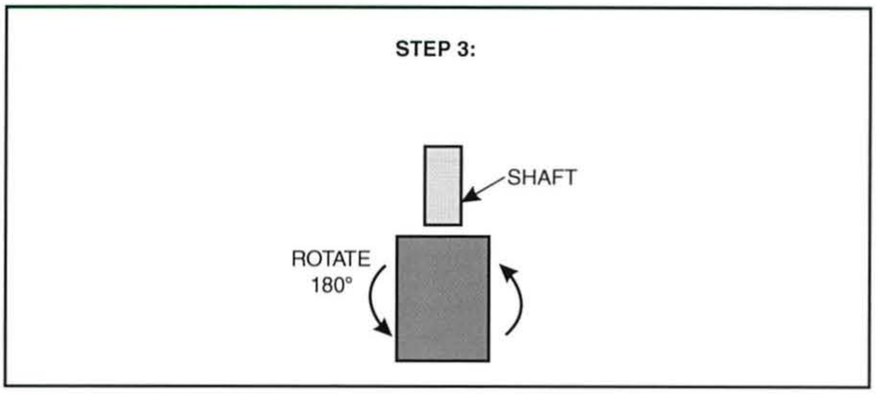

Figure 19. Rotate Float Device

D. Slide the float device back on the shaft and replace the retaining clip, as shown in figure 20.

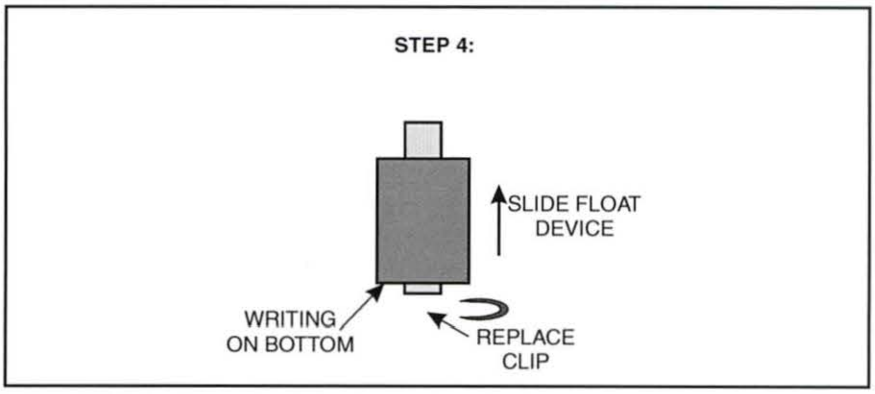

Figure 20. Replace Float Device and Retaining Clip

❑ 6. Perform the following substeps to set the float switches at the desired lower and upper levels.

The float switch shafts, shown in figure 21, are mounted so you can slide the shafts up and down by loosening the adjustment screws.

A. Loosen LS1's adjustment screw by turning it counter-clockwise one or two turns so that the shaft can be moved up or down.

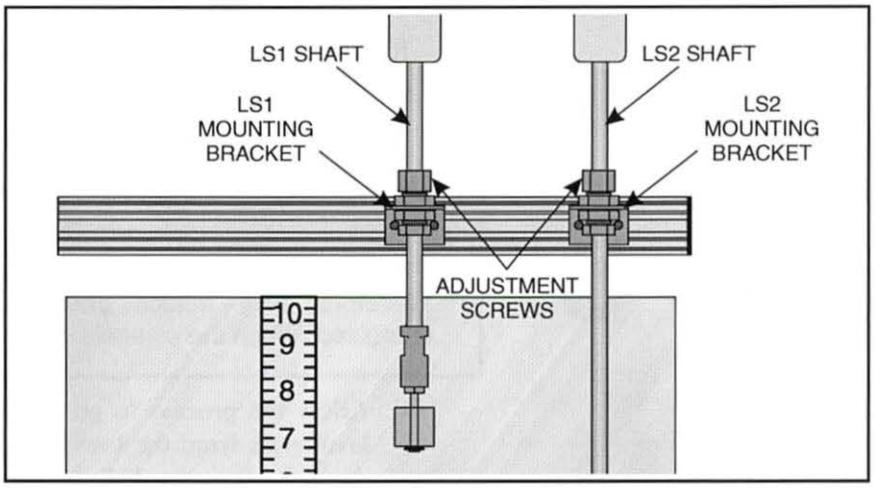

Figure 21. Float Switch Mounting Brackets

B. Move LS1's shaft so that the bottom of the switch is even with the 1-inch mark, as shown in figure 22. Then tighten the adjustment screw to lock it in position. This is the lower level.

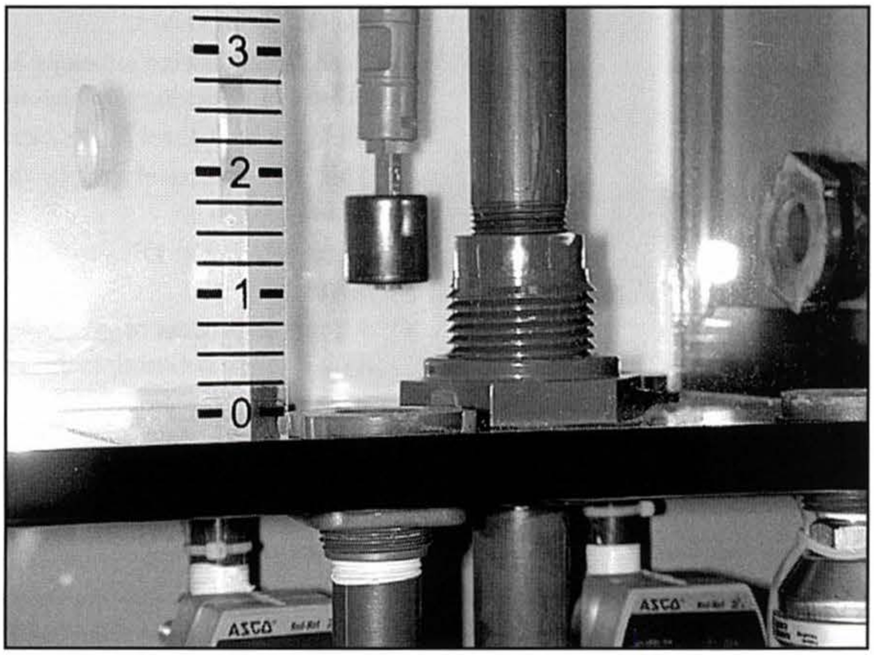

Figure 22. Level Switch at 1-Inch Mark

C. Reposition LS2 to the 2-inch level using the same procedure as substeps A and B.

This is the high level.

Setting the low level switch to 1-inch and the high level switch to 2-inches creates a dead band of 1 inch.

❑ 7. Remove the lockout/tagout.

❑ 8. Perform the following substeps to operate the circuit.

A. Open the manual flow control valve (HFV2) by turning it fully counterclockwise.

B. Make sure that **SS1** is in the **OFF** (up) position.

C. Turn on the main circuit breaker.

D. Place **SS1** in the **ON** position and observe the operation of the circuit.

NOTE

All solenoid valves on the T5552 are normally closed. Therefore, they remain closed until their solenoid coil is energized. When the solenoid coil is energized, the valve opens.

E. Allow the process to go through a complete cycle (i.e. water level rises from the low level limit to the high level limit and drops back to the low limit) and record how long it takes to complete the cycle.

Time to complete cycle: ______________________ (seconds)

F. Remove control power by placing **SS1** in the **OFF** position.

G. Drain the process tank using the manual drain valves until the water is below the low-level switch (LS1). Then, close the manual drain valves.

❑ 9. Perform the following substeps to operate the circuit and observe the effects of widening the dead band.

A. Slide the high-level float switch (LS2) up to the 4-inch level.

This will effectively triple the dead band (from 1 inch to 3 inches).

B. Place **SS1** in the **ON** position and observe the operation of the circuit.

C. Allow the process to go through another cycle and record how long it takes to complete the cycle.

Time to complete cycle: ______________________ (seconds)

D. Determine if the circuit cycles more or less frequently than in step 8?

Cycle Frequency ________________________ (higher/lower)

You should find that the circuit cycles less frequently. This is due to the increased dead band.

E. Remove control power by placing **SS1** in the **OFF** position.

❑ 10. Perform the following substeps to shut down the T5552.

A. Open both of the manual drain valves on the process tank to completely drain the tank. When the tank is empty, close both valves.

B. Turn off the main circuit breaker.

C. Disconnect the control circuit.

SKILL 2 DESIGN AN ON/OFF LEVEL CONTROL SYSTEM

Procedure Overview

In this procedure, you will design an On/Off level control system. The purpose of this system is to maintain the liquid level between two points.

❑ 1. Review the following design parameters. These parameters contain the information you need to design the circuit.

- Selector switch SS1 will be used to simulate a pushbutton that energizes the circuit.
- Selector switch SS2 will be used to simulate a "stop" pushbutton.
- Use a high-level float switch set at 7 inches.
- Use a low-level float switch set at 2 inches.
- The pump will be controlled by one control relay contact.
- The solenoid valve will be controlled by a second control relay contact.
- The pump should start when selector switch SS1 is turned on and should continue to run when the switch is turned off (simulated start pushbutton).
- The pump should continue to run and fill the tank until the high-level float switch is reached. At this point, the pump should stop and the solenoid valve should open and begin draining the tank.
- The tank should drain until the low-level float switch is reached. At this point, the solenoid valve should close and the pump should turn on and begin filling the tank.
- Both float switches will be NC switches.

NOTE

This circuit will require the use of a third relay to provide the seal-in contact for the start switch (SS1).

❑ 2. Design your circuit on a sheet of paper.

❑ 3. Ask your instructor to verify your circuit and give you permission to connect the circuit.

❑ 4. Perform a lockout/tagout.

❑ 5. Perform the following substeps to set up the T5552.

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 0 psi.

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two manual process tank drain.

E. Close (fully clockwise) the manual flow control valve.

F. Place selector switch **SS1** in the **OFF** position.

G. Place selector switch **SS2** in the **ON** position.

❑ 6. After receiving permission, connect your circuit.

❑ 7. Notify your instructor that you are ready to operate the circuit.

Your instructor must check and approve your setup before you can continue.

❑ 8. Remove the tagout tag and lockout device.

❑ 9. Turn on the main circuit breaker.

❑ 10. Turn selector switch **SS1** on and then off immediately to simulate the pressing of a start pushbutton.

The pump should start and begin to fill the process tank with water. The solenoid drain valve should be closed. The tank should continue to fill past the low level switch. When the level reaches the high-level float switch (7-inch mark), the pump should stop and the solenoid drain valve should open and begin to drain the tank.

When the level reaches the low-level float switch (2-inch mark), the solenoid valve should close and the pump should restart and begin filling the tank. The circuit should continue to cycle in this manner until selector switch SS2 is turned off (stop button pressed).

❑ 11. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS2** to stop the circuit.

B. Close the manual flow control valve.

C. Open both manual drain valves to drain the process tank. When the tank is completely drained, close the valves.

D. Turn off the main circuit breaker.

E. Disconnect the circuit.

SEGMENT 1

SELF REVIEW

1. On/off control is also referred to as ___________ control.

2. On/off control gives an output that is either 0% or _________ %.

3. One of the first types of control systems used to perform on/off control were ___________________ relay control systems.

4. The simplest and often least expensive method of control is __________ control.

5. In on/off control, the area between the upper and lower level is called the ______________ because there is no change in the controller output and no change in valve position.

6. Programmable controllers and __________________-based control systems have replaced relays in complex systems.

SEGMENT 2

PROCESS METER ON/OFF CONTROL

OBJECTIVE 3 DESCRIBE HOW TO PROGRAM A HONEYWELL UDI 1700 PROCESS METER'S DISCRETE OUTPUTS TO CONTROL ALARMS

Read This

Many process meters have relay (discrete) outputs that can be programmed to turn on alarms or perform on/off control. The process meter measures the process using an analog sensor of some type and turns an output on or off when the sensor's signal reaches a certain programmed level.

Figure 23 shows a buzzer wired to one of the meter's two internal relays. The buzzer is wired to the normally open contact of relay 1 (terminals 20 and 21) and functions as a high level alarm for the system.

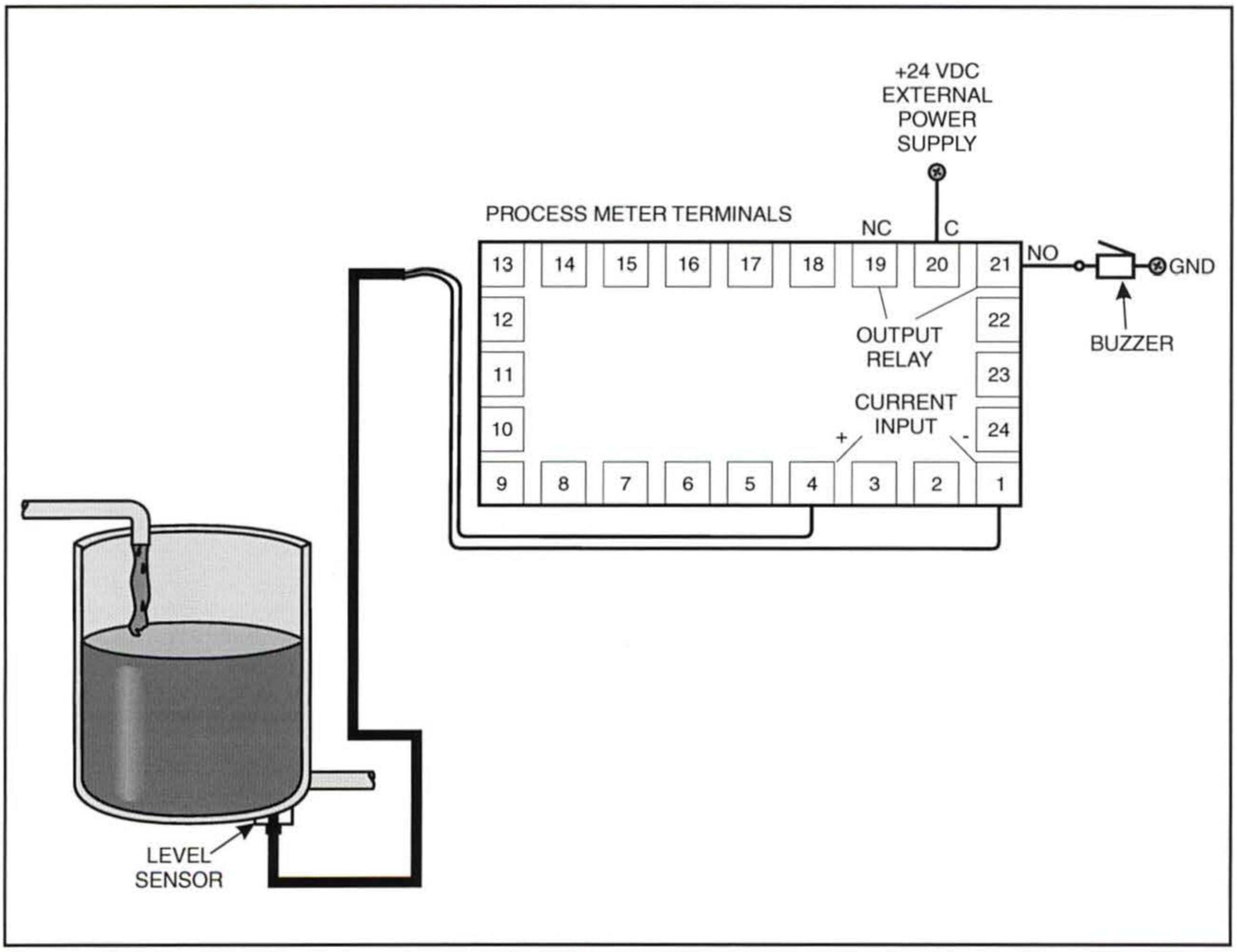

Figure 23. Relays on a Process Meter Wired to a Buzzer

Alarm Output Parameters

The discrete or alarm outputs are programmed by setting certain parameters in the process meter Configuration Menu.

- **Alarm Type -** The alarm type parameters (ALA1-ALA5) determine whether an alarm is a process high alarm (P_Hi), a process low alarm (P_Lo), or is disabled (none).
- **Alarm Hysteresis -** The alarm hysteresis parameters (AHY1-AHY5) sets a range on the safe side of the alarm values in which the alarm will remain energized. For example, if a high alarm value is set to 5.0 and the alarm hysteresis is set to 0.5, the alarm remains energized until the PV falls below 4.5.
- **Alarm Values -** If the alarm is a high alarm, the desired value is et in the high alarm parameter (PhA1-PhA5). If the alarm is a low alarm, the desired value is set in the low alarm parameter (PLA1-PLA5).
- **Output Usage -** The output usage parameters (USE1-USE5) determine what action is taken when an alarm occurs and which output relay is controlled by which alarm. For example, if USE1 is set to A1nd, the contacts of output relay 1 will change states when alarm 1 becomes active. The setting A1nd also sets the action as direct, which means that when an alarm occurs, the NO contact closes and the NC contact opens.

Alarm Parameter Program Procedure

The following steps describe how to program the discrete alarm outputs on the Honeywell UDI 1700 process meter:

Step 1: Enter the Select Mode - Pressing and holding the SETUP key and then pressing the up ▲ arrow key places the meter in the Select Mode, as shown in figure 24.

Figure 24. Honeywell UDI 1700 Meter in the Select Mode

Step 2: Enter the Configuration Menu - Scroll through the menus using the up ▲ and down ▼ keys until "ConF" is displayed. Then press the SETUP key to enter the Configuration Menu. The Configuration Menu is locked, so the unlock code (20) is entered using the up ▲ and down ▼ arrow keys and accepted by pressing the SETUP key.

Step 3: Enter the Alarm Type - Scroll to the Alarm 1 type (ALA1) parameter and set it as desired. The choices are: Process High Alarm (PhA1), Process Low Alarm (PLA1), or none (nonE). Pressing the SETUP key causes the yes prompt to appear. Pressing the up ▲ arrow key accepts the setting.

Step 4: Enter the Alarm Value - Scroll to the next parameter. Depending on the type of alarm set in the previous step, either the High Alarm 1 (PhA1) or the Low Alarm 1 (PLA1) parameter will appear. Set the desired value using the up ▲ and down ▼ arrow keys. Pressing the SETUP key causes the Yes prompt to appear. Pressing the up ▲ arrow key accepts the value.

Step 5: Enter the Alarm Hysteresis Value - Scroll to the Alarm 1 Hysteresis (AHY1) parameter and set it as desired. When the value is correct, pressing the SETUP key causes the Yes prompt to appear. Pressing the ▲ arrow key accepts the setting.

Step 6: Repeat steps 3-5 for Other Alarms - Up to 5 alarms can be programmed on the Honeywell UDI 1700 process meter.

Step 7: Set the Output Usage for each Alarm - Scroll to the Output 1 Usage (USE1) parameter and set as desired. Some of the choices for this parameter include:

- Alarm 1, direct, non-latching (A1nd)
- Alarm 1, reverse, non-latching (A1nr)
- Alarm 1, direct, latching (A1Ld)
- Alarm 1, reverse, latching (A1Lr)

Pressing the SETUP key causes the Yes prompt to appear. Pressing the up ▲ arrow key accepts the setting. The process is repeated for other alarms.

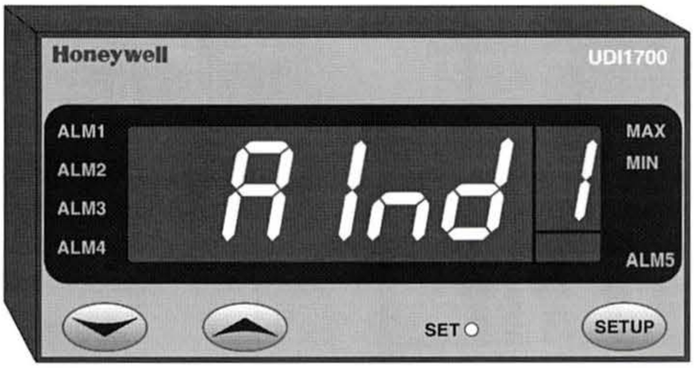

Figure 25. Output 1 Usage Parameter Set to A1nd

Step 8: Exit the Configuration Menu – Pressing and holding the Setup key and then pressing the up ▲ arrow key exits the Configuration Menu and returns to the Select Mode.

Step 9: Exit the Select Mode - Scroll using the up ▲ and down ▼ arrow keys until "OPtr" appears on the display. Pressing the SETUP key with "OPtr" on the display exits the Select Mode and returns the meter to the normal operating mode.

SKILL 3 PROGRAM A HONEYWELL UDI 1700 PROCESS METER'S DISCRETE OUTPUTS AS ALARMS

Procedure Overview

In this procedure, you will connect and operate a circuit to measure the level in a process tank. You will also program a process meter to use its relay contacts as high and low level alarms.

- ❑ 1. Perform a lockout/tagout.
- ❑ 2. Perform the following substeps to set up the T5552, as shown in figure 26.

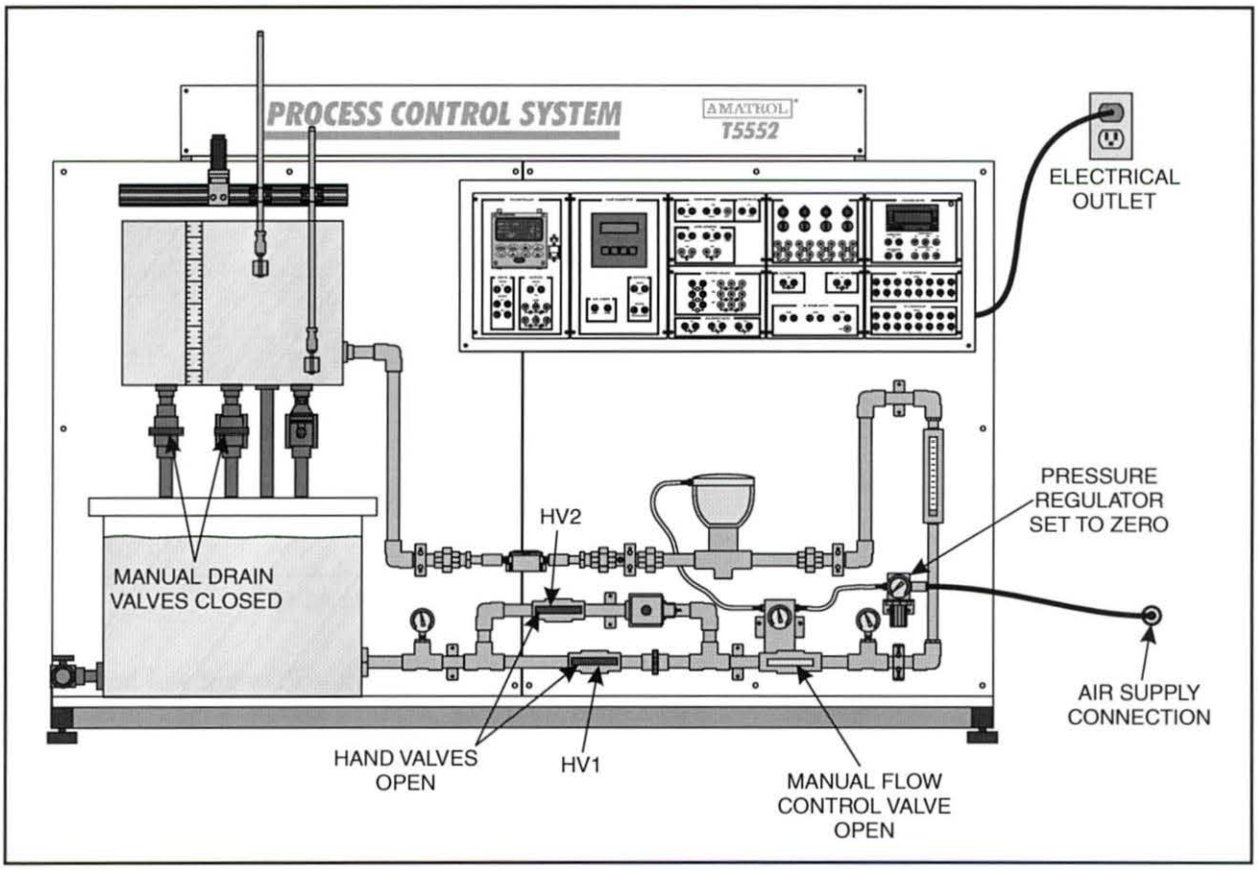

Figure 26. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 0 psi.

You will not control flow with the diaphragm actuator control valve in this skill.

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two manual process tank drain valves.

E. Open the manual flow control valve.

F. Connect the circuit shown in figure 27.

This circuit allows you to determine the level of water in the process tank using the process meter and indicates high and low level alarm conditions using indicator lamps.

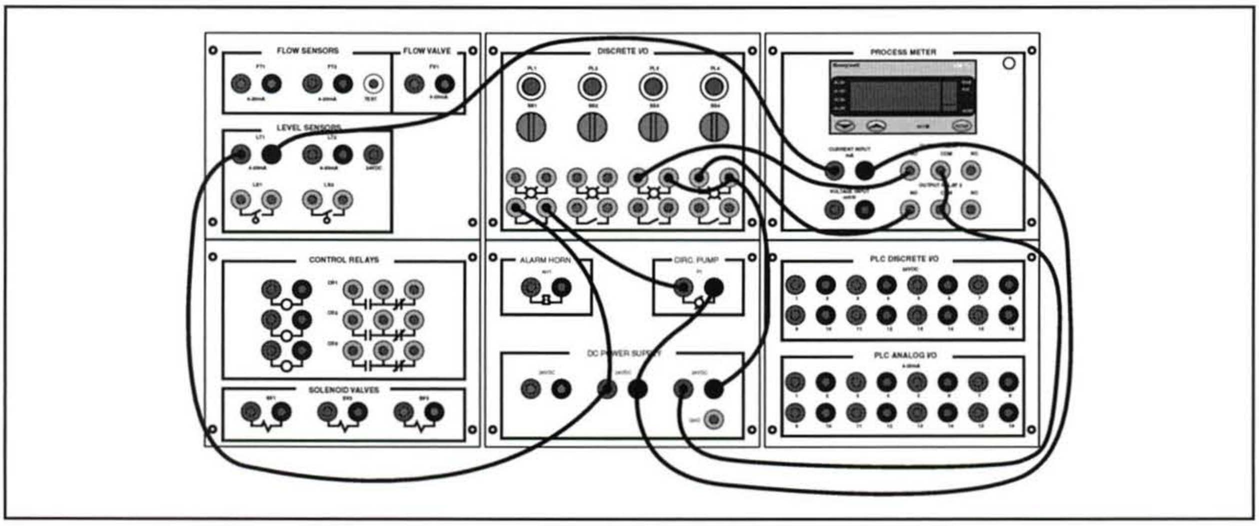

Figure 27. Level Circuit Using Process Meter Alarm Relays

Figure 28 shows the wiring diagram for the level circuit.

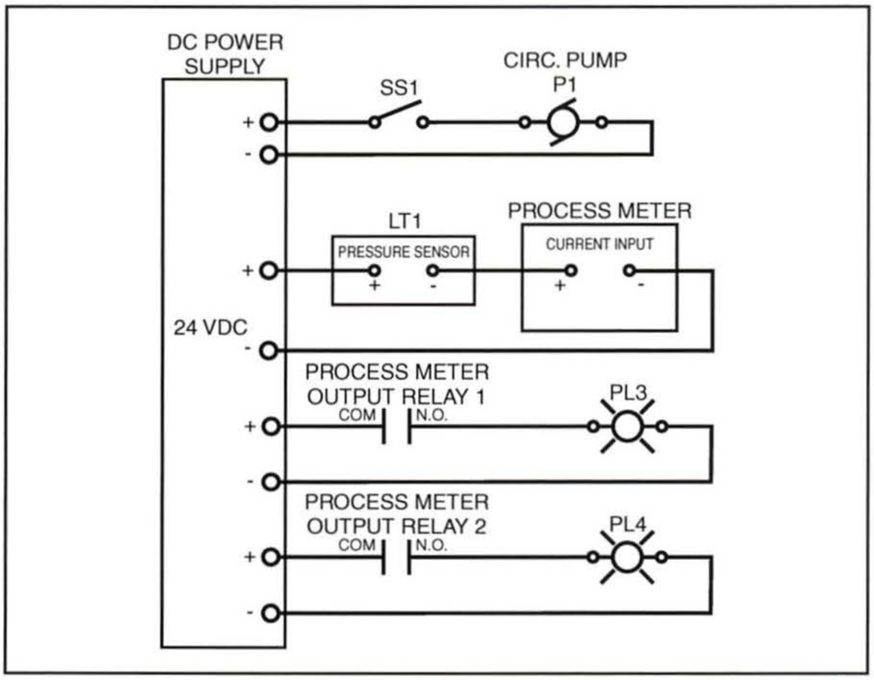

Figure 28. Wiring Diagram for the Level Circuit Using Process Meter Alarm Relays

❑ 3. Remove lockout/tagout.

❑ 4. Make sure selector switch **SS1** is in the **OFF** (up) position.

❑ 5. Perform the following substeps to enter the Configuration Menu on the Honeywell UDI 1700 process meter.

A. Turn on the main circuit breaker.

B. Press and hold the **SETUP** key and then press the up ▲ arrow key.

This places the meter in the Select Mode.

C. Use the up ▲ and down ▼ arrow keys to scroll to the Configuration Menu (ConF).

The Configuration Menu is locked and requires the unlock code.

D. Use the up ▲ and down ▼ arrow keys to set the value to **20** and press the **SETUP** key to enter the unlock code.

The first parameter in the Configuration Menu (inPt) should appear.

❑ 6. Perform the following substeps to verify the Input Type (inPt) and Scale Range Limits (ruL and rLL).

A. If necessary, use the up ▲ and down ▼ arrows to change the input type parameter.

The parameters should be set to "4_20" for 4-20 mA.

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

B. Scroll to the next parameter, Scale Range Upper Limit (ruL).

C. If necessary, use the up ▲ and down ▼ arrows to change the parameter.

The parameter should be set to 27.7.

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

D. Scroll to the next parameter, Scale Range Lower Limit (rLL).

E. If necessary, use the up ▲ and down ▼ arrows to change the parameter.

The parameter should be set to 0.0.

If you change the parameter setting, press the SETUP key to bring up the Yes prompt and press the up ▲ arrow key to accept the new value.

❑ 7. Perform the following substeps to set the Alarm 1 parameters. These parameters are located in the Configuration Menu.

A. Scroll to the Alarm 1 Type parameter (ALA1).

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **P_Lo**.

This sets Alarm 1 as a Process Low Alarm.

C. Press the **SETUP** key to bring up the Yes prompt.

D. Press the up ▲ arrow key to accept the setting.

E. Scroll to the next parameter (PLA1).

This is the Process Low Alarm 1 parameter.

F. Use the up ▲ and down ▼ arrow keys to set the value to **2.0**.

This sets the low alarm value as 2.0 inches.

G. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

H. Scroll to the next parameter (AHY1).

This is the Hysteresis setting for alarm 1.

I. Use the up ▲ and down ▼ arrow keys to set the value to 0.1.

This sets the hysteresis to 0.1 inch.

J. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

❑ 8. Perform the following substeps to set the Alarm 2 parameters.

A. Scroll to the Alarm 2 Type parameter (ALA2).

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **P_H1**.

This sets Alarm 2 as a Process High Alarm.

C. Press the **SETUP** key to bring up the Yes prompt.

D. Press the up ▲ arrow key to accept the setting.

E. Scroll to the next parameter (PhA2).

This is the Process High Alarm 2 parameter.

F. Use the up ▲ and down ▼ arrow keys to set the value to **8.0**.

G. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

H. Scroll to the next parameter (AHY2).

This is the Hysteresis setting for Alarm 2.

I. Use the up ▲ and down ▼ arrow keys to set the value to **0.1**.

This set the hysteresis to 0.1 inch.

J. Press the **SETUP** key to bring up the Yes prompt and then press the ▲ arrow key to accept the setting.

❑ 9. Perform the following substeps to set the Output Usage parameter for the Alarms.

These parameters are also located in the Configuration Menu.

A. Scroll to the Output 1 Usage parameter (USE 1).

This parameter sets the relay action for alarm 1.

B. Use the up ▲ and down ▼ arrow keys to set the parameter to **A1nd**.

This sets Alarm Relay 1 as direct acting, non-latching. That means that when the process variable value is below the low alarm value (2.0), the NO contact of Alarm Relay 1 is closed and the NC contact is open. Since non-latching is also selected, the contacts will return to their normal states when the process variable exceeds 2.0.

C. Press the **SETUP** key to bring up the Yes prompt and then press the up ▲ arrow key to accept the setting.

D. Repeat substeps A-C to set the Output Usage 2 parameter (USE 2) to **A2nd**.

❑ 10. Perform the following substeps to exit the Configuration Menu and the Select Mode.

A. Press and hold the **SETUP** key and then press the up ▲ arrow key.

This exits the Configuration Menu and returns to the Select Mode.

B. Use the up ▲ and down ▼ arrow keys to scroll until "OPtr" appears on the display.

C. Press the **SETUP** key to exit the Select Mode and return the meter to the normal operating mode.

❑ 11. Perform the following substeps to set the Process Variable Offset parameter (OFFS).

The Process Variable Offset Parameter is located in the Set Up Menu. Since the level sensor is mounted beneath the process tank, the offset value is used to make the process variable value read 0.0 when the level is at the zero inch mark on the tank.

A. Press and hold the **SETUP** key and then press the up ▲ arrow key to enter the Select Mode.

B. Use the up ▲ and down ▼ arrow keys to scroll to the Set Up Menu (SEtP).

The Set Up Menu is locked and requires the unlock code.

C. Use the up ▲ and down ▼ arrow keys to set the value to **10** and press the **SETUP** key to enter the unlock code.

The first parameter in the Set Up Menu is the Input Filter Time Constant (FILt) parameter.

D. Scroll to the Process Variable Offset (OFFS) parameter.

E. Use the up ▲ and down ▼ keys to change the value to **-1.6**.

The sensing element for the level sensor is located approximately 1.6 inches below the zero inch mark in the tank. A setting of -1.6 offsets the zero reading so that the meter displays 0.0 when the water is at the zero inch mark on the tank.

F. Press the **Setup** key to accept the value.

G. Press and hold the **Setup** key and press the up ▲ arrow key to exit the Set Up Menu.

H. Scroll until "OPtr" appears on the display and press the **Setup** key to exit the Select Mode and return the meter to normal operation.

The process meter is now programmed and should return to the normal operating mode. When the process meter returns to the operating mode, the display should indicate 0.0, as shown in figure 29. If it does not indicate 0.0, you may need to go back and adjust the Process Variable Offset parameter (OFFS) value.

Figure 29. Process Meter Display PV Value of 0.0

❑ 12. Start the circulation pump by placing selector switch **SS1** in the **ON** position.

Does an alarm condition exist? ____________________ (Yes/No)

You should find that the low-level alarm indicator lamp (PL3) is on because the level is below the low level alarm value (2 inches).

❑ 13. When the level reaches the 3-inch mark, turn off selector switch **SS1** to stop the pump.

Does an alarm condition exist? ____________________ (Yes/No)

You should find that the low (PL3) and high-level (PL4) alarm indicator lamps are off because the level is within the acceptable range (2.0-8.0 inches).

❑ 14. Turn on selector switch **SS1** to start the pump.

❑ 15. When the level reaches the 9-inch mark, turn off selector switch **SS1** to stop the pump.

Does an alarm condition exist? ____________________ (Yes/No)

You should find that the high-level alarm indicator lamp (PL4) is on because the level is above the high alarm value (8 inches).

As long as the level stays between the low and high level settings (low = 2.0, high = 8.0), neither alarm is active. If the level falls below the low level setting, the low level alarm (alarm 1) is active. If the level exceeds the high level setting, the high level alarm (alarm 2) is active.

❑ 16. Perform the following substeps to shut down the T5552.

A. Open both of the manual drain valves to drain the tank. When the tank is empty, close the valves.

B. Turn off the main circuit breaker.

C. Disconnect the circuit.

OBJECTIVE 4 DESCRIBE HOW TO PROGRAM A HONEYWELL UDI 1700 PROCESS METER TO PERFORM ON/OFF CONTROL

Read This

A Honeywell UDI 1700 process meter can be used for on/off control by connecting one of its output relays to a device such as a solenoid valve and setting the parameters in the same manner as setting an alarm.

Figure 30 shows a level control process that uses a process meter for on/off control. In this example, the process meter controls the level between 6.0 and 4.0 inches. The Process High Alarm 1 (PhA1) is set to 6.0. The alarm 1 hysteresis (AHY1) is set to 2.0. The hysteresis value is applied on the safe side of the alarm. For a high alarm, the safe side is below the high alarm value. Therefore, the control range is between 6.0 and 4.0 inches.

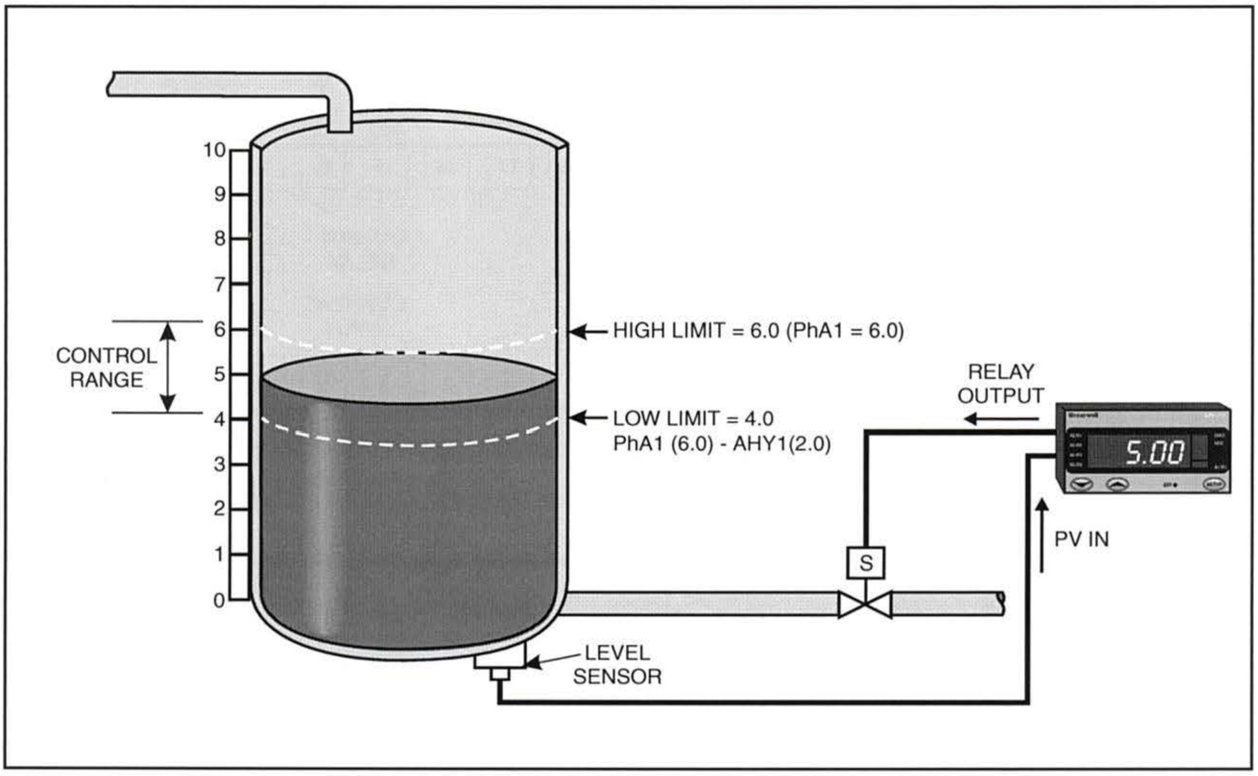

Figure 30. Level Control System Using Process Meter Relays for On/Off Control

The output relay of the process meter is configured so the solenoid valve opens when the level in the tank reaches 6.0 inches and remains open until the level drops to 4.0 inches. When the level reaches 4.0 inches, the solenoid valve closes and allows the level to increase until it reaches 6.0. Then the cycle repeats.

As an alternative, the alarm could be set as a Process Low Alarm and the hysteresis could be used to set the upper limit.

Control elements are wired to a Honeywell process meter's relay terminals in the same manner as alarm elements. An external power supply is required to power the solenoid.

Figure 31 shows a liquid level control process with a solenoid valve wired to the normally open contacts of output relay 1 on a Honeywell process meter. A pressure-type level sensor is wired to the input terminals of the process meter, as figure 31 also shows. In this configuration, the process meter receives an analog input and provides a discrete (on/off type) output. The advantage of this type of on/off control system is that the high and low levels are programmable and therefore do not require switches to be changed.

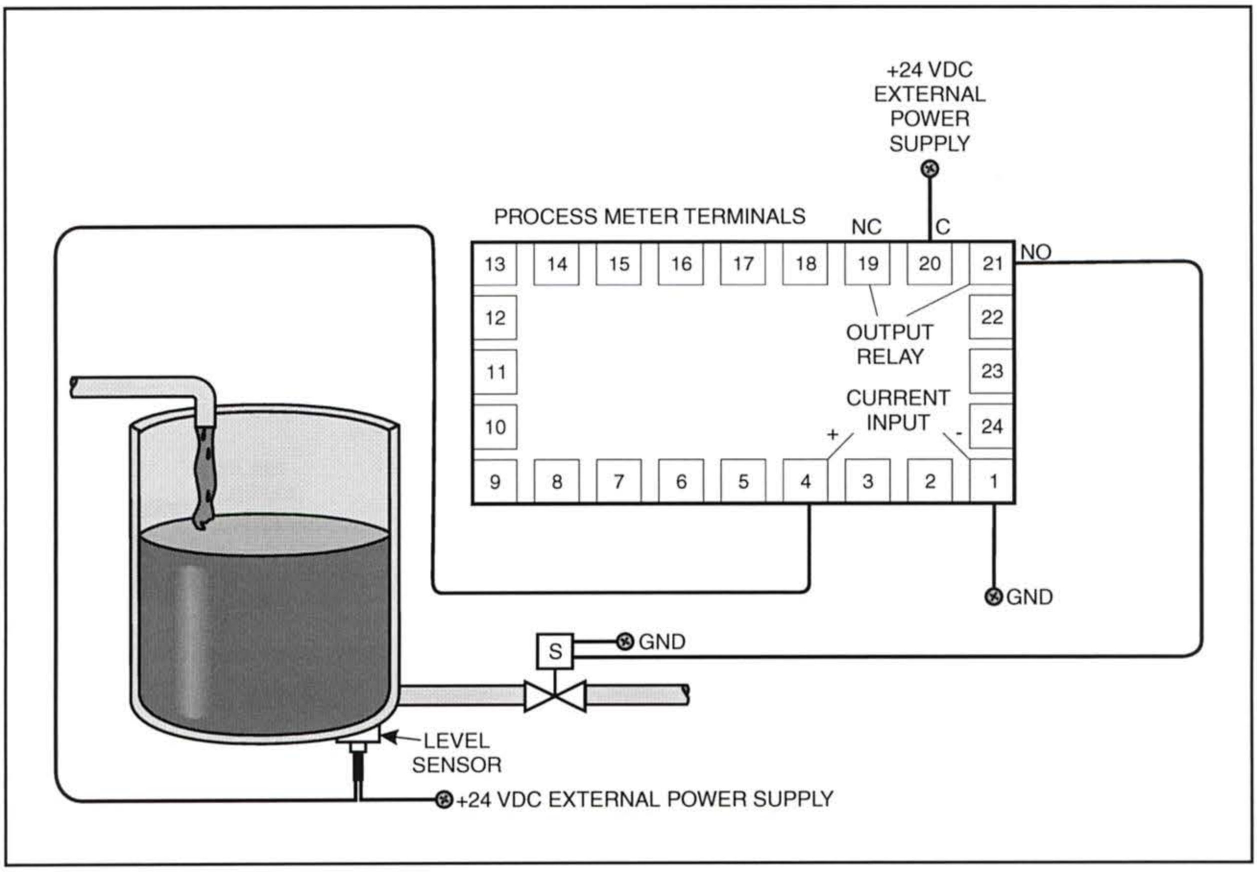

Figure 31. Relay on a Process Meter Wired to a Solenoid Valve for On/Off Control

Programming Procedure for On/Off Control

The following steps describe how to program a Honeywell UDI 1700 process meter to perform on/off control:

Step 1: Enter the Configuration Menu - Pressing and holding the SETUP key and then pressing the up ▲ arrow key places the meter in the Select Mode. Scroll to the Configuration Menu (ConF) and press the SETUP key. Set the unlock code (20) using the up ▲ and down ▼ arrow keys to accept the code by pressing the SETUP key.

Step 2: Program the Relay Parameters - Scroll through the Alarm and Output Usage parameters and set them as desired. The parameters that will need to be set include the Alarm Type (ALA1-ALA5), the Alarm Value (PhA1 or PLA1), the Alarm Hysteresis (AHY1-AHY5), and the Output Usage (USE1-USE5).

Step 3: Disable the Unused Alarms and Relays - Usually only one relay is necessary for on/off control with a Honeywell UDI 1700 process meter. If this is the case, the unused alarms (i.e. ALA2-ALA5) are set to "nonE".

Step 4: Exit the Configuration Menu and Select Mode - Pressing and holding the SETUP key and pressing the up ▲ arrow key exits the Configuration Menu and returns to the Select Mode. Scrolling through the menus until "OPtr" appears and pressing the SETUP key exits the Select Mode and returns the meter to normal operation.

SKILL 4 PROGRAM A HONEYWELL UDI 1700 PROCESS METER'S DISCRETE OUTPUTS TO PERFORM ON/OFF CONTROL

Procedure Overview

In this procedure, you will connect and operate a circuit to measure the level in a process tank. You will also program a Honeywell UDI 1700 process meter to use its relay contacts for on/off control.

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5552, as shown in figure 32.

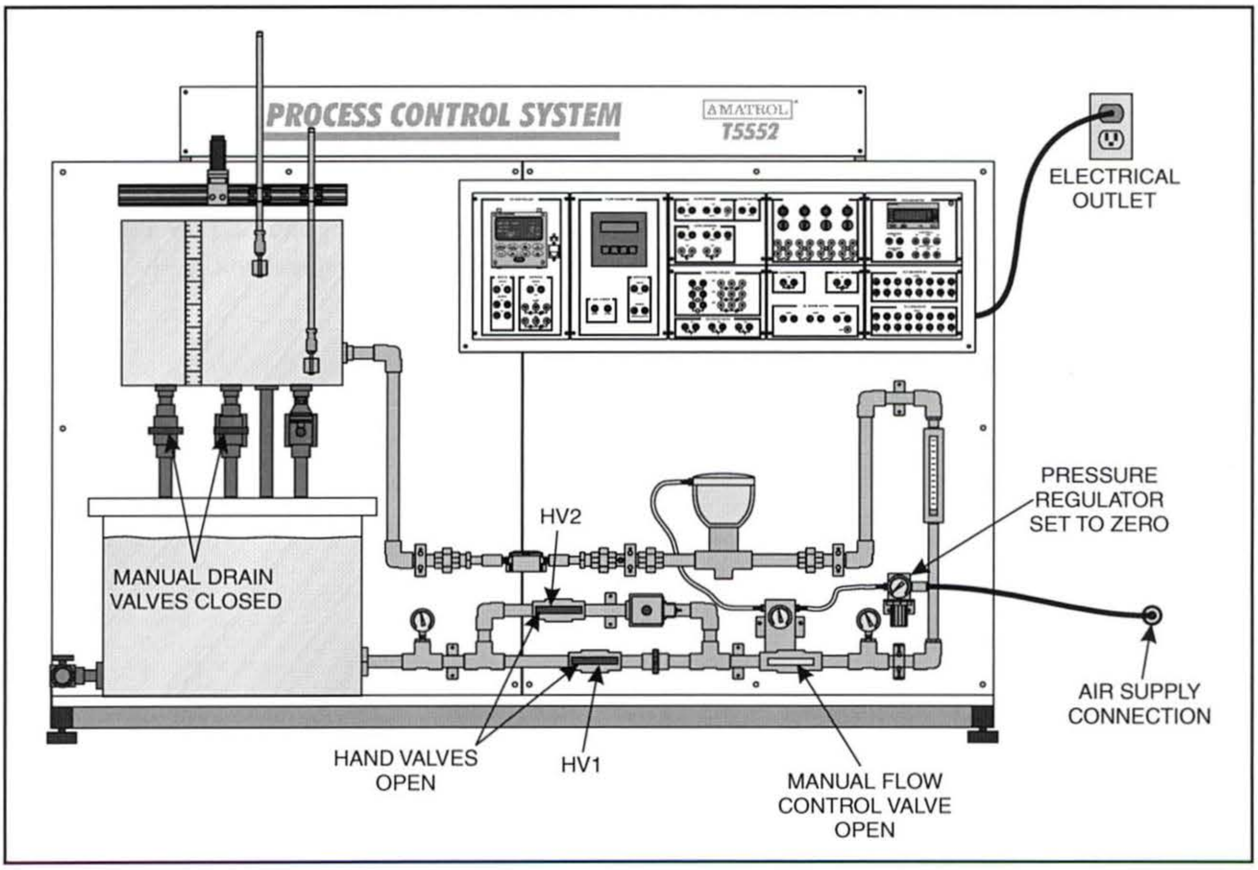

Figure 32. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 0 psi.

You will not control flow with the diaphragm actuator control valve in this skill.

C. Fill the reservoir tank with water.

D. Close (fully clockwise) the two manual process tank drain valves.

E. Open the manual flow control valve.

F. Connect the circuit shown in figure 33.

This circuit allows you to determine the level of water in the process tank using the process meter and control the level in the tank using on/off control.

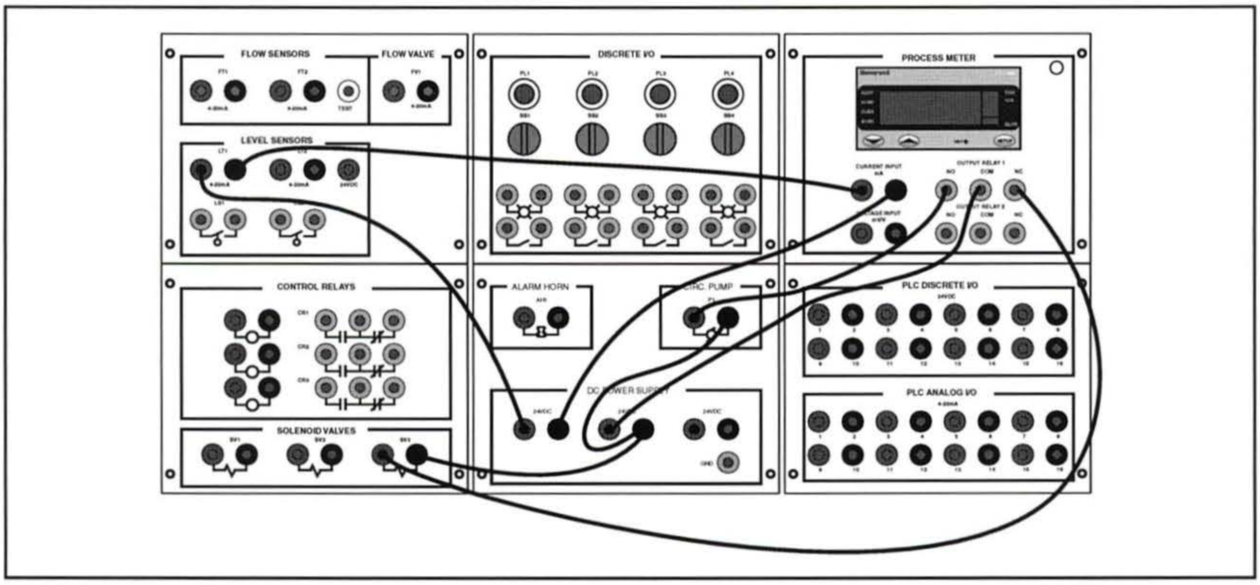

Figure 33. Circuit for On/Off Level Control Using a Low Level Alarm

Figure 34 shows the wiring diagram for the level circuit.

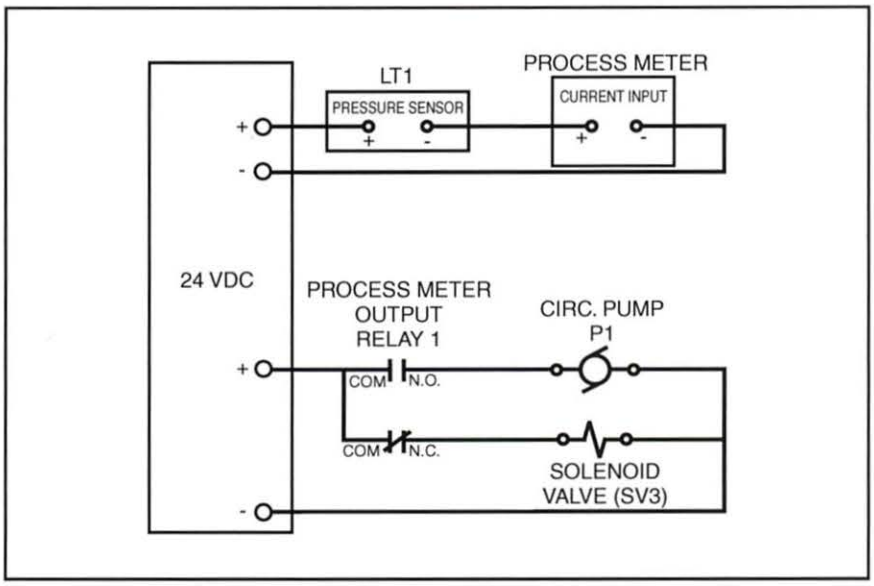

Figure 34. Wiring Diagram for the Level Circuit Using Process Meter Alarm Relays

Figure 35 shows the P&ID for the T5552. The active components and wiring are highlighted.

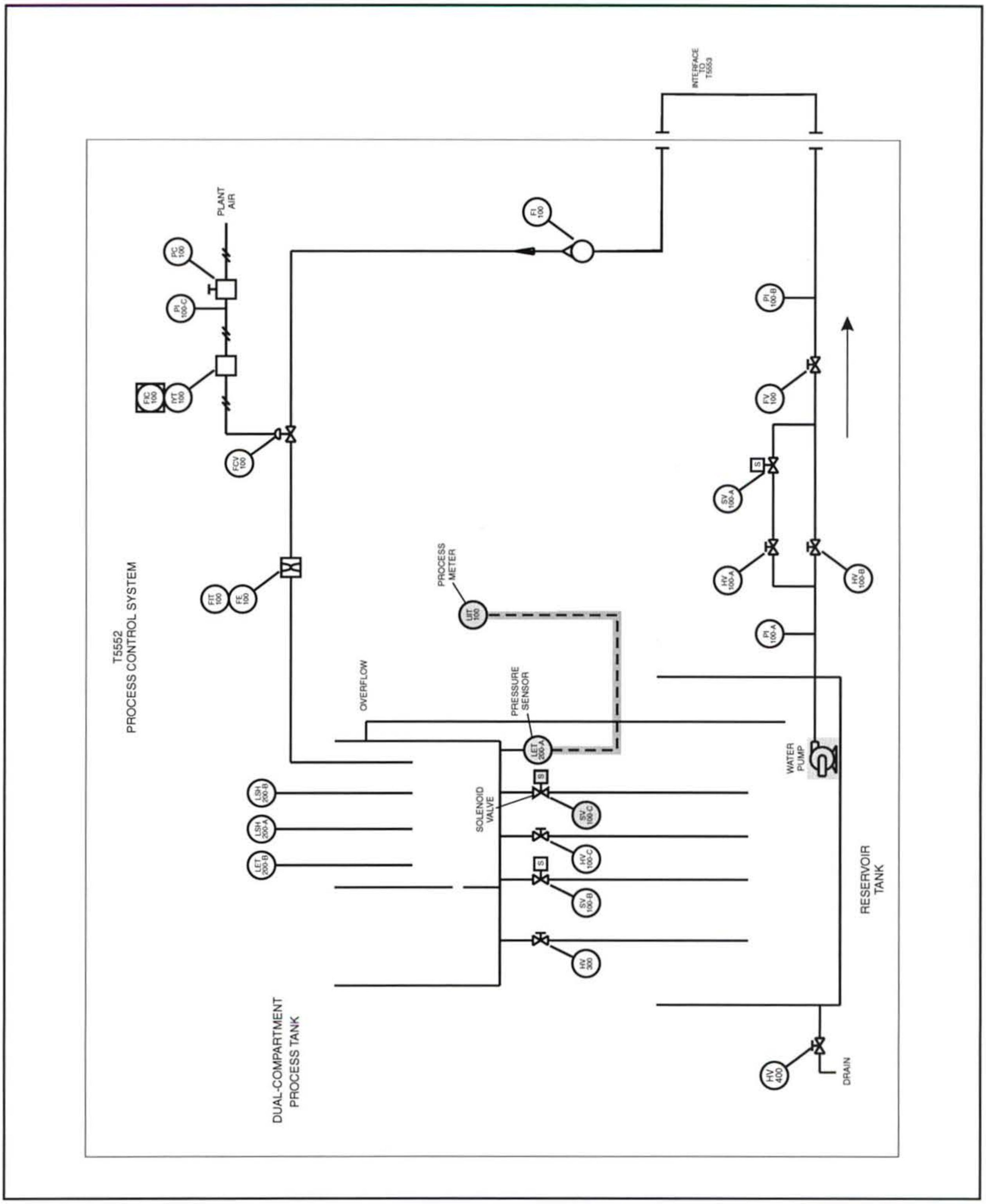

Figure 35. T5552 P&ID

❑ 3. Remove lockout/tagout.

❑ 4. Program the process meter according to the parameter values listed in the table in figure 36. Notice that it shows that you will turn off alarms 2-5 because you will not use them in this skill.

Also notice that the Output Usage (USE 1) setting is set for Alarm 1, reverse, non-latching. That makes the NO contact energized as long as there is no alarm condition and the NC contact is not energized. When an alarm condition is present, the NO contact is not energized and the NC contact is energized.

With the PhA1 parameter set to 6.0, and the AHY1 parameter set to 2.0, the process meter maintains the level between 6.0 and 4.0 inches.

MENU GROUP	PARAMETER	VALUE
ConF	inPt	4_20
	ruL	27.7
	rLL	0.0
	ALA1	P_H1
	Pha1	6.0
	AHY1	2.0
	ALA2-ALA5	nonE
	USE1	A1nr
SP2	OFFS	-1.6

Figure 36. Honeywell UDI 1700 Process Meter Parameter Settings for On/Off Control

❑ 5. Turn on the main circuit breaker.

❑ 6. Perform the following substeps to control the level in the process tank using on/off control.

A. Determine the state of the process pump and the solenoid valve (SV3).

Process Pump ______________________________ (On/Off)

Solenoid Valve _______________ (Energized/De-energized)

You should find that the process pump is on and the solenoid valve is de-energized. The process pump is connected to the normally open relay contact, and the relay is programmed reverse, non-latching. Therefore, the pump is running because the level is below the high level limit (6.0). Also, because the process variable (PV) is below the high level limit, the normally closed relay contact that is wired to the solenoid valve is open. Therefore, the solenoid valve is de-energized (closed). You should notice that the process tank is filling.

B. Allow the tank to continue to fill and determine the level at which the solenoid valve becomes energized (opens). You can determine this by listening for a "click."

Level ____ (inches)

You should find that the solenoid valve opens and begins to drain the process tank when the level reaches 6.0 inches, which is the high alarm value.

C. Determine the state of the process pump.

Process Pump ________________________________ (On/Off)

You should find that the process pump is off. After the level reaches the upper limit, an alarm condition exists. Therefore, the relay contacts return to their normal state (normally open for the contact wired to the process pump). You should notice that the process tank is draining because the solenoid valve is open.

D. Determine the state of the process pump and the process tank solenoid drain valve when the level drops to 4.0 inches.

Process Pump ________________________________ (On/Off)

Solenoid Valve ________________ (Energized/De-energized)

You should find that the process pump turns on and the solenoid valve de-energizes. This allows the tank to begin to fill again.

E. Allow the cycle to repeat so that you understand the process.

F. Turn off the main circuit breaker.

You should hear a "click," indicating that the solenoid valve is de-energized (closed). This is normal.

G. Open the process tank hand drain valves to drain the process tank faster. When the process tank is empty, close the valves.

❑ 7. Perform the following substeps to shut down the T5552.

A. Turn off the main circuit breaker.

B. Open the manual drain valves to drain the process tank. When the tank is empty, close the valves.

C. Disconnect the circuit.

SEGMENT 2

SELF REVIEW

1. The __________ parameter determines whether an alarm is a process high alarm, a process low alarm, or is disabled.

2. When using on/off control, an output relay on the Honeywell process meter is connected to a device such as a ____________ .

3. The __________ parameter determines what action is taken when an alarm occurs.

4. The ____________ parameter sets a range on the safe side of the alarm value in which the alarm will remain energized.

5. Most process meters have ___________ outputs that can be used as alarms.

6. When programming the Honeywell process meter for on/off control, unused alarms and relays should be __________.

SEGMENT 3

CLOSED LOOP LIQUID LEVEL CONTROL

OBJECTIVE 5 DESCRIBE THE OPERATION OF A CLOSED LOOP LIQUID LEVEL CONTROL SYSTEM

A closed loop liquid level control system has the ability to automatically maintain the liquid level at a specific point that is determined by the operator. It gives more precise control than an on/off control system, which can only maintain the level between high and low limits.

Figure 37 shows a block diagram of a closed loop liquid level control system. It has both an analog output and an analog input. The system's controller receives an analog feedback signal that is produced by a level sensor and compares it to a setpoint contained in the controller's memory. If the signals are different, the controller changes the value of its analog output signal, which causes a control element, such as a valve, to increase or decrease flow so that the feedback level signal becomes equal to the setpoint.

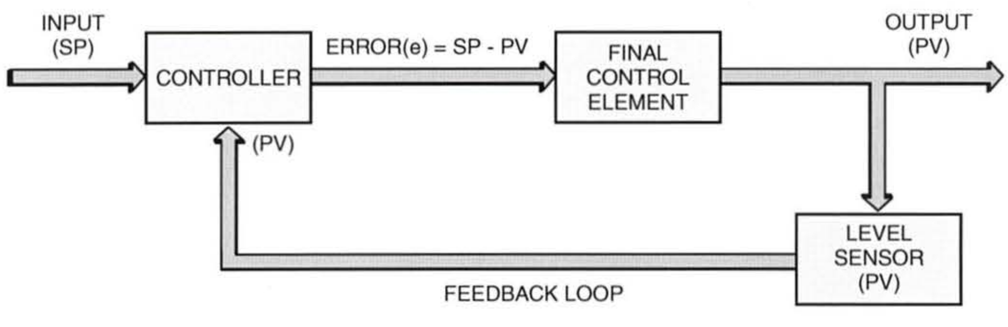

Figure 37. Block Diagram of a Closed Loop Liquid Level System

Figure 38 shows the components of a typical closed loop liquid level control system. This system includes a pressure sensor to measure the liquid level, a controller, a signal conditioner that converts the controller's electrical output signal to a proportional air pressure signal, and a diaphragm-actuator valve to control the input flow. The valve, an air-to-close valve, is the final control element of the system.

The level sensor continuously monitors the level in the tank and sends a feedback signal to the controller. The controller compares the signal from the sensor to the programmed setpoint to determine what adjustments, if any, should be made to the output signal to the final control element. In this example, the controller sends a 12 mA signal to the I/P converter, which converts it to a 9 psi signal that goes to the diaphragm-actuator valve. This signal causes the valve to open halfway (assuming the valve operates over a 3-15 psi range) to maintain the level at the setpoint.

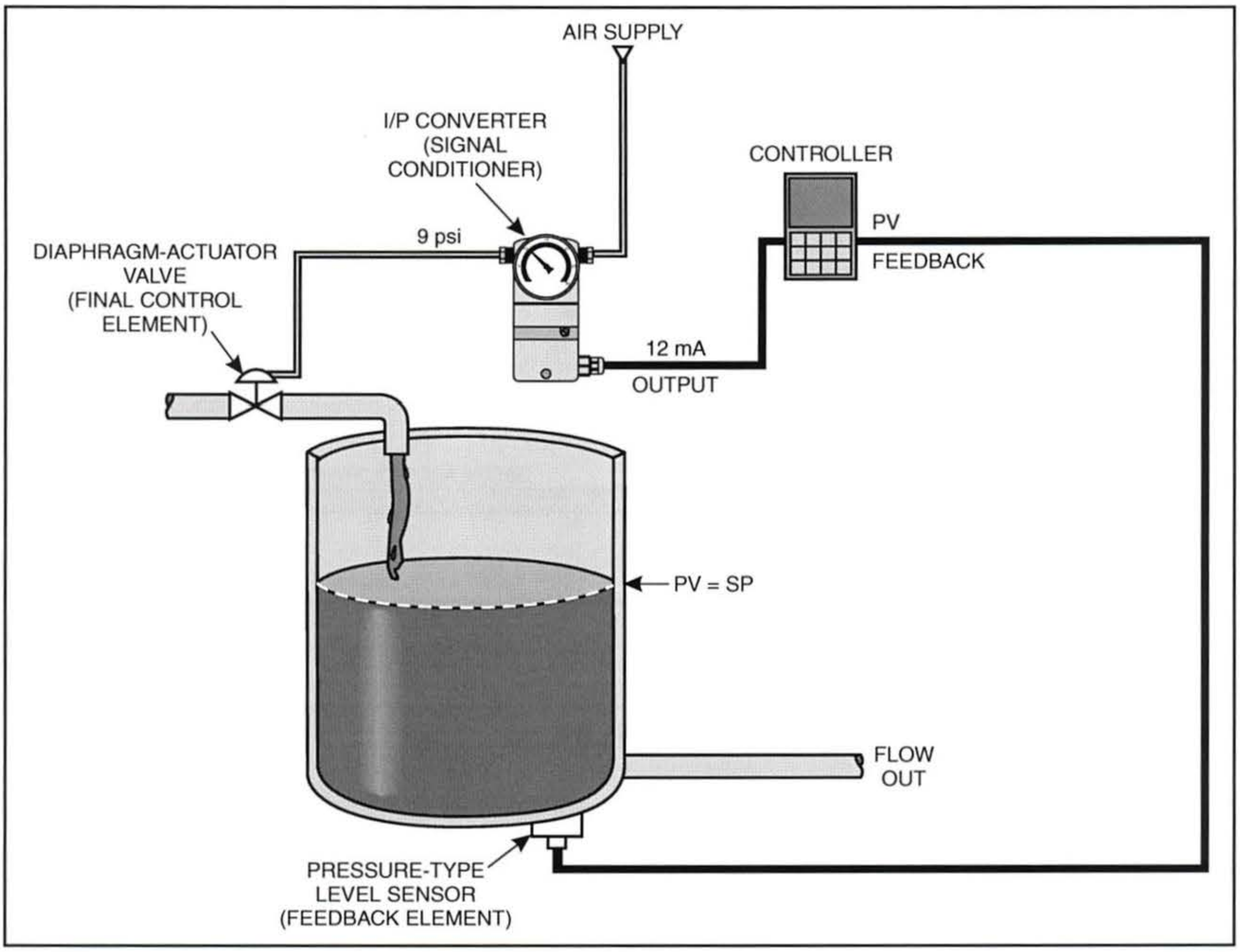

Figure 38. Closed Loop Liquid Level System

The system remains stable at this setpoint as long as all conditions stay the same. However, if the output flow decreases, as shown in figure 39, the sensor detects an increase in level and therefore increases the signal it sends to the controller.

The controller corrects the error between the SP and PV by increasing its output to the I/P converter, which increases its signal to the diaphragm-actuator valve. The valve closes just enough to decrease the flow to the point that the level returns to the setpoint.

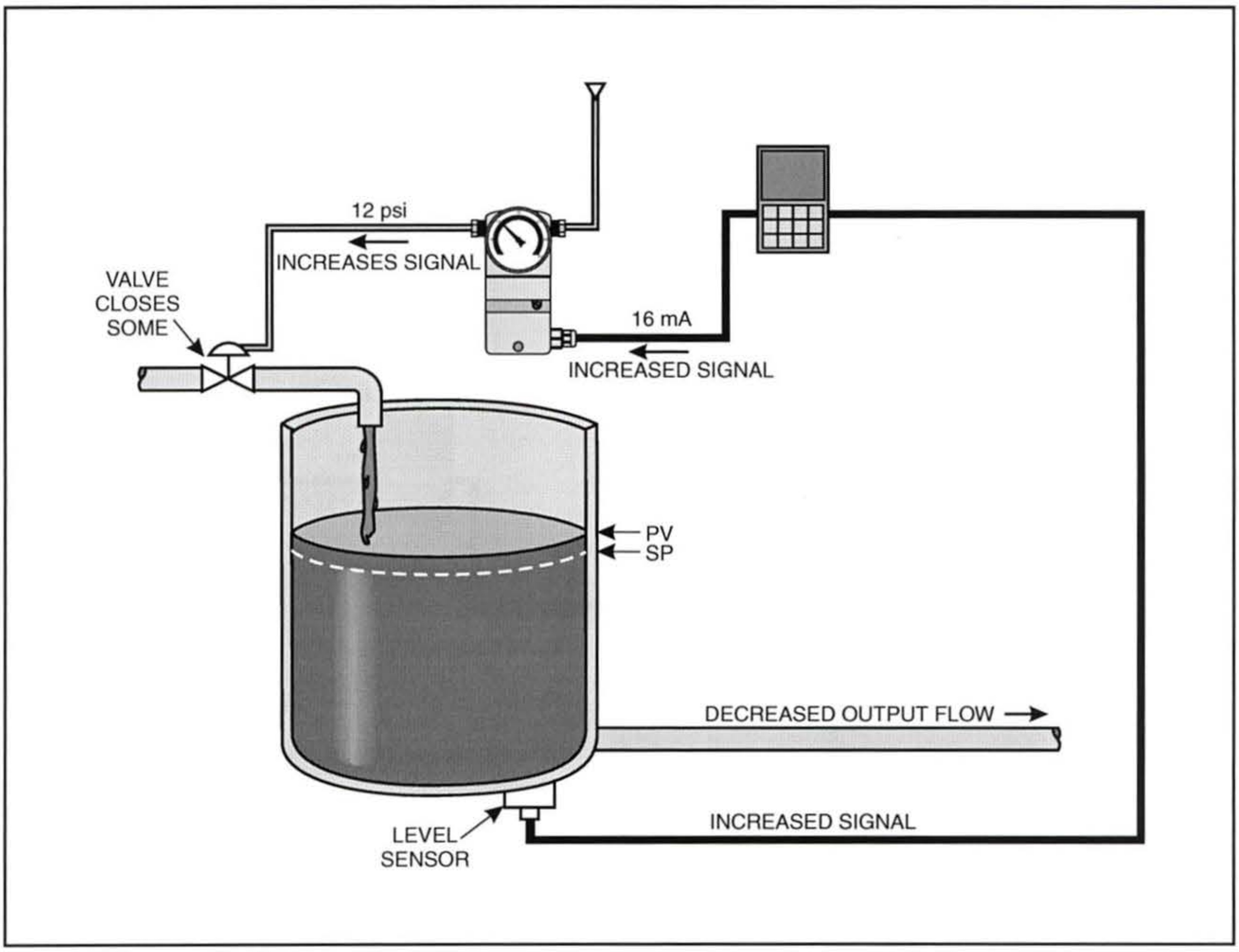

Figure 39. Controller Response to Decreased Output Flow

An increase in output flow has the opposite effect. The level sensor decreases its signal to the controller. This causes the controller to adjust its output to open the valve and increase the input flow.

Over time, the controller constantly readjusts its output as conditions in the system change, so that the level in the tank remains constant.

OBJECTIVE 6 DESCRIBE THE EFFECT OF TWO TYPES OF DISTURBANCES ON A CLOSED LOOP SYSTEM

In an ideal world, the process control system would hold a constant output once the system's process variable reaches its setpoint. Unfortunately, there are outside factors called disturbances that can cause the PV to drift away from the SP, requiring the system to continuously adjust its output.

There are two types of disturbances: supply disturbances and demand disturbances.

Supply Disturbance

A supply disturbance occurs when the supply to a process changes. For example, a supply disturbance to a liquid level control system occurs when the flow rate into the tank changes, either increasing or decreasing. Factors such as increased pressure upstream or a change in fluid viscosity can cause this type of disturbance.

If the supply disturbance causes a decrease in flow into the tank, as shown in figure 40, the level (PV) starts to drop below the SP because the flow rate out of the tank is greater than the flow rate into the tank. A decrease in the pressure at the valve inlet can cause this type of disturbance.

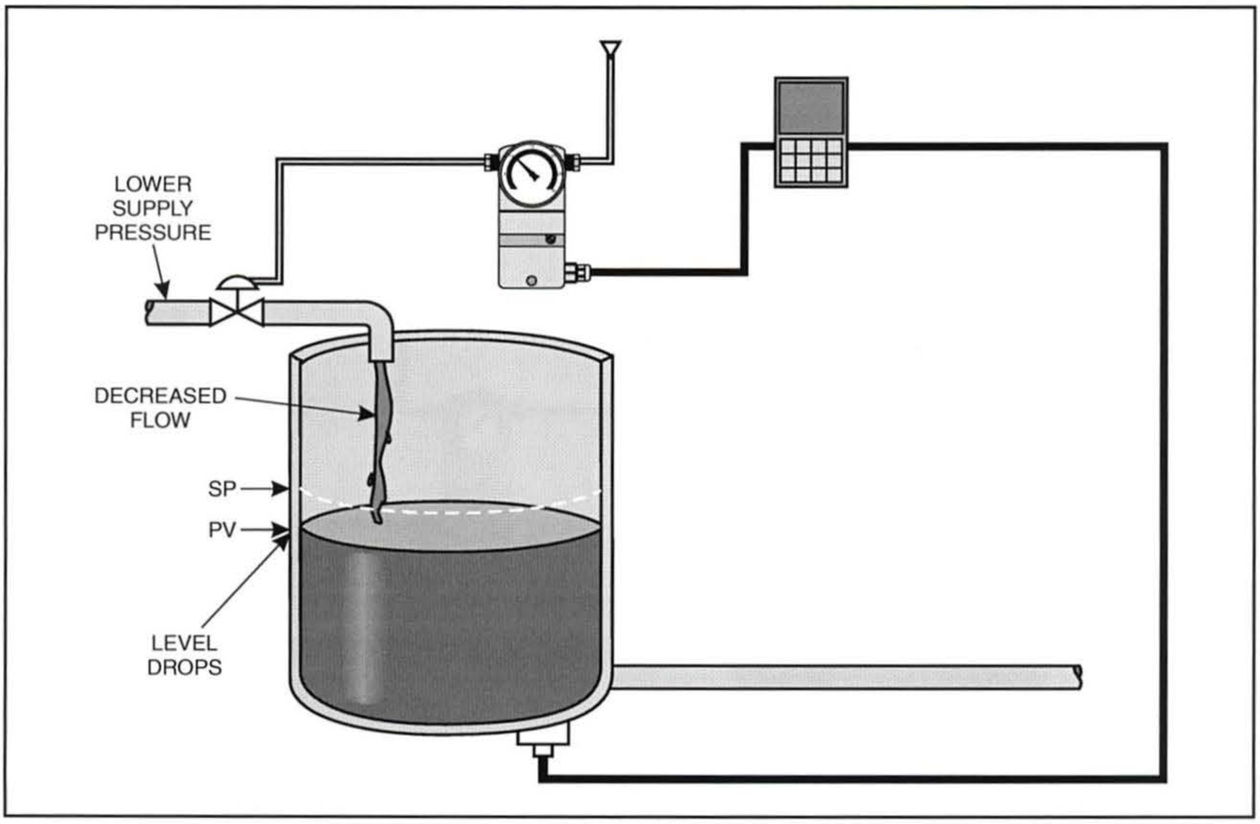

Figure 40. Effects of a Flow Decrease Supply Disturbance on Level Control

To correct for the supply disturbance, the controller decreases its output to the I/P converter. This causes the I/P converter to decrease its pneumatic output signal to open the control valve enough to allow the level to return to the SP, as shown in figure 41.

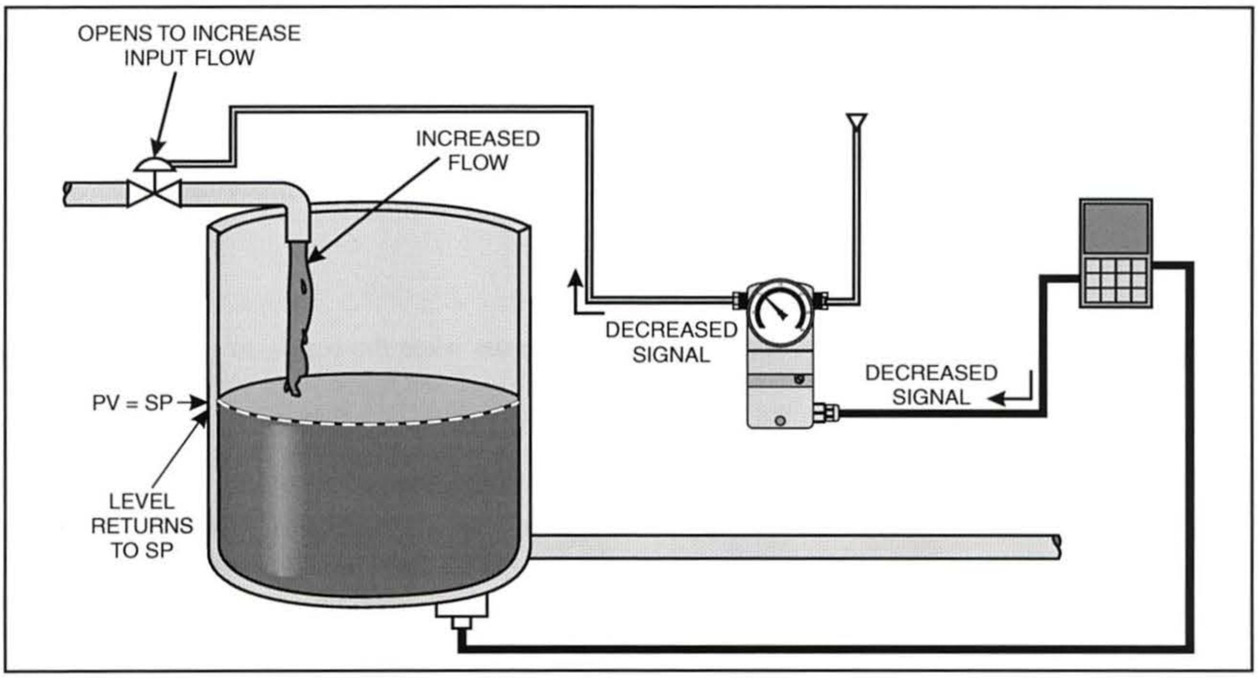

Figure 41. Correction of Flow Decrease Supply Disturbance

Figure 42 shows an increase in the level in the tank as a result of an increased input flow supply disturbance on the process. An increase in pressure before the valve can cause this type of disturbance.

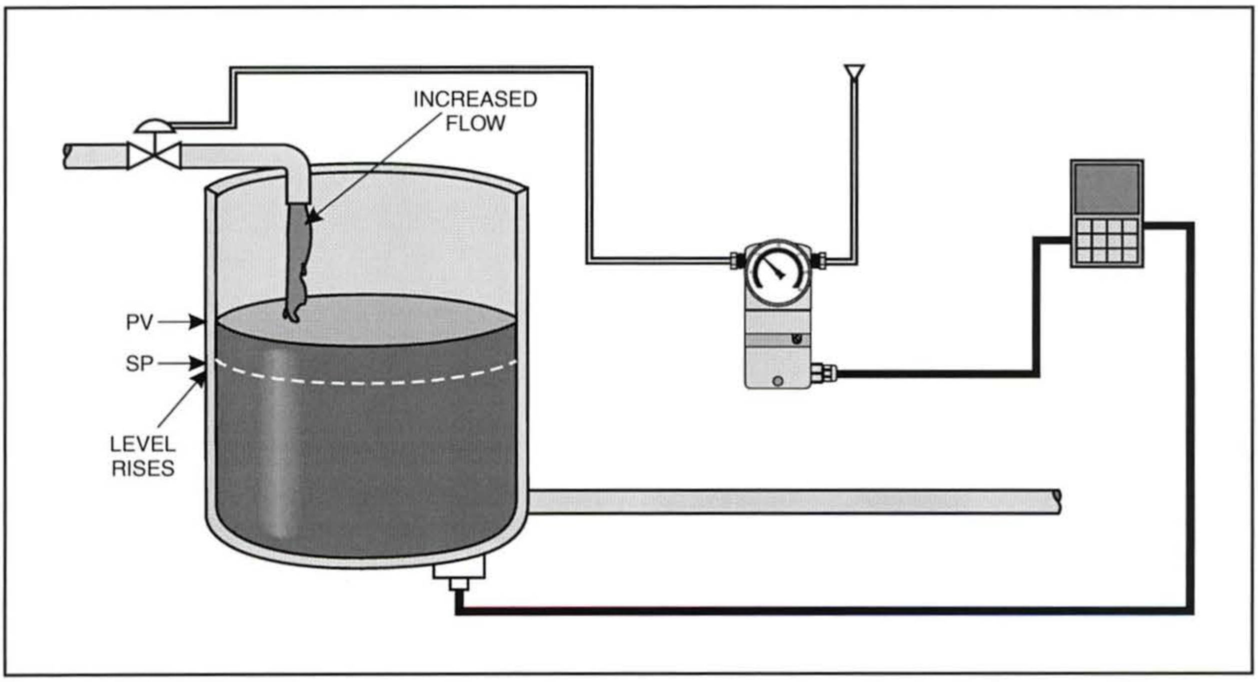

Figure 42. Effects of a Flow Increase Supply Disturbance on Level Control

An increase in flow to the tank causes the controller to increase its signal to the I/P converter, which increases the pneumatic signal to the control valve. This causes the valve to close enough to allow the level to drop back to the SP, as shown in figure 43.

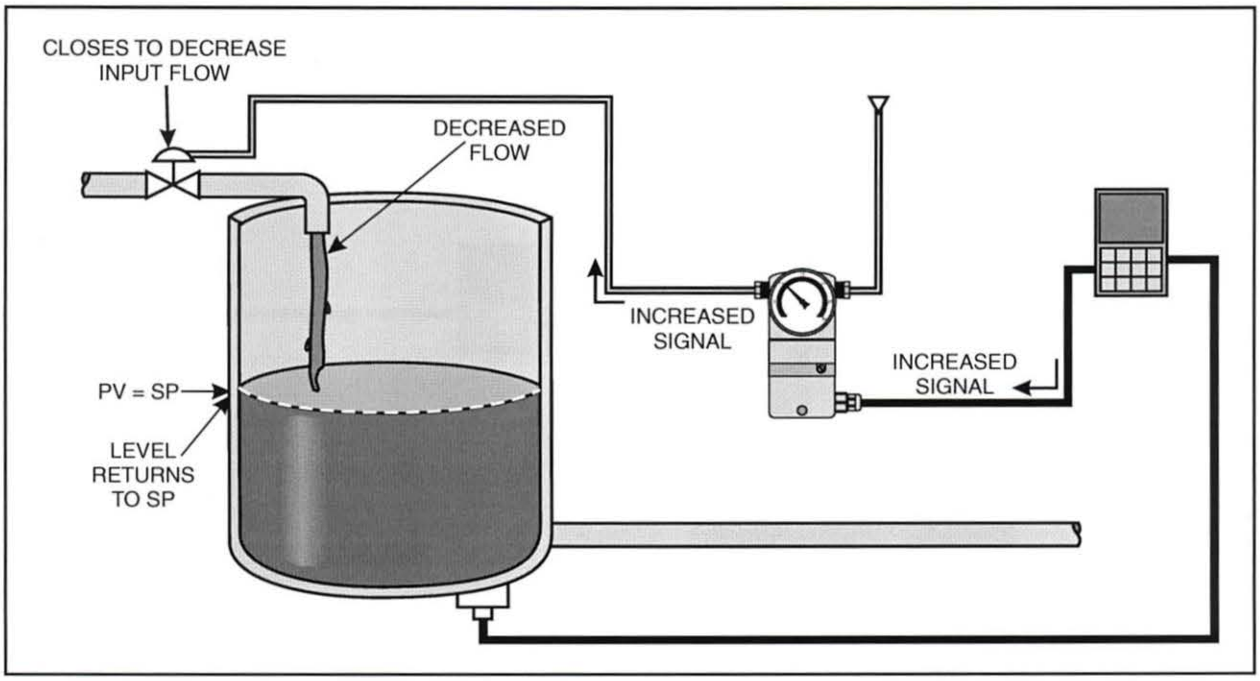

Figure 43. Correction of Flow Increase Supply Disturbance

Demand Disturbance

A demand disturbance occurs when a process downstream requires a change in output from the system. This creates an effect on the system similar to a supply disturbance.

If the demand disturbance is a decrease in flow out of the tank, as shown in figure 44, the level (PV) starts to increase above the SP.

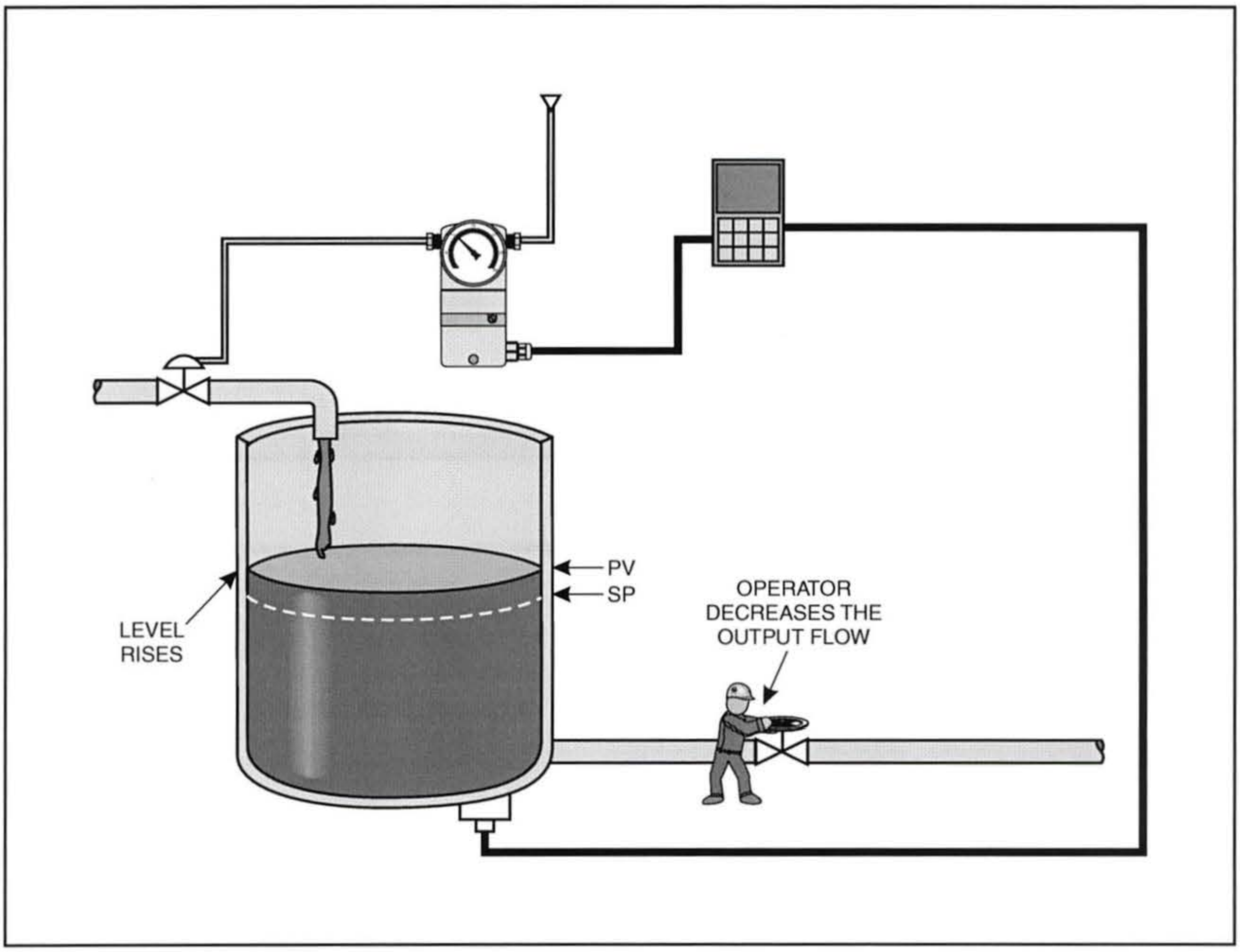

Figure 44. Example of a Demand Disturbance

To correct for the demand disturbance, the controller increases its output to the I/P converter. The I/P converter increases the pneumatic signal to close the control valve so that the input flow decreases enough to allow the level to drop back to the SP, as shown in figure 45.

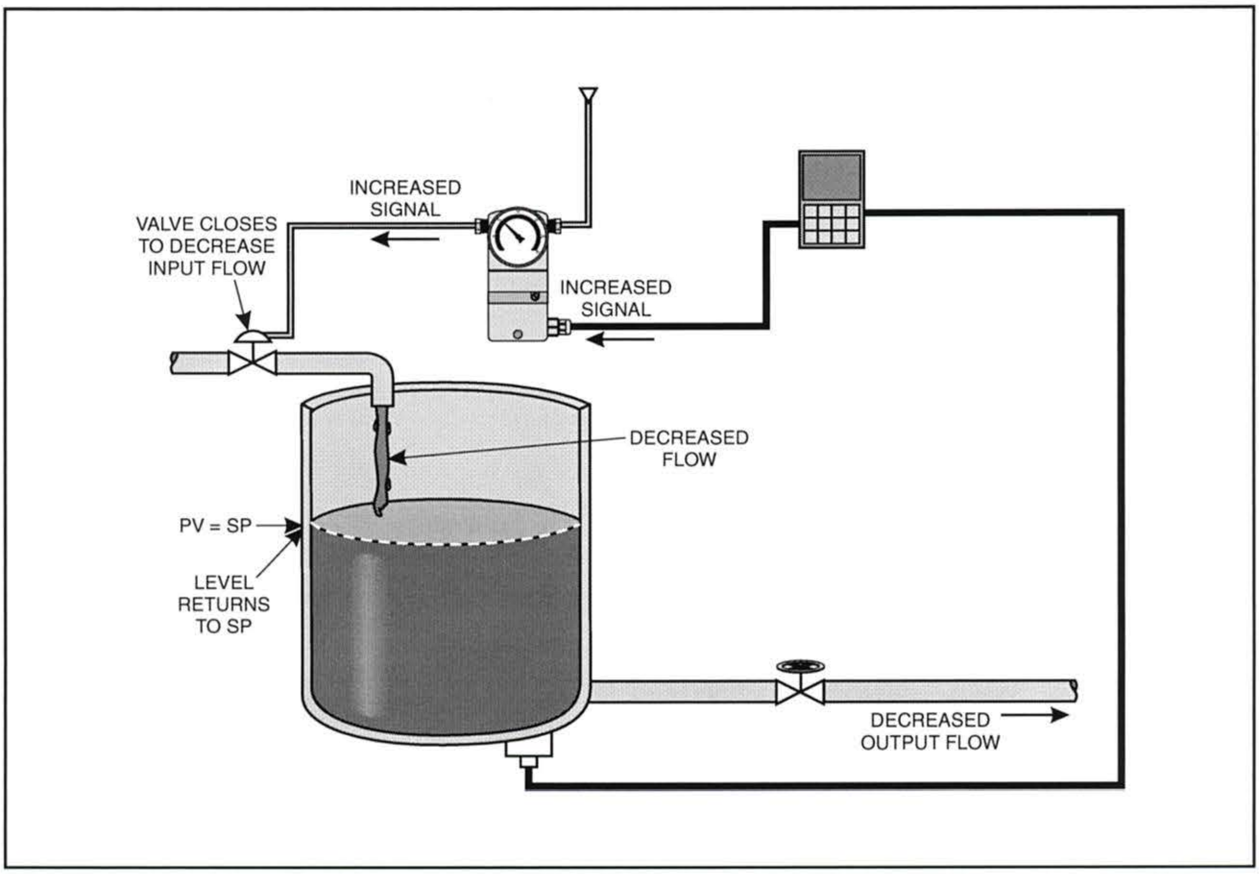

Figure 45. Demand Disturbance Correction

Figure 46 shows a decrease in the level in the tank as a result of an increased output flow demand disturbance on the process.

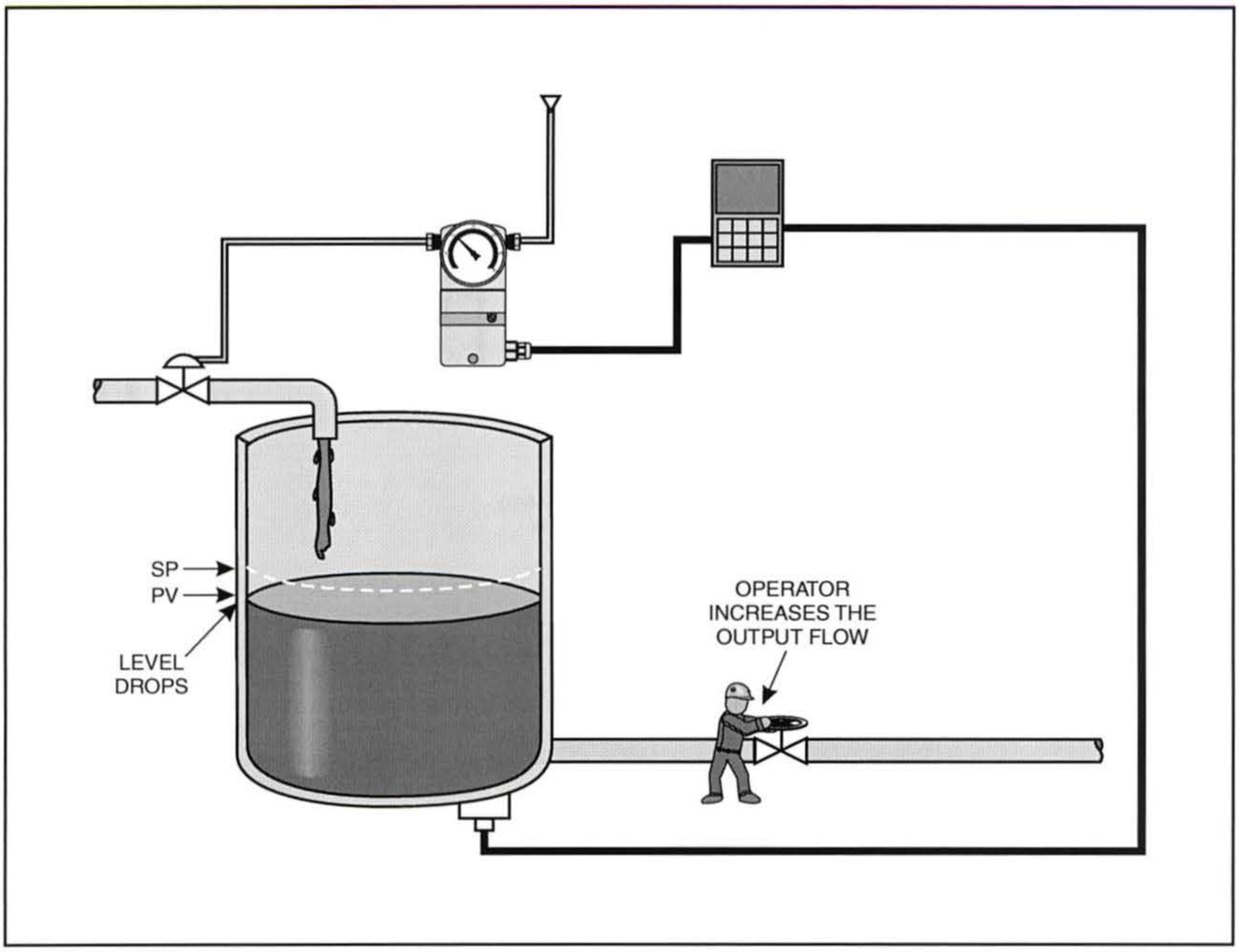

Figure 46. Effects of a Flow Increase Demand Disturbance on Level Control

An increase in flow out of the tank causes the controller to decrease its signal to the I/P converter. The I/P converter then decreases the pneumatic signal to the control valve, causing it to open enough to allow the level to return to the SP, as shown in figure 47.

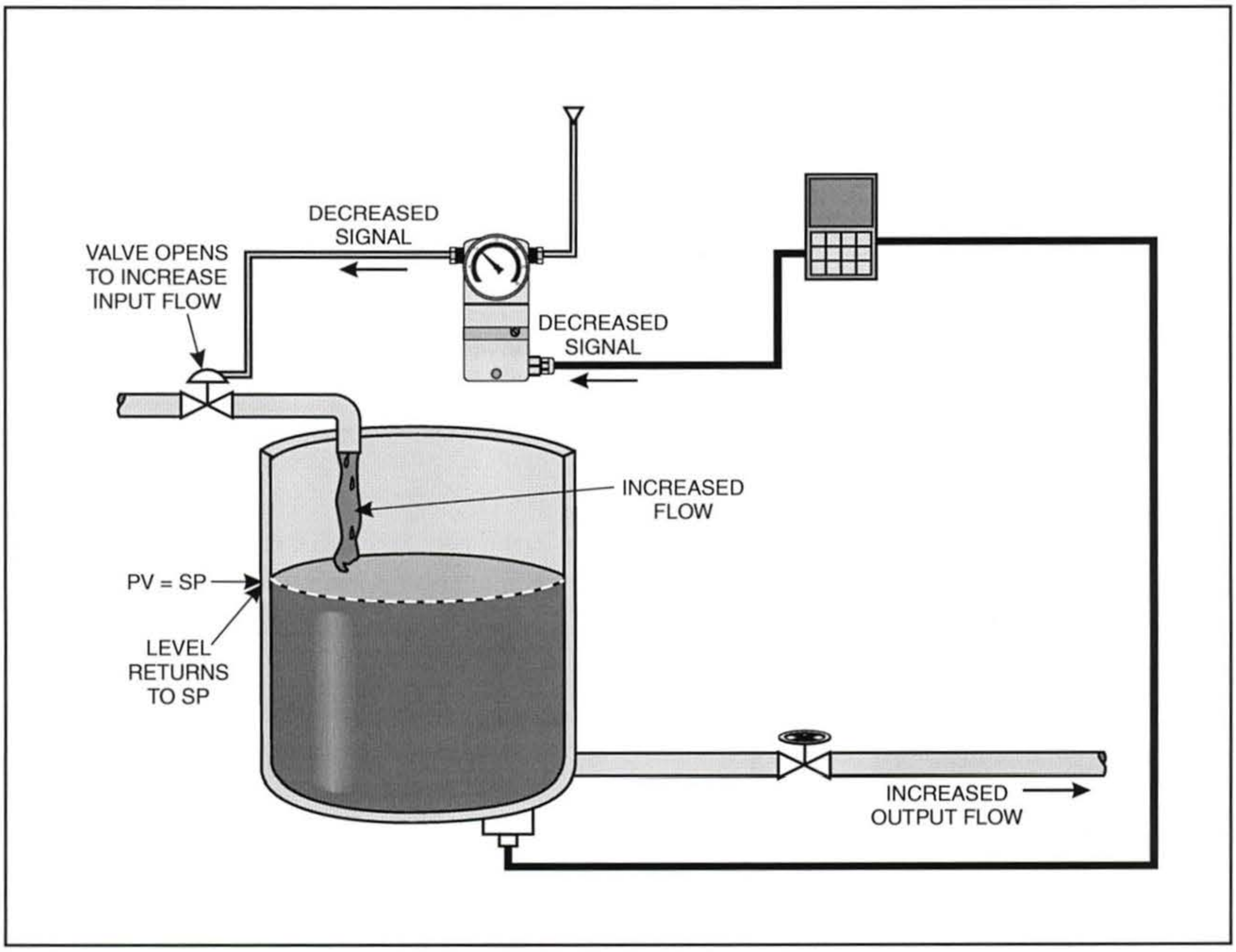

Figure 47. Increased Output Flow Demand Disturbance Correction

OBJECTIVE 7 DESCRIBE HOW TO CONFIGURE AND OPERATE A HONEYWELL UDC 3500 CONTROLLER BASED CLOSED LOOP SYSTEM

Read This

The Honeywell UDC 3500 controller can control many types of closed loop processes such as liquid level, flow, temperature, pressure, and pH. To perform one of these types of closed loop control, the UDC 3500's analog input and output must be connected to the process, certain parameters must be entered, and the controller must be placed in the automatic mode.

Controller Analog Input/Output Connections

One example of a closed loop application is the control of a liquid level process. As shown in figure 48, one of the UDC 3500's analog outputs connects to an I/P converter that sends a signal to a control valve. One of its analog inputs connects to a sensor that monitors the level.

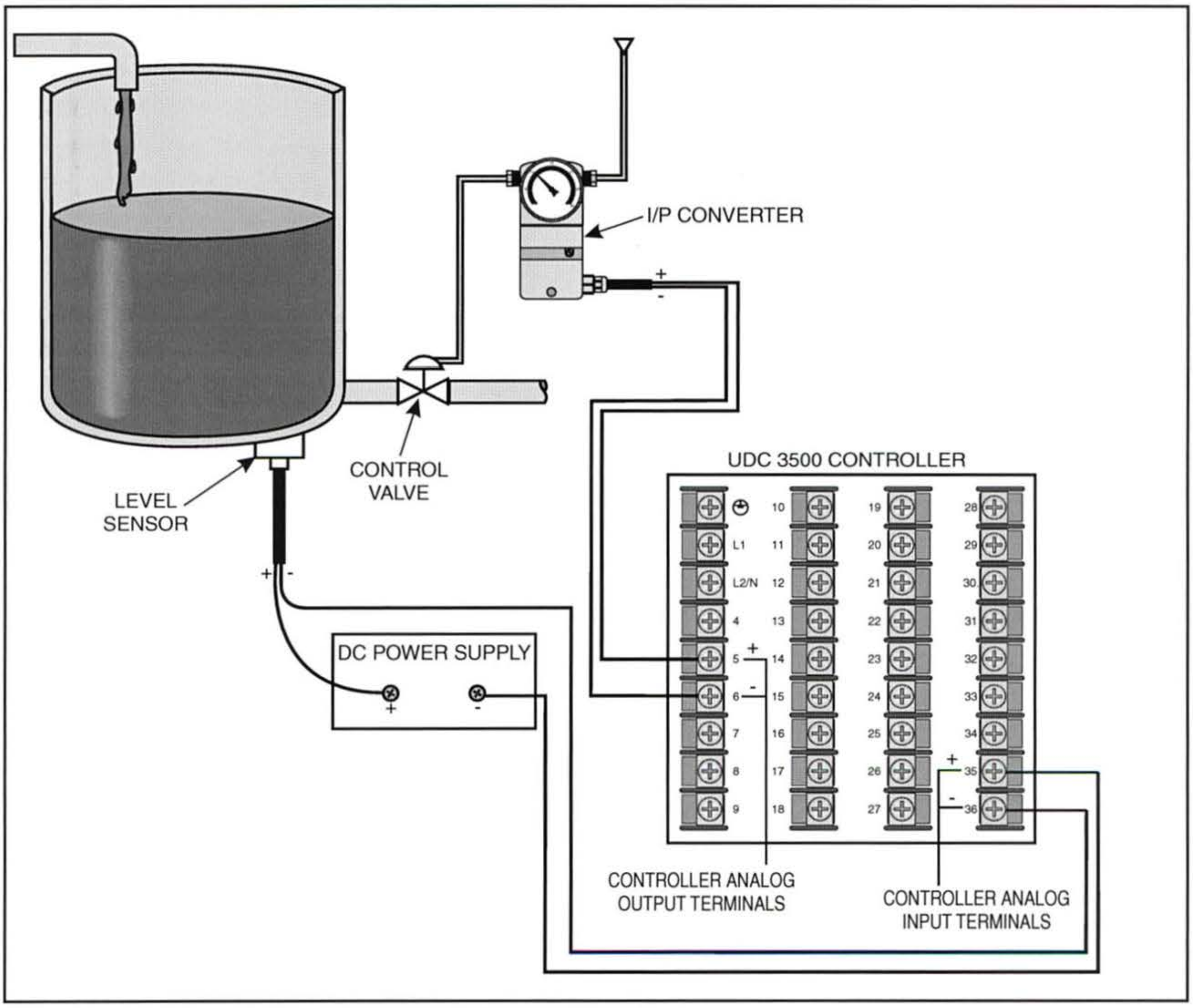

Figure 48. Honeywell Controller Wired for Closed Loop Level Control

Parameter Settings

The parameter settings are the same for any closed loop process, although the specific settings vary according to the process and the types of components to which the analog inputs and outputs are connected. The categories of parameters that must be set for closed loop control include:

- **Tuning Parameters** – The tuning parameters program the controller to respond to disturbances in the process as quickly as possible without causing the system to oscillate above and below the setpoint. Tuning parameters are covered in a separate objective on automatic control methods.
- **Input parameters** – The input parameters enable the controller to properly scale its output and the displayed value. The input parameters that should be set include: IN1 TYPE, XMITTER, IN1 HIGH, and IN1 LOW. The IN1 TYPE parameter refers to the type of input (e.g. 4-20 mA, 0-10 V, TC, etc.) that the controller is to receive. The XMITTER parameter refers to the type of transmitter (e.g. linear, square root, thermocouple, etc.). The IN1 HIGH parameter sets the display value that corresponds to the maximum input. The IN1 LOW parameter sets the display value that corresponds to the minimum input. These parameters are the minimum required to scale the display on the UDC 3500 controller.
- **Control parameters** – The control parameters determine the type of tuning parameters the controller uses and whether the controller is direct or reverse acting. Selecting DIRECT for the controller action causes the controller output to increase as the error increases. Selecting REVERSE for the controller action causes the controller output to decrease as the error increases. Most level control processes that use an air-to-close valve also use direct action for the controller. Level processes that use an air-to-open valve use reverse action for the controller.

After the parameters are set, the operator programs the setpoint and places the controller in automatic mode so it can control the process.

To show how to set parameters for a given application, figure 49 shows an example of a level control system. The system includes a tank that has a maximum level of 55.4 inches, a pressure-type level sensor that has a 4-20 mA output, and a controller. When the level is at 0 inches, the output from the level sensor is 4 mA. When the level is at 55.4 inches, the output from the level sensor is 20 mA.

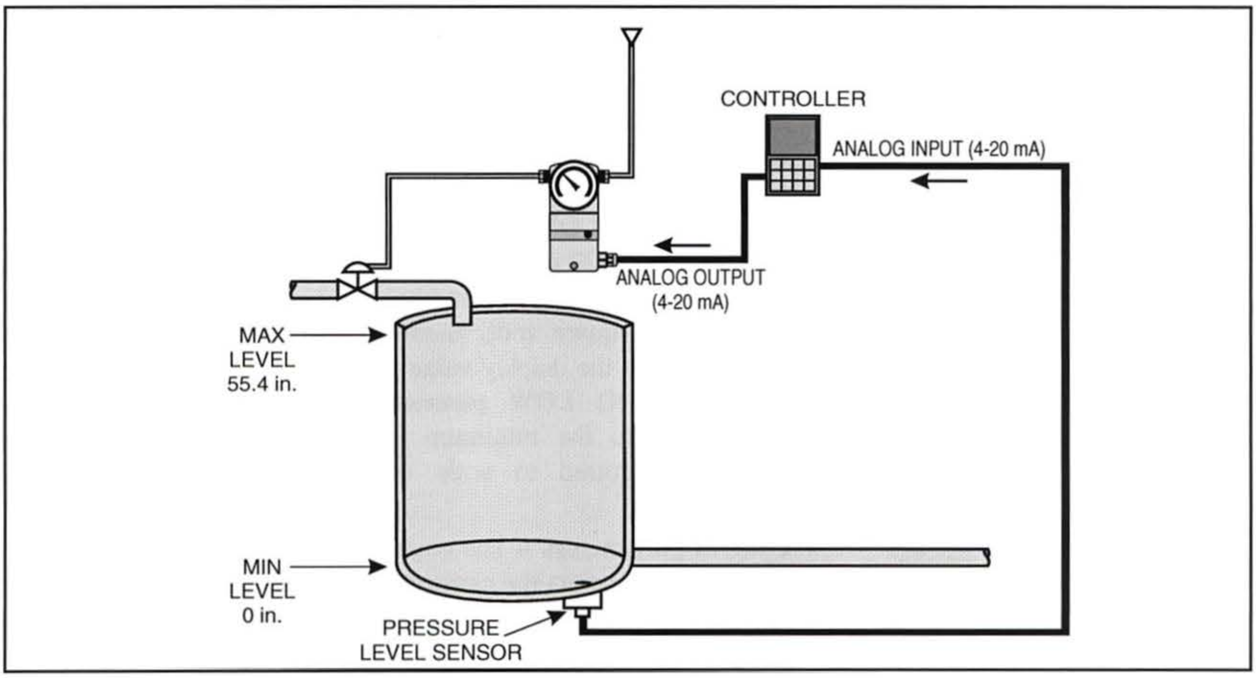

Figure 49. Closed Loop Level System

The input parameters for a Honeywell UDC 3500 controller for this application would be set according to the following table.

INPUT 1	
PARAMETER	SETTING
IN 1 TYPE	4-20
XMITTER	Linear
IN 1 HIGH	55.4
IN 1 LOW	0

Using these parameters, the controller automatically calculates the scale factor so that the displayed value is proportional to the input signal value.

The system in figure 49 operates over the entire range of the input signal. However, this is not always the case. For example, the bottom of the tank could contain extra material or the level sensor could be positioned in such a way that even when the tank is empty, the sensor measures a pressure and sends an output signal greater than 4 mA, as shown in figure 50.

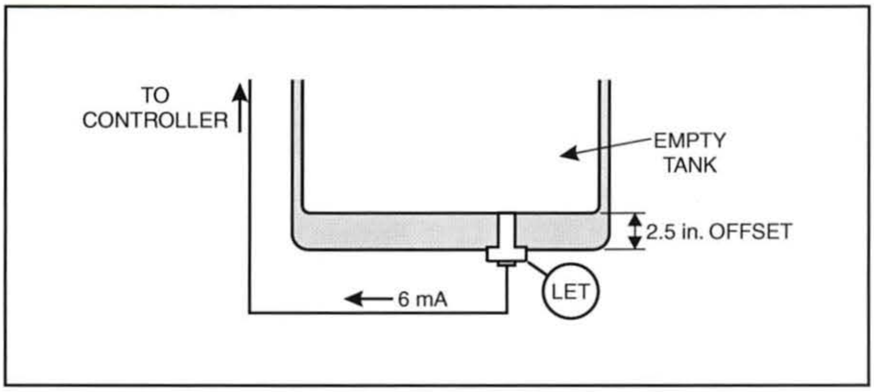

Figure 50. Sensor Position Results in Higher Output at Zero Level

The controller compensates for the offset using an input bias. "BIAS" is one of the parameters in the "INPUT" setup group of many controllers. It adjusts the display value so that the controller displays 0 when the level is at 0 inches. The bias setting for the example shown in figure 50 would be -2.5.

Another way to compensate is to use a sensor with an adjustable zero and span.

SKILL 5	CONFIGURE AND OPERATE A HONEYWELL UDC 3500 CONTROLLER BASED CLOSED LOOP LIQUID LEVEL SYSTEM

Procedure Overview

In this procedure, you will set up and operate a basic closed loop control system to control the level of a liquid in a process tank. You will first configure the controller then operate the closed loop system.

Do This

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5552, as shown in figure 51.

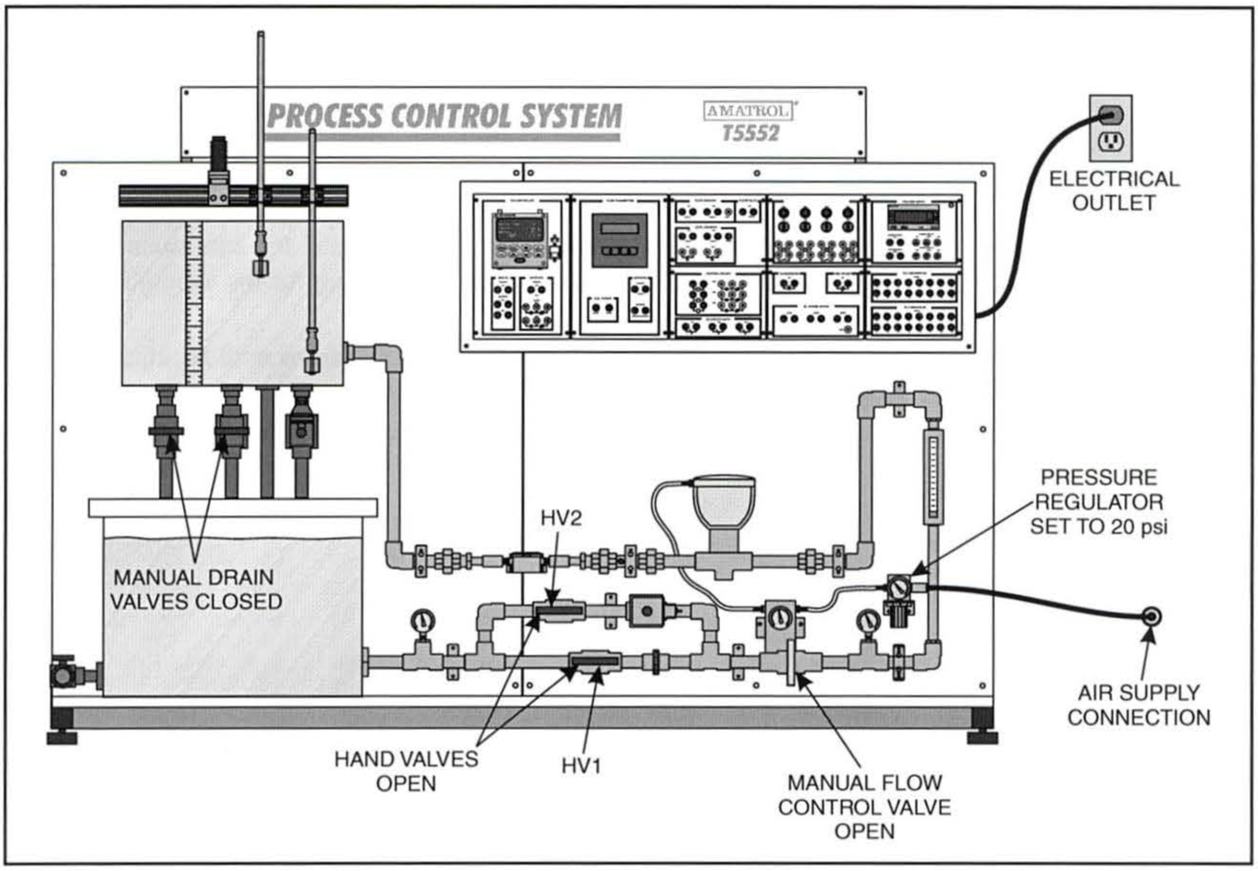

Figure 51. T5552 Setup for Closed Loop Level Control

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 20 psi.

C. Fill the reservoir with water.

D. Close (fully clockwise) the two manual process tank drain valves.

E. Open the manual flow control valve.

F. Connect the circuit shown in figure 52.

This circuit allows you to operate a closed loop level control system.

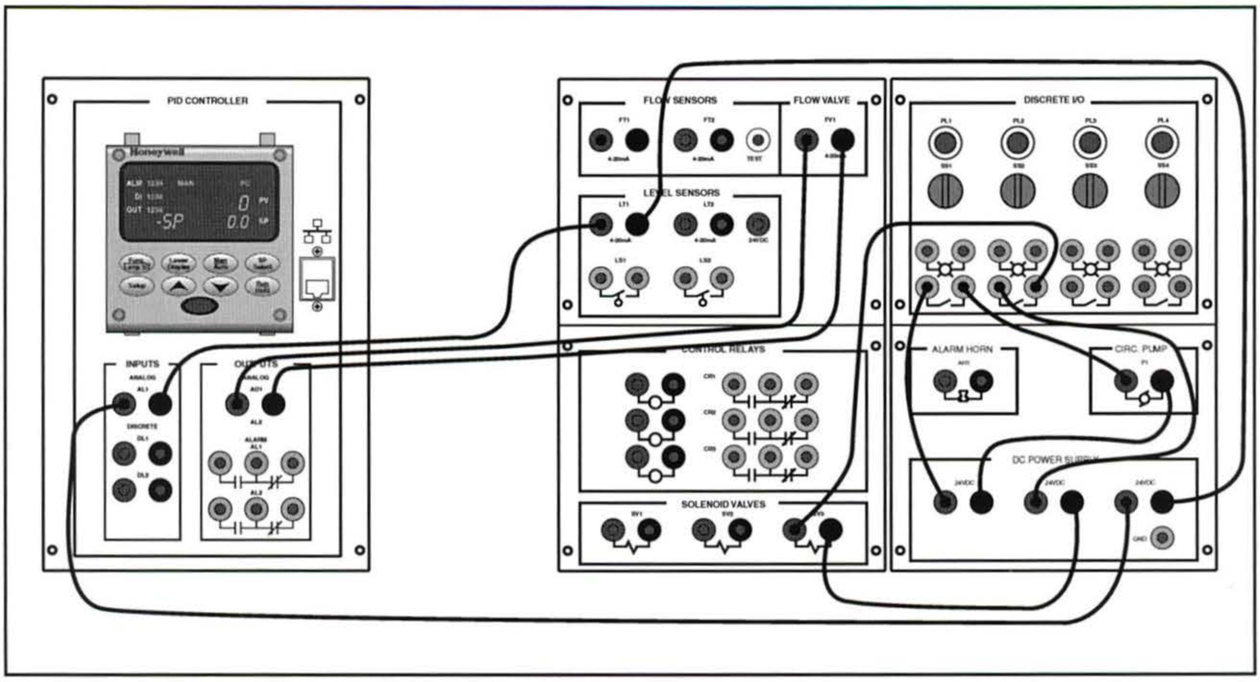

Figure 52. Connections for Closed Loop Level Control

Figure 53 shows the wiring diagram for the level control circuit.

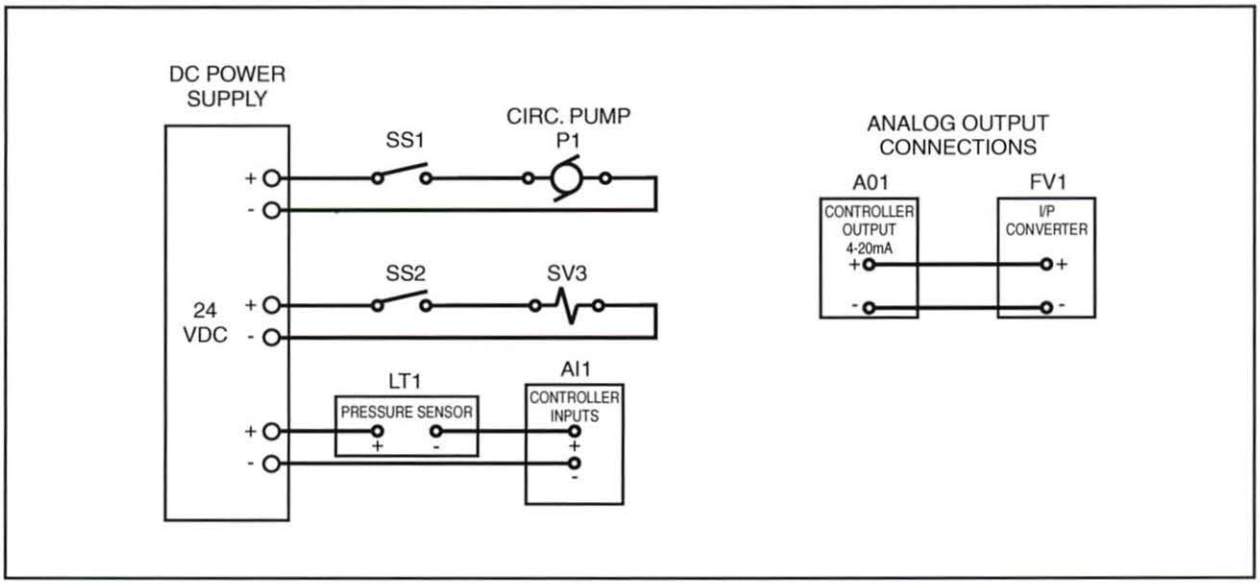

Figure 53. Wiring Diagram for a Level Sensor Connected to a Honeywell Controller

Figure 54 shows the P&ID for the T5552. The active components and wiring are highlighted.

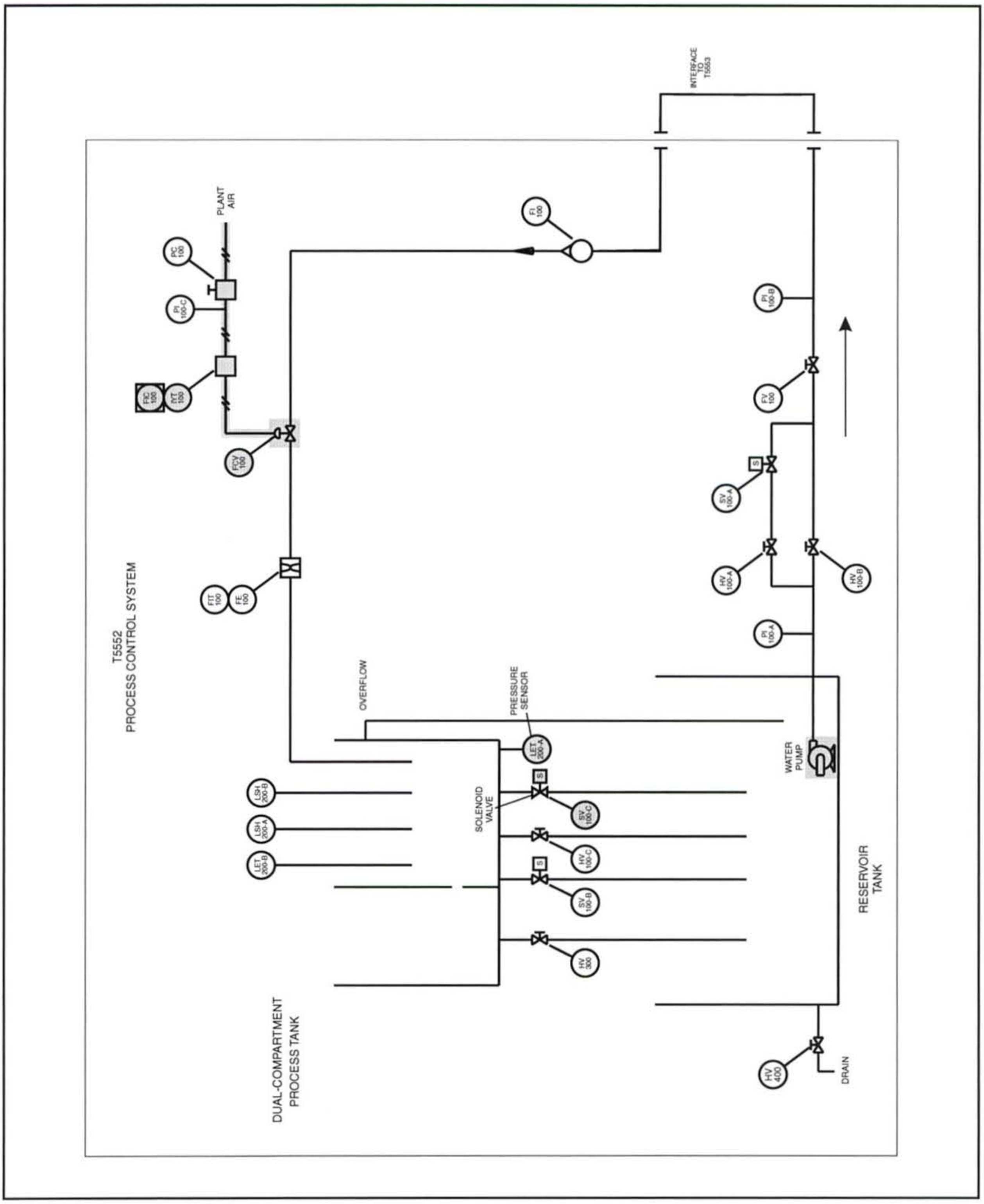

Figure 54. T5552 P&ID

❑ 3. Remove the lockout/tagout.

❑ 4. Make sure selector switch **SS1** is in the **OFF** position (up).

SS1 is used to turn the circulation pump on and off.

❑ 5. Perform the following substeps to set up the Honeywell process controller for closed loop control.

A. Turn on the main circuit breaker to apply power to the system.

B. Observe the display of the process controller as it goes through its power-up sequence.

When the startup diagnostic test is done, "TEST DONE" appears on the display briefly.

The controller should then enter the control display mode.

C. Press the **Setup** key repeatedly to scroll through the different selections until INPUT 1 appears on the display.

D. Press the **Func Loop 1/2** key.

The parameter "IN 1 TYPE" should appear on the screen.

E. Use the up ▲ and down ▼ keys to set the parameter to **1-5**. This indicates an electrical input type of 1 - 5 V.

F. Press the **Func Loop 1/2** key to move to the next parameter, "XMITTER 1".

G. Use the up ▲ and down ▼ keys to set this parameter to **LINEAR**.

This indicates that the output varies linearly with the input.

H. Press the **Func Loop 1/2** key to move to the next parameter, "IN 1 HIGH".

I. Use the up ▲ and down ▼ keys to set this parameter to **27.7**. This is the maximum value for the pressure sensor on the T5552.

J. Press the **Func Loop 1/2** key to move to the next parameter, "IN1LOW."

K. Use the up ▲ and down ▼ keys to set this parameter to **0.0**. This indicates the displayed value when the input signal is 1V.

L. Press the **Func Loop 1/2** key repeatedly until the "BIAS IN1" parameter appears.

M. Use the up ▲ and down ▼ keys to set the parameter to **-1.6**.

There is approximately a 1.6 inch offset between the bottom of the tank and the zero reading for the sensor. Entering this bias allows the tank sight scale to closely agree with the controller display.

N. Press the **Lower Display** key repeatedly to exit the Setup menu and return to the control display mode.

❑ 6. Perform the following substeps to use the controller to automatically control the process.

A. Use the **Lower Display** key to display the SP value in the lower display.

B. Use the up ▲ and down ▼ keys to set the SP value to **3.0**.

C. Place the controller in the automatic mode by pressing the **Man/Auto** key.

D. Place selector switch **SS1** in the **ON** position.

You should notice that water starts to flow into the tank. The controller is sending out a signal that tells the diaphragm-actuated valve to open and allow water to flow into the tank so that the actual level (PV) can reach the programmed setpoint (SP).

E. Note the time that the water starts to flow into the tank.

This will allow you to determine how long it takes to reach the setpoint.

F. Now observe the display of the controller as the tank continues to fill.

You should notice that the current PV value is displayed above the SP value, as figure 55 shows. The PV value should continue to increase as it approaches the SP.

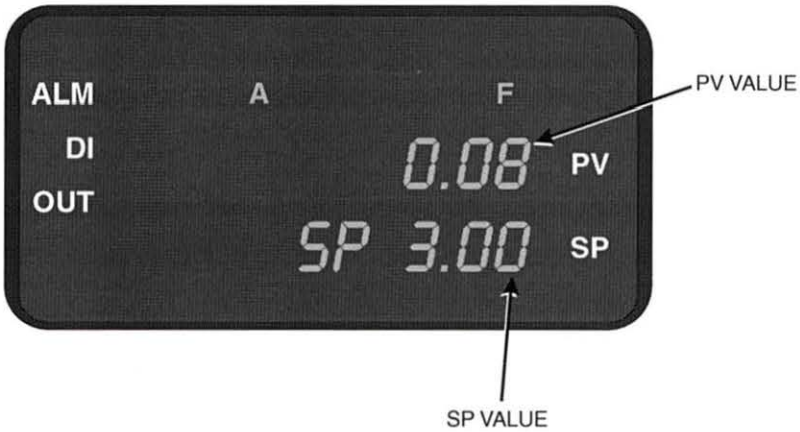

Figure 55. PV and SP Displayed

G. Use the **Lower Display** key to display the output (OUT) in the lower display.

H. Determine if the controller is changing the output to control the valve as the PV approaches the SP.

Is the output changing? ______________________ (Yes/No)

You should find that the controller is changing the output because it is in automatic mode.

I. When the output of the controller reaches 100%, observe the value of the PV as indicated on the display of the controller.

Is the PV above or below the SP? __________(Above/Below)

You should find that the PV stabilizes above the SP. The controller may not be programmed (tuned) to properly control the PV at the SP.

NOTE

This result depends on the settings in the controller. If the settings have been changed from the default values, you may get a different result.

J. Place selector switch **SS2** in the **ON** position.

This opens one of the process tank drain solenoid valves, creating a demand disturbance on the process.

K. Observe the display of the controller.

You should notice that the PV value starts to drop.

L. Determine if the controller increases or decreases the output.

Output ________________________(Increasing/Decreasing)

You should find that the controller decreases the output. This causes the valve to open and allow more flow so that the level rises.

❑ 7. Place selector switch **SS2** in the **OFF** (up) position to close the solenoid valve.

❑ 8. Place selector switch **SS1** in the **OFF** (up) position to stop the pump.

❑ 9. Change the SP to **5.00** and repeat step 6.

You should find that when you increase the SP to 5.00, the controller decreases its output signal to the I/P converter so that the valve opens. As the level approaches the SP, the controller should begin to increase its output signal to close the valve.

❑ 10. Perform the following substeps to shut down the T5552.

A. Place selector switch **SS1** in the **OFF** position (up).

This will stop the circulation pump.

B. Place selector switch **SS2** in the **OFF** position (up).

This will close the drain solenoid valve.

C. Open both of the manual drain valves on the process tank to completely drain the tank. When the tank is empty, close both valves.

D. Turn off the main circuit breaker.

E. Disconnect the control circuit.

SEGMENT 3

SELF REVIEW

1. The controller determines if a(n) _________ exists by calculating the difference between the SP and the PV.
2. A closed loop liquid level system differs from an open loop liquid level system because it includes a level sensor and a __________ loop.
3. A _______________ disturbance occurs when the supply to a process changes.
4. A ______________ disturbance occurs when a process downstream requires a change in the output from the supply system.
5. The __________ parameters enable the controller to properly scale its output and the displayed value.
6. The controller compensates for an offset when the system does not operate over the entire range of the sensor by using an input _________.

SEGMENT 4

DISCRETE INPUT/OUTPUT FUNCTIONS

OBJECTIVE 8 DESCRIBE THE FUNCTION OF LOOP CONTROLLER ALARM OUTPUTS AND GIVE AN APPLICATION

Read This

Most electronic loop controllers have output relays. These relays can be wired to devices such as a horn to sound an alarm when the process reaches a state where conditions are dangerous for the equipment, personnel, or the product being made.

Figure 56 shows an example of a level control system that uses alarms. In this system, a level sensor sends a feedback signal to the controller so that it knows the actual level (PV) in the tank. The controller sounds an alarm when the level rises above 15 inches or drops below 5 inches. The relay contacts are wired to a buzzer so that the operator knows that an alarm condition exists.

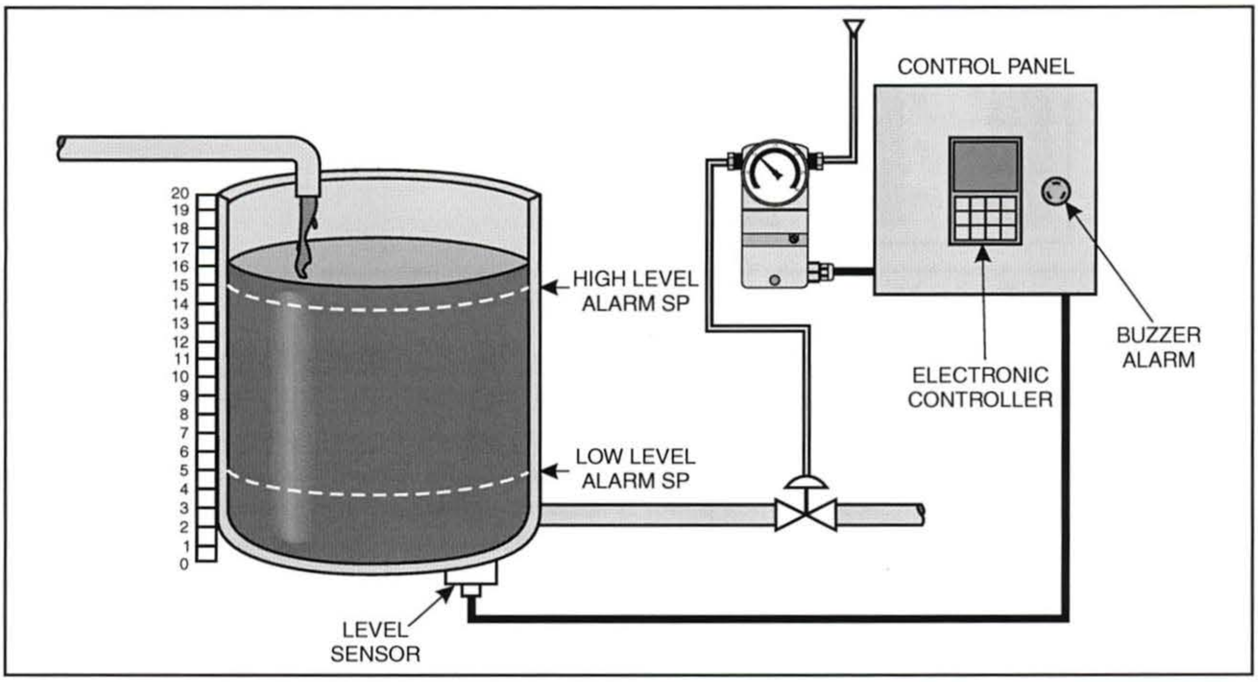

Figure 56. Level System Using Controller Alarms

Another application of controller alarms is environmental processes like wastewater treatment. For example, the alarms could be set up to trigger if the pH level of the water is too high or too low.

OBJECTIVE 9	DESCRIBE HOW TO CONNECT AND OPERATE ALARM RELAYS ON A HONEYWELL UDC 3500 CONTROLLER

Most loop controllers' alarm relays can be wired so that the contacts are either normally open or normally closed. The Honeywell UDC 3500 Honeywell controller shown in figure 57 has 3 alarm relays that can be used. Terminals 10-12 are for relay 3, terminals 13-15 are for relay 4, and terminals 16-18 are for relay 5. Figure 57 shows a buzzer wired to the N.C. contact of relay 3.

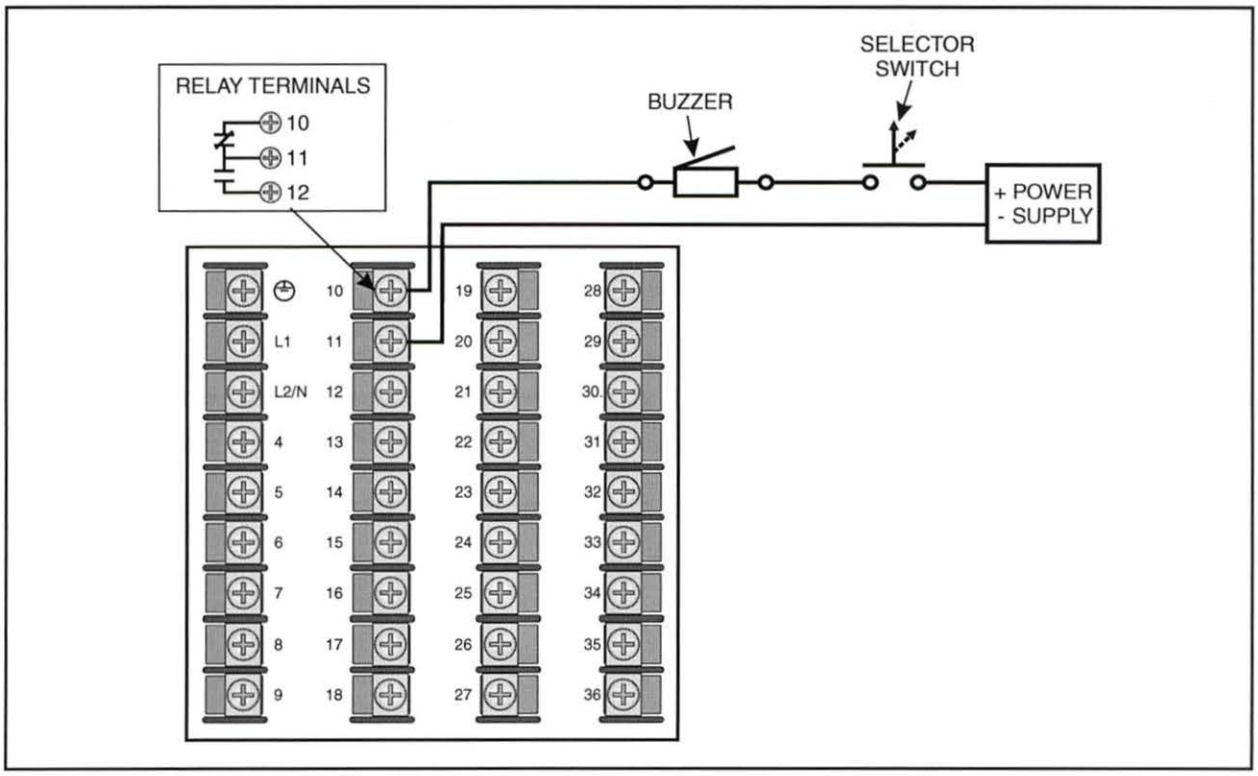

Figure 57. Buzzer Wired to Honeywell Controller Relay Terminals

All alarm relays on the Honeywell UDC 3500 are designed to operate in the failsafe mode. That means the relays are energized as long as power is applied and there are no alarm conditions. While the relays are energized, the N.O. contacts are closed and the N.C. contacts are open. When power is removed or when an alarm condition is present, the relays are de-energized and their contacts return to their normal states.

Therefore, an alarm condition causes a N.C. relay contact to close and a N.O. relay contact to open. That is why the buzzer in figure 57 is connected to the N.C. contact of the alarm relay.

The alarm parameters are in the "ALARMS" group of the setup menu. Common parameters programmed for alarms include the type of condition or event that energizes/de-energizes the contacts, the alarm state (i.e. high or low alarm), and the alarm setpoint values.

The following steps describe how to view and set the alarm parameters in a Honeywell controller:

Step 1: Enter the Setup Menu - Pressing the Setup key enters the setup menu and scrolls through the setup groups until you reach the "ALARMS" programming group.

Step 2: View/Change Parameters - Using the Func Loop 1/2 key, view the parameters in the group. Using the up ▲ and down ▼ keys, change a parameter value/setting.

Step 3: Exit the Setup Menu - Pressing the Lower Display key returns to the control display mode when all of the desired values have been set.

The Honeywell UDC 3500 Honeywell controller indicates on the display that an alarm has been programmed by lighting a number next to the "ALM" label, as shown in figure 58, when an alarm condition is sensed. The number that appears depends on the alarm number programmed. For example, if alarm 1 is selected, 1 appears on the display.

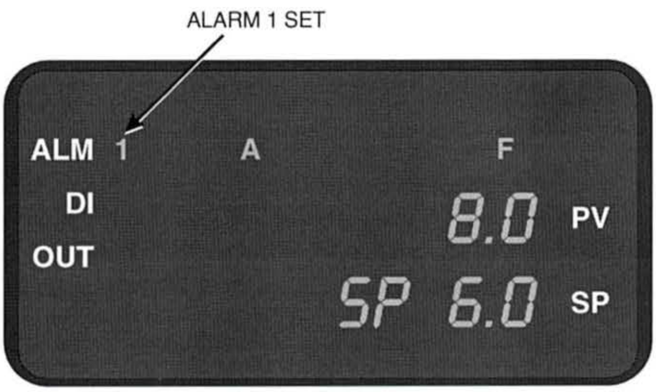

Figure 58. Alarm Set Indicator on a Honeywell Controller

The parameters that are set in the "ALARMS" group are listed in the table of figure 59. The table includes a description and definition of each parameter.

ALARMS PROGRAMMING GROUP PARAMETERS		
PARAMETER	**DESCRIPTION**	**DEFINITION**
A1S1TYPE	Alarm 1 Setpoint 1 Type	Signal or event used to trigger alarm. Could be analog input, digital input, process variable, output, etc.
A1S1 VAL	Alarm 1 Setpoint 1 Value	The value at which the alarm actuates.
A1S1 H L	Alarm 1 Setpoint 1 High/Low	Select whether the alarm is high or low.
A1S2TYPE	Alarm 1 Setpoint 2 Type	Same as A1S1TYPE.
A1S2 VAL	Alarm 1 Setpoint 2 Value	Same as A1S1 VAL.
A1S2 H L	Alarm 1 Setpoint 2 High/Low	Same as A1S1 H L.
ALHYST1	Alarm Hysteresis for Alarm 1	Sets a Hysteresis value for when the alarm deactivates. Programmed as a percentage of signal span.
A2S1TYPE	Alarm 2 Setpoint 1 Type	Same as A1S1TYPE.
A2S1 VAL	Alarm 2 Setpoint 1 Value	Same as A1S1 VAL.
A2S1 H L	Alarm 2 Setpoint 1 High/Low	Same as A1S1 H L.
A2S2TYPE	Alarm 2 Setpoint 2 Type	Same as A1S1TYPE.
A2S2VAL	Alarm 2 Setpoint 2 Value	Same as A1S1 VAL.
A2S2 H L	Alarm 2 Setpoint 2 High/Low	Same as A1S1 H L.
ALHYST2	Alarm Hysteresis for Alarm 2	Same as ALHYST1.
A3S1TYPE	Alarm 3 Setpoint 1 Type	Same as A1S1TYPE.
A3S1 VAL	Alarm 3 Setpoint 1 Value	Same as A1S1 VAL.
A3S1 H L	Alarm 3 Setpoint 1 High/Low	Same as A1S1 H L.
A3S2TYPE	Alarm 3 Setpoint 2 Type	Same as A1S1TYPE.
A3S2 VAL	Alarm 3 Setpoint 2 Value	Same as A1S1 VAL.
A3S2 H L	Alarm 3 Setpoint 2 High/Low	Same as A1S1 H L.
ALHYST3	Alarm Hysteresis for Alarm 3	Same as ALHYST1.
A4S1TYPE	Alarm 4 Setpoint 1 Type	Same as A1S1TYPE.
A4S1 VAL	Alarm 4 Setpoint 1 Value	Same as A1S1 VAL.
A4S1 H L	Alarm 4 Setpoint 1 High/Low	Same as A1S1 H L.
A4S2TYPE	Alarm 4 Setpoint 2 Type	Same as A1S1TYPE.
A4S2 VAL	Alarm 4 Setpoint 2 Value	Same as A1S1 VAL.
A4S2 H L	Alarm 4 Setpoint 2 High/Low	Same as A1S1 H L.
ALHYST4	Alarm Hysteresis for Alarm 2	Same as ALHYST1.

Figure 59. Alarms Programming Group Parameters

After the alarms have been programmed into the Honeywell controller, they are an active part of the controller's configuration. Therefore, to clear an alarm, you have to remove the alarm settings. On the Honeywell controller, you can accomplish this by setting the alarm type (i.e. A1S1TYPE) to "NONE" (i.e. the default setting). Setting it to "NONE" tells the controller that there is no alarm for that alarm parameter.

SKILL 6 CONNECT AND OPERATE ALARMS ON A HONEYWELL UDC 3500 CONTROLLER

Procedure Overview

In this procedure, you will operate a level control circuit that uses the alarm relays on the Honeywell controller to indicate when the process variable goes above and below preset high and low limits, respectively.

Do This

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5552, as shown in figure 60.

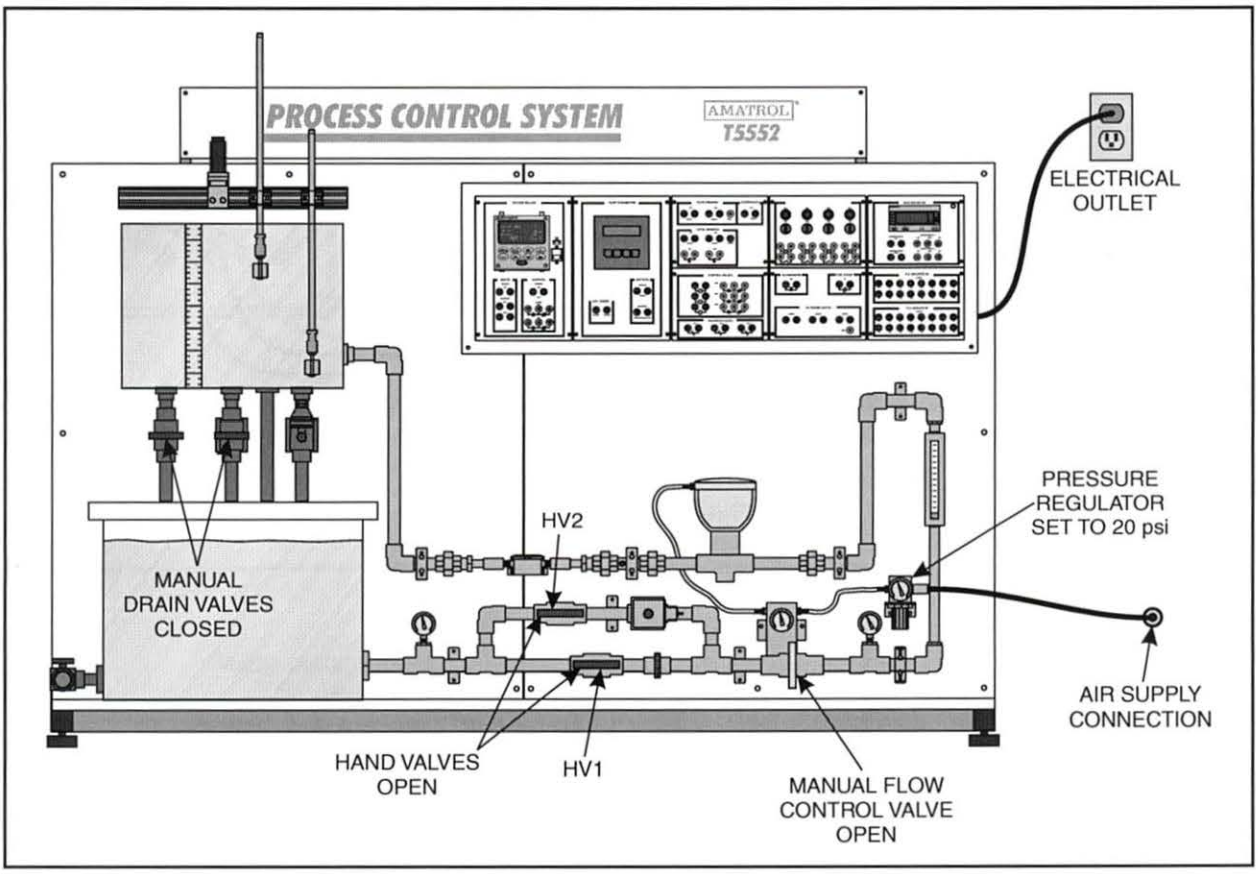

Figure 60. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator is set to 20 psi.

C. Fill the reservoir tank with water.

D. Close the two manual process tank drain valves (turned fully clockwise).

E. Close the manual flow control valve (turned fully clockwise).

F. Connect the circuit shown in figure 61.

This circuit allows you to measure, display, and control the level in the process tank. The circuit also indicates high and low level alarm conditions.

Since the alarm relays on the UDC 3500 operate in the failsafe mode, the indicator light (PL2) is connected to the N.C. contacts of the alarm relay. That means PL2 turns on (N.C. contacts closed) only when an alarm condition occurs or if power to the relay is removed. When no alarm condition is present, the N.C. contact will be in its energized state (open).

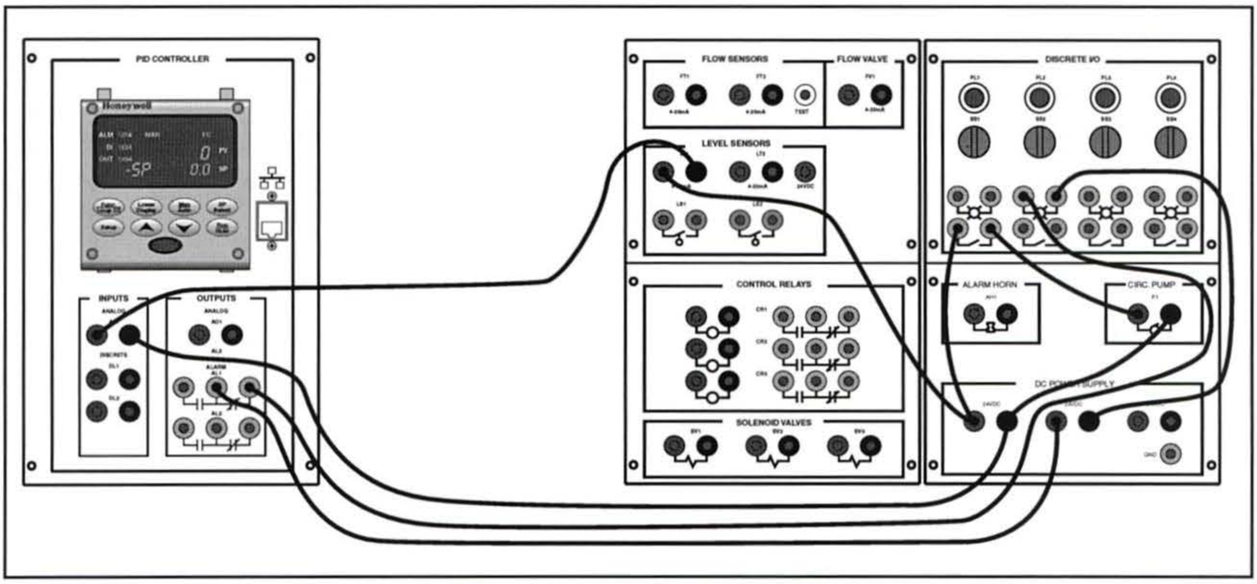

Figure 61. Level Circuit Using Controller Alarm Relays

Figure 62 shows the wiring diagram for the circuit.

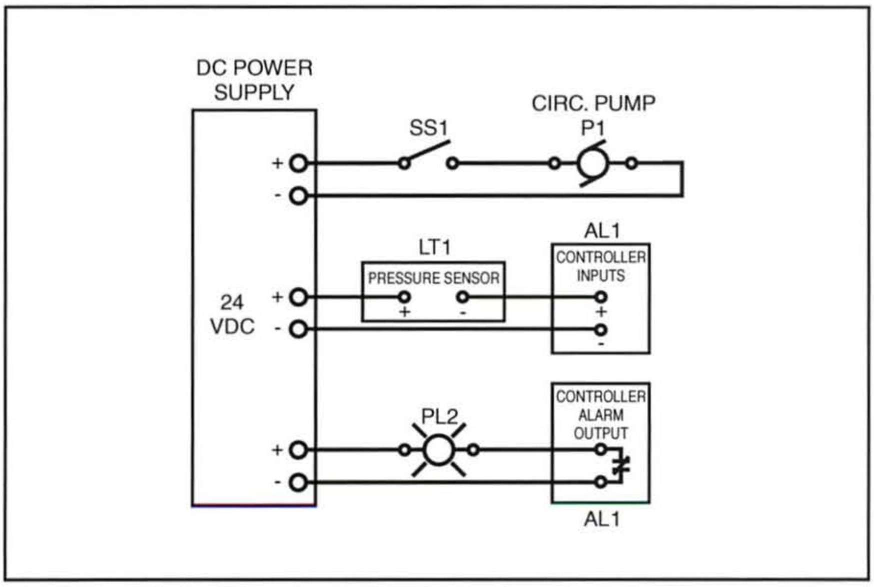

Figure 62. Wiring Diagram for Level Circuit

Figure 63 shows the P&ID for the T5552. The active components and wiring are highlighted.

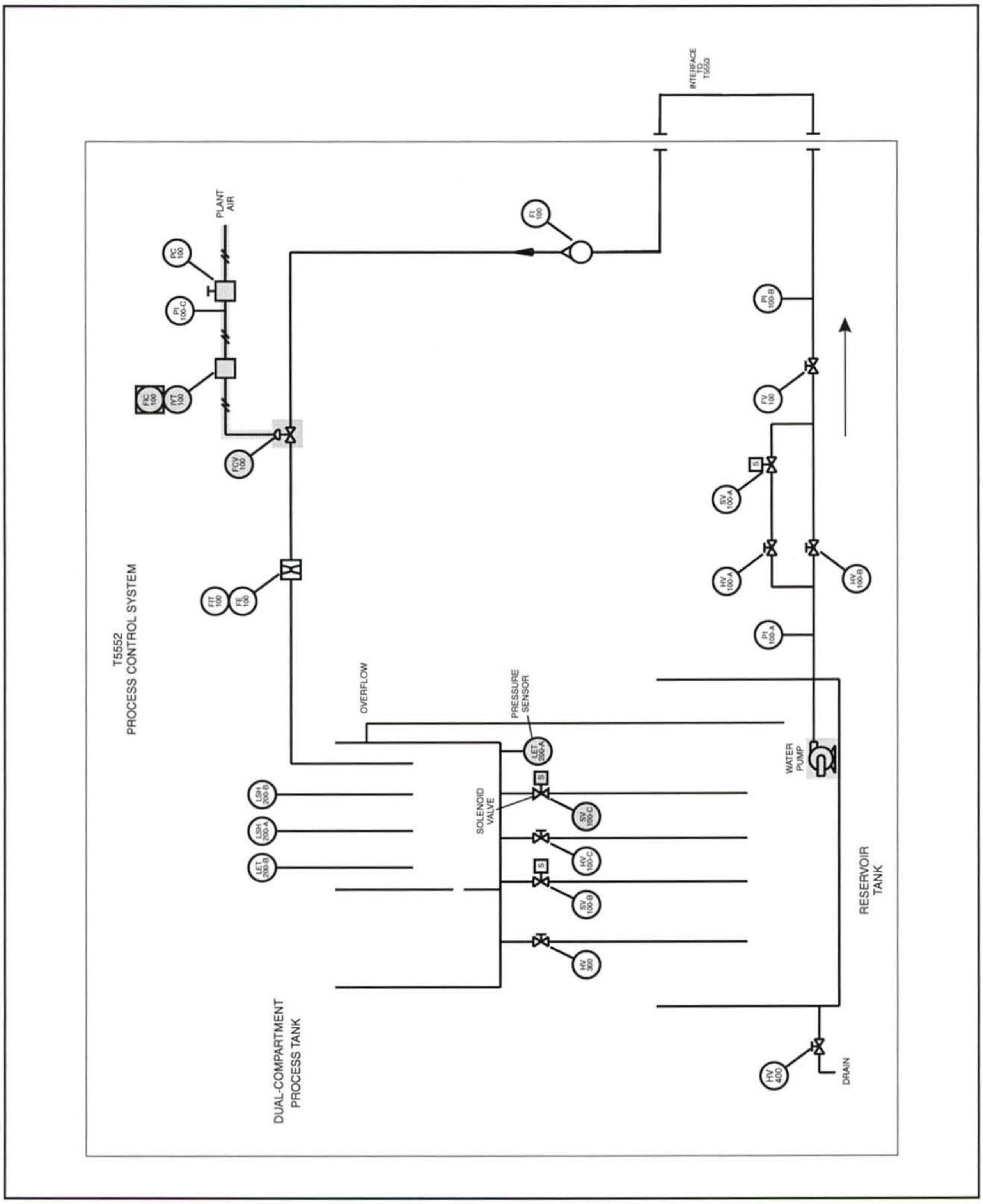

Figure 63. T5552 P&ID

- ❑ 3. Remove the lockout/tagout.
- ❑ 4. Turn on the main circuit breaker.
- ❑ 5. Perform the following substeps to set up the controller.
  - A. Place the controller in manual mode.
  - B. Press the **Setup** key to go to the setup menu.
  - C. Set the following parameters in the "INPUT 1" setup group:

NOTE

Recall that to scroll through the setup groups, press the Setup key. To scroll through the parameters in a group, press the Func Loop 1/2 key, and to change the parameter settings, press the ▲ and ▼ keys.

PARAMETER	SETTING
IN1 TYPE	1-5 V
XMITTER1	LINEAR
IN1 HIGH	27.70
IN 1 LOW	0.000
BIAS IN 1	-1.6

  - D. Set the following parameters in the "ALARMS" setup group:

PARAMETER	SETTING
A1S1TYPE	PV
A1S1 VAL	1.00
A1S1 H L	L
A1S2TYPE	PV
A1S2 VAL	5.00
A1S2 H L	H

A1S1TYPE and A1S2TYPE parameters determine the type of value that triggers the alarm. In this case, A1S1TYPE and A1S2TYPE are based on the process variable (PV).

The A1S1 VAL parameter indicates the alarm 1 setpoint 1 value, which for this application is 1.0 inch. The A1S2 VAL parameter indicates the alarm 1 setpoint 2 value, which is 5.0 inches for this application.

The parameters A1S1 H L and A1S2 H L indicate whether the alarm is high (H) or low (L). Therefore, A1S1 is a low alarm and A1S2 is a high alarm.

E. Press the **Lower Display** key to return to the control display mode.

F. Make sure the output is displayed on the controller. If it is not, press the **Lower Display** key until "OUT" is displayed.

G. Determine if the alarm indicator light is on. Also, determine if the alarm indicator is present on the display of the controller.

Is the Alarm Indicator On? ______________________ (Yes/No)

Is the alarm indicator present on the controller display? ____________________________(Yes/No)

You should find that the indicator light (PL2) is on and the alarm indicator (3) appears on the controller display.

H. If the alarm indicator light is on, determine which level condition triggered the alarm.

Level Condition _________________ (High Level/Low Level)

The level is below the 1-inch mark in the tank. Therefore, a low level condition exists.

❑ 6. Fully open the manual flow control valve (counterclockwise).

❑ 7. Turn on selector switch **SS1** to start the pump and allow the tank to fill above the 1-inch mark.

❑ 8. When the level rises above the 1-inch mark, fully close the manual flow control valve.

❑ 9. Determine if the alarm indicator light (PL2) stays on and the alarm indicator remains.

Does the Alarm Indicator Light Stay On? ____________ (Yes/No)

Does the alarm indicator on the controller display remain?__________________________(Yes/No)

You should find that the alarm indicator light does not stay on nor does the alarm indicator remain after the level rises above 1-inch because it is in the operation range (1-5 inches).

With no alarm condition present, the alarm relay contacts are in their energized states. That means the N.C. contact is open.

❑10. Open the manual flow control valve and allow the tank to fill until the level is above the 5-inch mark.

❑11. When the level is above 5 inches, close the manual flow control valve.

❑12. Check the alarm indicator light and display indicator again.

Is the alarm indicator light on? ______________________(Yes/No)

Is the alarm indicator present on
the controller display? ______________________________(Yes/No)

You should find that the indicator light is on and the alarm indicator appears because the level is above the high level alarm setpoint (5 inches).

❑13. Repeat steps 5D - 12. Set the A1S1 VAL parameter to **3.000** and the A1S2 VAL parameter to **8.000.**

You should find that the indicator light turns on (alarm indicator appears) when the level is either less than 3.0 inches or greater than 8.000 inches.

❑14. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS1** to stop the circulation pump.

B. Open both manual process tank drain valves to drain the tank. When the tank is empty, close the valves.

C. Turn off the main circuit breaker.

D. Disconnect the circuit.

OBJECTIVE 10 DESCRIBE THE FUNCTION OF LOOP CONTROLLER DISCRETE INPUTS AND GIVE AN APPLICATION

Read This

Many loop controllers have discrete (digital) inputs to which input devices such as selector switches, proximity switches, and pushbuttons can be wired. When connected and programmed, the discrete inputs cause the controller to perform certain functions. For example, the controller could be set up to change from automatic control to manual control when the discrete input contacts close. Other common applications include changing from one local setpoint to another, changing from a local setpoint to a remote setpoint, starting or stopping a setpoint program, and starting a timer.

Figure 64 shows an example of a level system that uses the discrete input of a loop controller that is remotely located. The discrete input is wired to a pushbutton at the local operator station. Therefore, the operator can switch between two setpoints from the operator station by pressing a pushbutton.

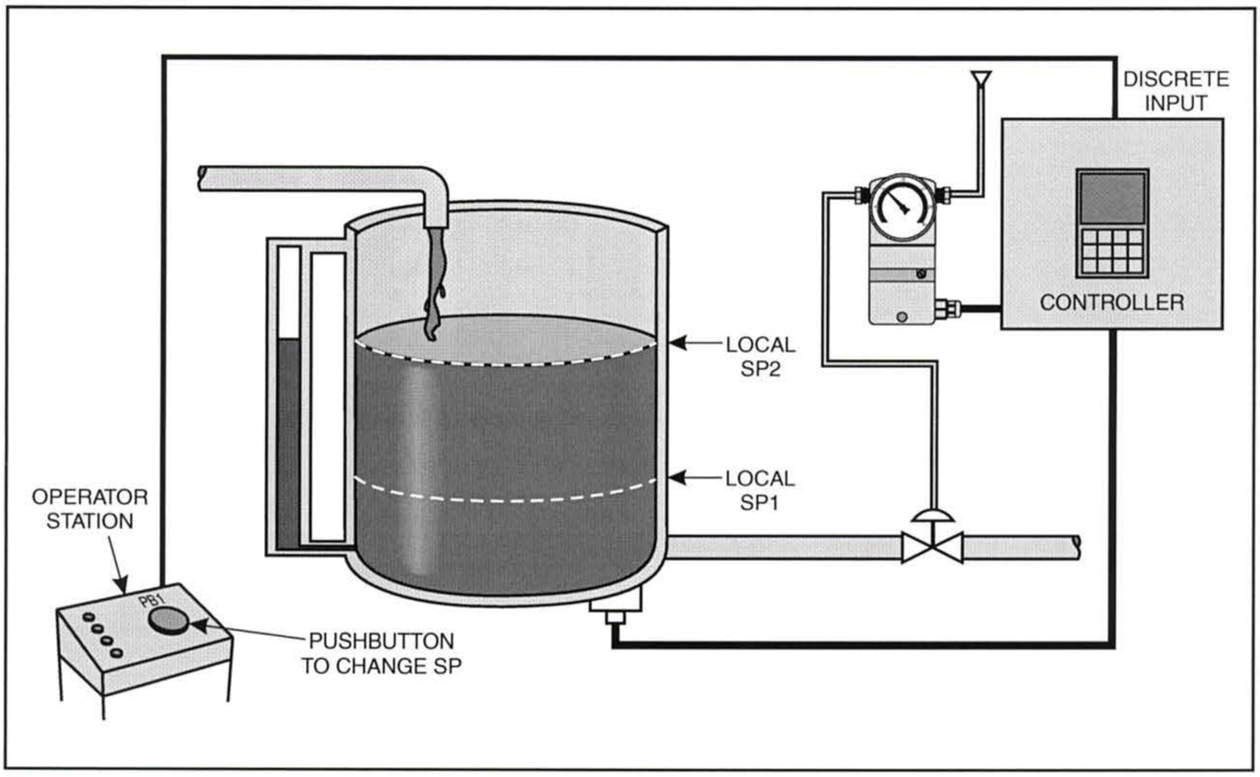

Figure 64. Loop Controller Discrete Input Used in a Level System

OBJECTIVE 11	DESCRIBE HOW TO CONFIGURE AND OPERATE THE DISCRETE INPUTS ON A HONEYWELL UDC 3500

Read This

The UDC 3500 has four discrete inputs that can be wired to discrete input switches. These inputs are located on the back of the controller at terminals 19-22. Terminal 23 is a common for the four inputs. The inputs only require a contact closure, which connects the input to the common at terminal 23.

When the contacts of an input device connected to the controller's discrete input close, the controller senses the closure and performs the programmed function. Figure 65 shows an example of a wiring diagram for discrete inputs on a Honeywell controller. The input device is connected between the common (23) and input 1 (19).

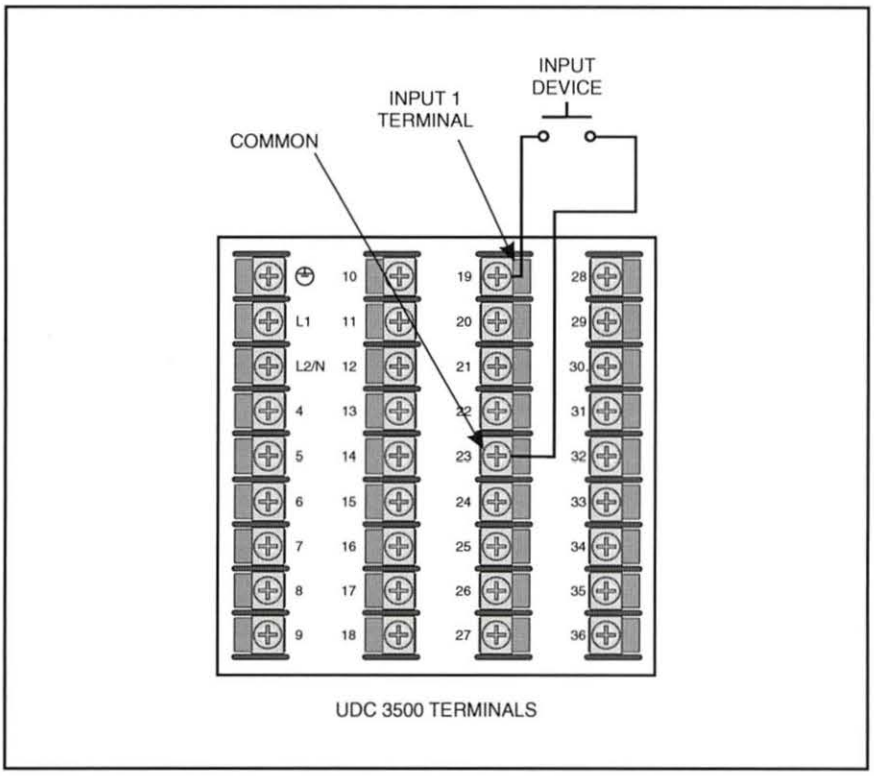

Figure 65. Discrete Input Wiring Diagram

The discrete input parameters for the Honeywell controller are located in the "OPTIONS" group of the setup menu. The controller's discrete inputs are contact closure. Therefore, the only parameter that needs to be set is the action that the controller should take when the input device causes the contacts to close.

The following steps describe how to view and set the discrete input parameters in a Honeywell controller:

Step 1: Enter the Setup Menu - Pressing the Setup key enters the setup menu and scrolls through the setup groups until you reach the "OPTIONS" group.

Step 2: View/Set the Parameters - Pressing the Func Loop 1/2 key allows viewing of all the parameters in the group. Pressing the up ▲ and down ▼ keys changes a parameter value/setting.

The discrete input parameters are listed as:

DIG INP1 (Digital Input 1)
DIG1 COMB (Digital Input 1 Combination)
DIG INP2 (Digital Input 2)
DIG2 COMB (Digital Input 2 Combination)
DIG INP3 (Digital Input 3)
DIG3 COMB (Digital Input 3 Combination)
DIG INP4 (Digital Input 4)
DIG4 COMB (Digital Input 4 Combination)

The combinations parameters force multiple actions when the discrete input is active. For example, if the parameter DIG1 INP is set to "To LOCK" and DIG1 COMB is set to "+SP2", then the controller locks all of the keys and switches to the second local setpoint when the input becomes active.

Step 3: Exit the Setup Menu - Pressing the Lower Display key returns to the control display mode when all of the desired actions have been set.

The Honeywell controller indicates on the display that a discrete input is active. Figure 66 shows discrete input 1 is active. If inputs 1 and 2 are active, 1 and 2 appear on the display.

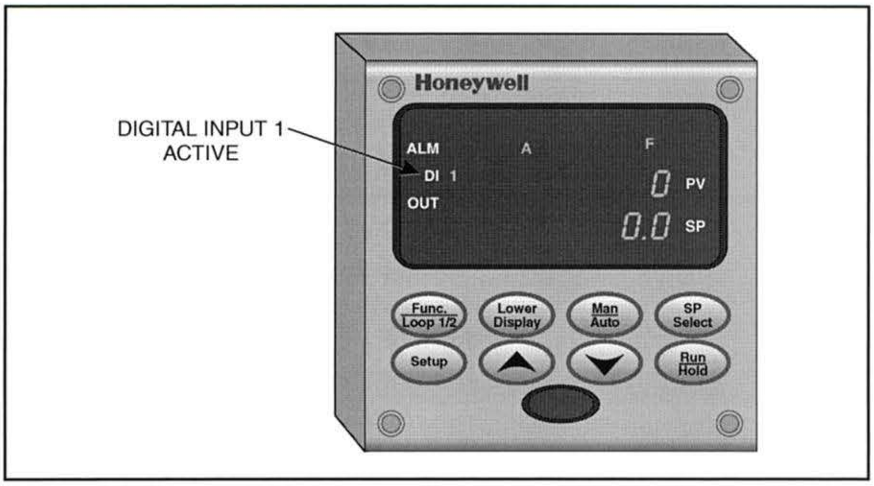

Figure 66. Discrete Input Active Indicator on a Honeywell Controller

After the discrete inputs have been programmed into the Honeywell controller, they are an active part of the controller's configuration. Therefore, to clear a discrete input, you have to remove the settings. On the Honeywell controller, you can accomplish this by setting the parameters "DIG INP1" to NONE and "DIG1 COMB" to DISABL (i.e. the default setting).

SKILL 7	CONNECT AND OPERATE DISCRETE INPUTS ON A HONEYWELL UDC 3500 CONTROLLER

Procedure Overview

In this procedure, you will connect a level control circuit that uses the controller's discrete inputs to switch from one setpoint to a different setpoint.

❑ 1. Perform a lockout/tagout.

❑ 2. Perform the following substeps to set up the T5552, as shown in figure 67.

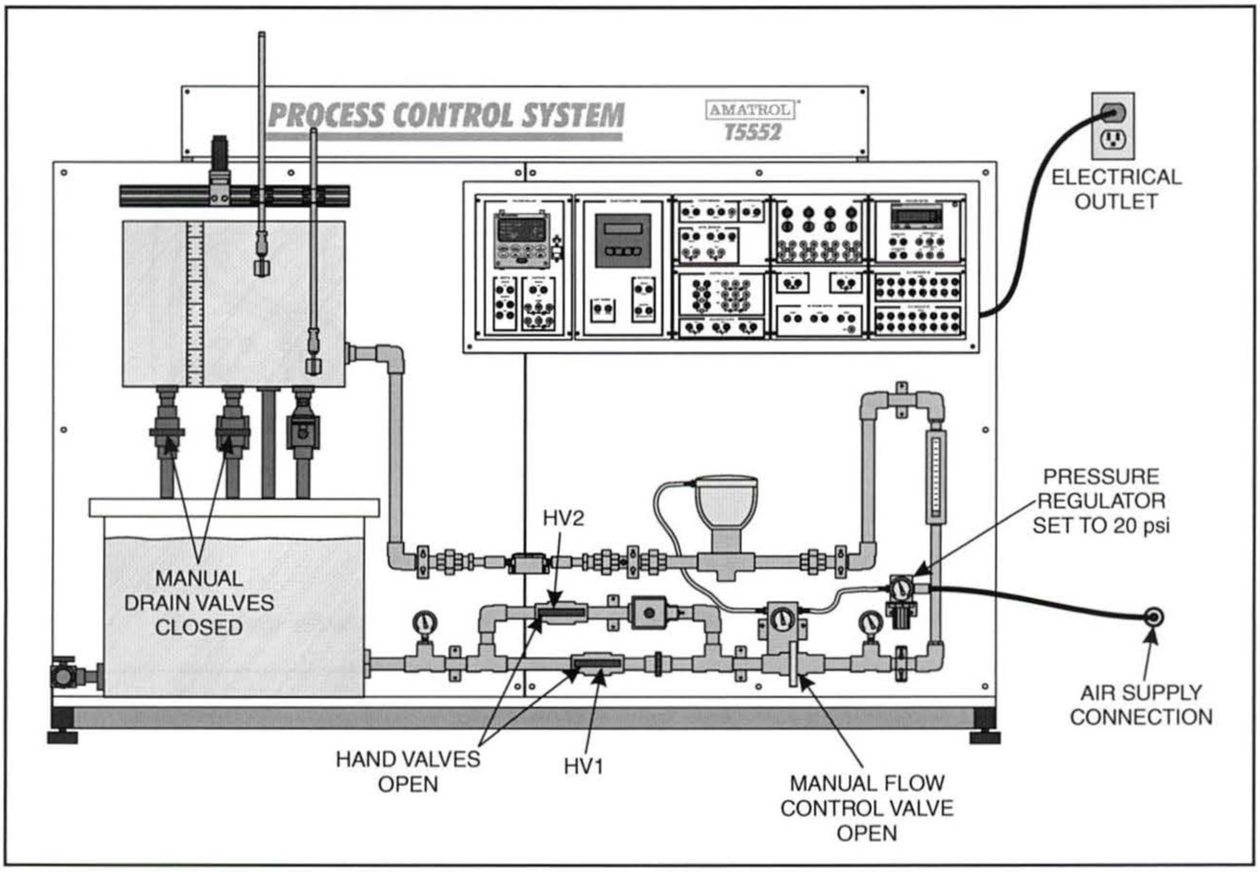

Figure 67. T5552 Setup

A. Connect the air supply line to the T5552.

B. Set the pressure regulator to 20 psi.

C. Fill the reservoir tank with water.

D. Close (turn fully clockwise) the two manual process tank drain valves.

E. Close (turn fully clockwise) the manual flow control valve.

CAUTION

The discrete inputs on the Honeywell controller are contact closure. Therefore, you should never send a voltage to these inputs. Doing so will damage the controller.

F. Connect the circuit shown in figure 68.

This circuit allows you to measure, display, and control the level in the process tank. This circuit also allows you to switch between different setpoints using the controller's discrete inputs.

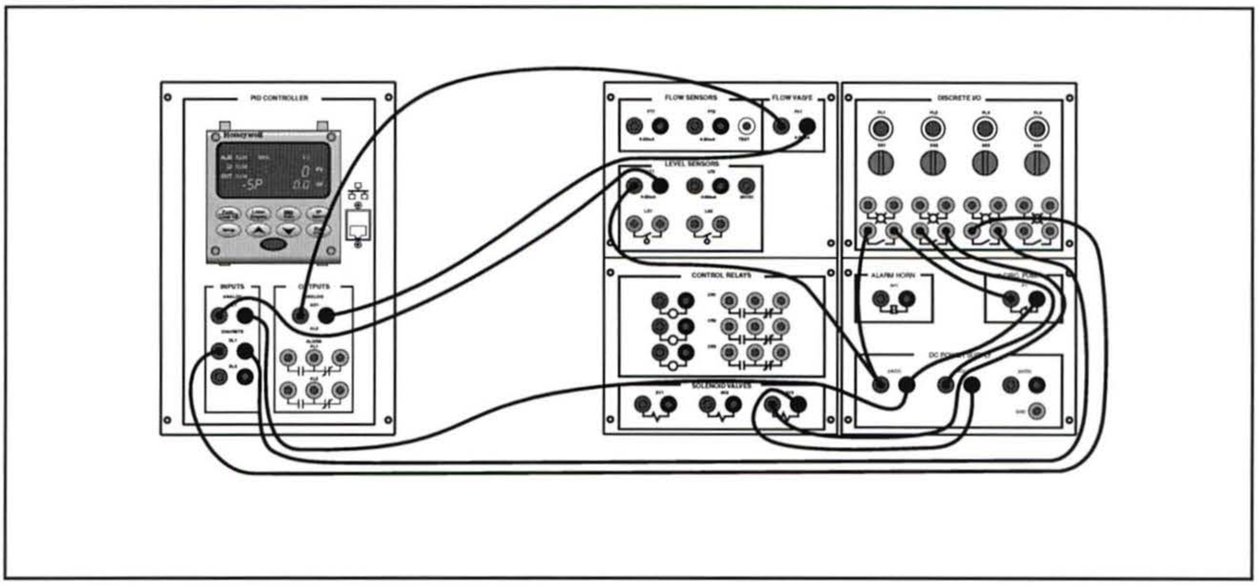

Figure 68. Level Control Circuit with Discrete Inputs

Figure 69 shows the wiring diagram for the circuit.

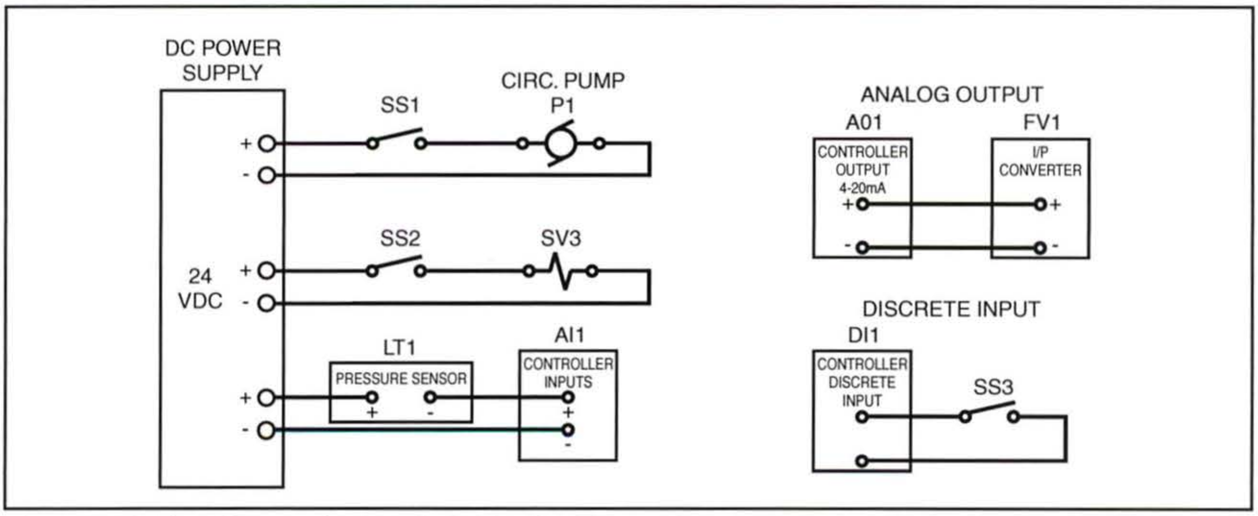

Figure 69. Wiring Diagram for Level Circuit with Discrete Inputs

Figure 70 shows the P&ID for the T5552. The active components and wiring are highlighted.

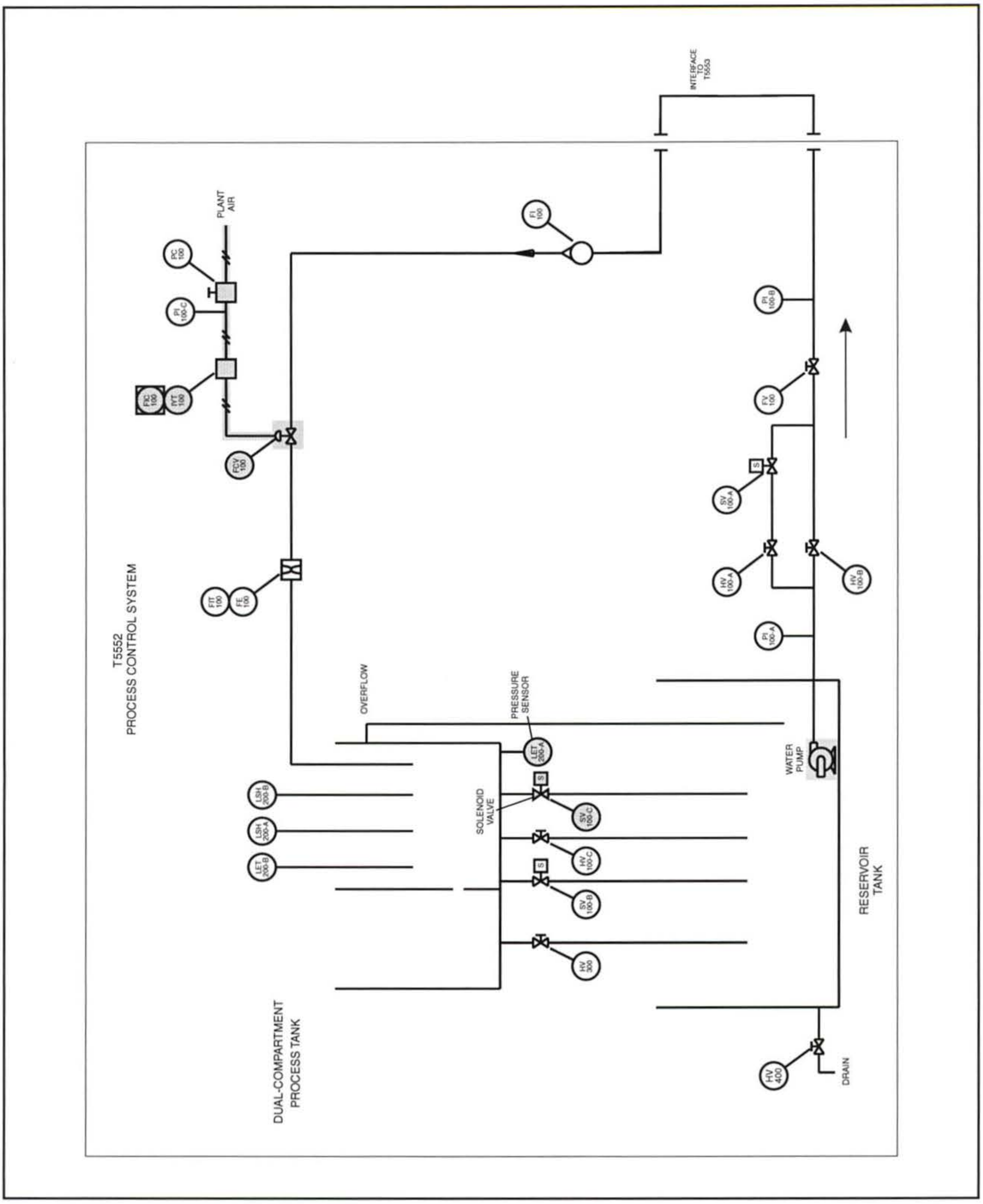

Figure 70. T5552 P&ID

❑ 3. Remove lockout/tagout.

❑ 4. Turn on the main circuit breaker.

❑ 5. Perform the following substeps to set up the controller

A. Place the controller in manual mode.

B. Press the **Setup** key to go to the setup menu.

> **NOTE**
>
> Recall that to scroll through the setup groups, press the Setup key. To scroll through the parameters in a group, press the Func Loop 1/2 key, and to change the parameter settings, press the up ▲ and down ▼ keys.

C. Set the following parameters in the "INPUT 1" group:

PARAMETER	SETTING
IN1 TYPE	1-5 V
XMITTER1	LINEAR
IN1 HIGH	27.70
IN1 LOW	0.000
BIAS IN1	-1.6

D. Press the **Setup** key repeatedly until you reach the "CONTROL" group.

E. Press the **Func Loop 1/2** key repeatedly until you reach the "LSP's" parameter.

This is the local setpoints parameter.

F. Use the up ▲ and down ▼ keys to set this parameter to **TWO**. This allows you to program 2 local setpoints into the controller.

G. In the "OPTIONS" group, set parameter "DIG INP1" to "TO 2SP."

This tells the controller to change from local setpoint 1 to local setpoint 2 when the contact closes. The controller switches back to the original setpoint (SP) when the contact opens.

H. Press the **Lower Display** key to return to the control display mode.

I. Use the **Lower Display** key to display the SP value.

J. Use the up ▲ and down ▼ keys to set the SP value to **3.00**.

K. Use the **Lower Display** key to display the 2SP value.

L. Use the up ▲ and down ▼ keys to set the 2SP value to **5.00**.

M. Press the **Man/Auto** key to place the controller in automatic mode.

❑ 6. Perform the following substeps to operate the circuit.

A. Fully open (counterclockwise) the manual flow control valve.

B. Turn on selector switch **SS2** to energize the solenoid drain valve.

C. Turn on selector switch **SS1** to start the pump.

Water should begin to fill the process tank. When the level reaches the 3-inch mark, the controller begins to adjust its output to maintain the level at this point.

NOTE

This may take a couple of minutes since the controller may not be properly tuned (i.e. programmed).

D. After the level stabilizes at 3 inches, turn on selector switch **SS3** to actuate the discrete input (DI1).

E. Determine if the level in the process tank changes.

Does the level change_________________________(Yes/No)

You should find that the level in the tank begins to rise to the second setpoint (5.0 inches). You should also notice a "1" next to the DI label on the display panel indicating that digital input 1 is active, as shown in figure 71.

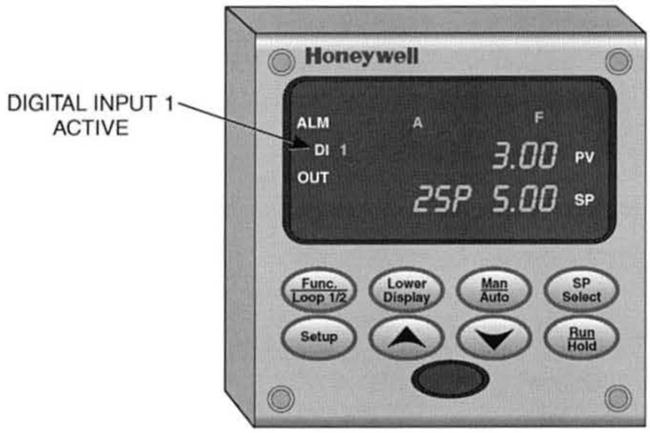

Figure 71. Discrete Input Active Indicator on a Honeywell Controller

F. After the level stabilizes at the second setpoint (5.00), turn off selector switch **SS3** to deactivate the discrete input.

G. Determine if the level changes.

Does the level change?__________________________(Yes/No)

You should find that the level in the tank begins to decrease to the original setpoint (3.0 inches). You should also notice that the "1" no longer appears next to the DI label on the display, indicating that the discrete input is not active.

❑ 7. Perform the following substeps to shut down the T5552.

A. Turn off selector switch **SS1** to stop the circulation pump.

B. Fully close (clockwise) the manual flow control valve.

C. Open both manual hand drain valves to drain the process tank. When the tank is completely drained, close the valves.

D. Turn off the main circuit breaker.

E. Disconnect the circuit.

SEGMENT 4

SELF REVIEW

1. Most controllers have ___________ that function as alarms.

2. The discrete inputs of loop controllers function when the discrete device contacts _____________.

3. Common parameters programmed for alarms include the alarm setpoints, the condition that energizes/de-energizes the contacts, and the alarm _____________.

4. A discrete input can be used to change from one local _____________ to another.

5. When the contacts of an input device connected to the controller's discrete input close, the controller senses the closure and performs the ____________.

6. To ________ an alarm, you have to remove the settings.