Modulating System Basics

The **technician's guide** to modulating systems based on the Honeywell MODUTROL IV®

- How modulating systems work
- How to test for failures
- Problem diagnosis checklist

Modulating System Basics

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Introduction

I was installing a modulating motor for a new burner control system but I was having trouble. I followed everything in the manufacturer's manual in careful detail. But when I turned the motor on, nothing would happen.

I checked and rechecked my work. Am I screwing up? I wondered. Or is it the manuals? The manufacturer's support people couldn't help. All they could do was read back to me the same documentation I was already looking at.

Then I realized that the only way I could solve this problem was if I learned exactly how the modulating system works.

So, I built a modulating system.

First, I connected the motor and a rheostat for basic operation and got that working. Then I added in more components in stages for increasing levels of operation.

Along the way, I discovered exactly where the error was in the manufacturer's manual. And as a bonus, I learned a ton about diagnosing and fixing problems with modulating motors.

Building a modulating system from scratch has made me faster and smarter on service calls.

And it can do the same for you—only you don't have to build a system yourself.

In this book are the schematics, notes, and photos of what I did to the build and test a working system. I suggest you walk through it step by step without skipping a thing. Then when you get to your next service call, you'll find yourself more confident and faster at diagnosing problems with modulating motors.

To get the most of this guide, keep it with your tools. The handy problem diagnosis chart on the back could save your day.

Chris Benedict

Contents

Components of a Modulating System

Here are the components used in the building of a modulating system.

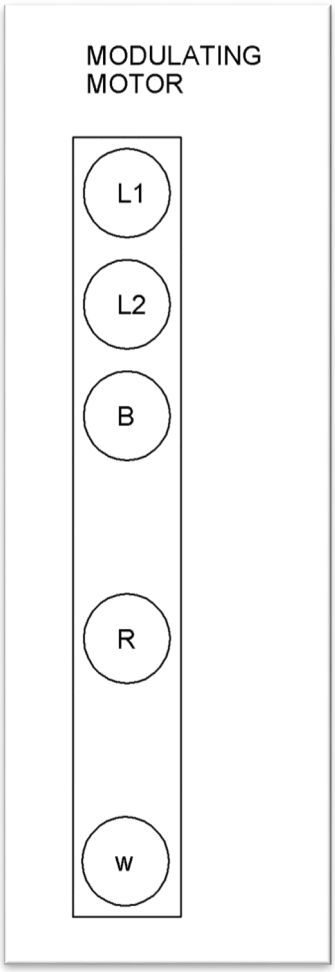
Honeywell modulating motor

Figure 1

MODULTROL IV® Motor series 90

24 volts or 120 volts with transformer

Shown with transformer installed



Honeywell pressure transducer

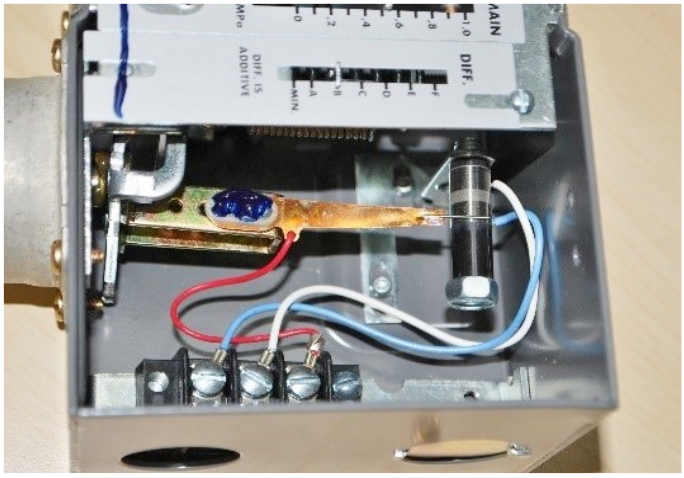
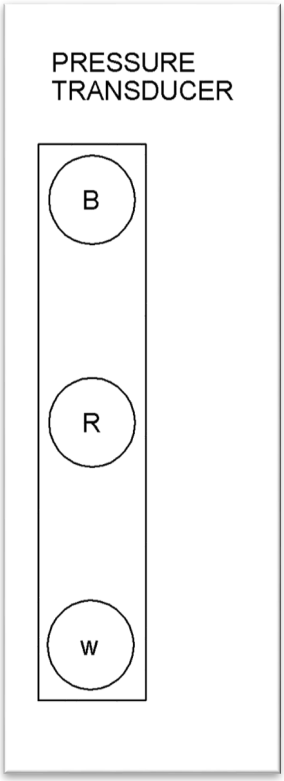


Figure 2 and 3

PRESSURETROL® (0 to 150 PSI model shown)



Flame Safety Relay

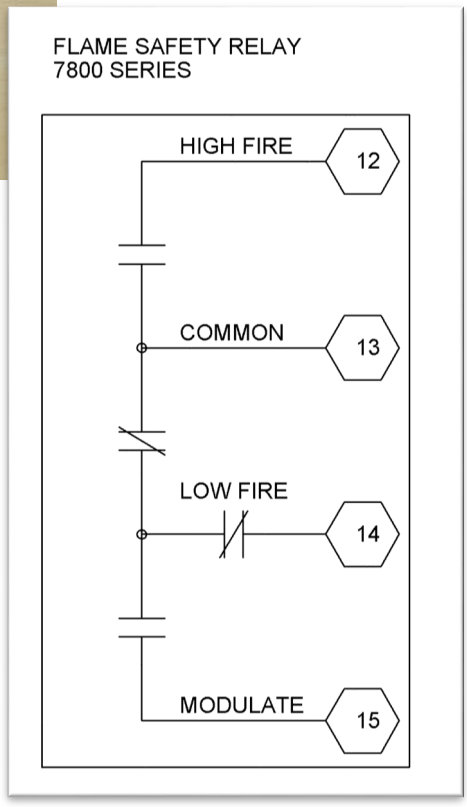
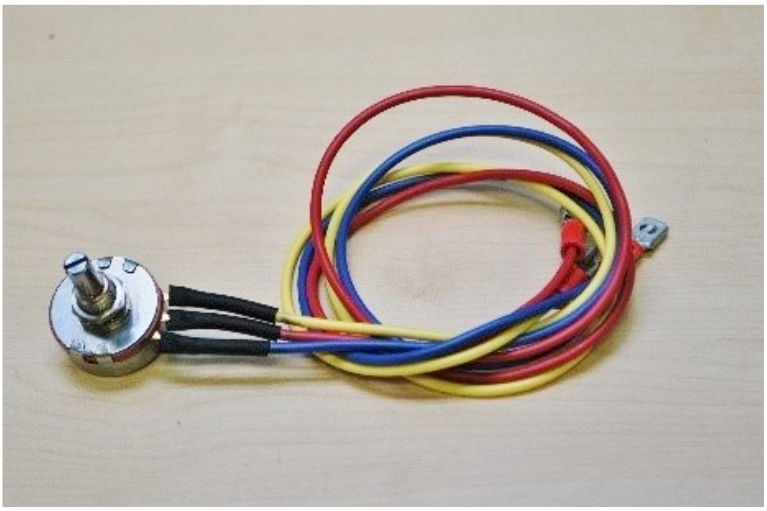


Figure 4

Honeywell flame safety relay and base (7800 series programmer)

Off the shelf 150 Ohm, 1 watt potentiometer (rheostat)



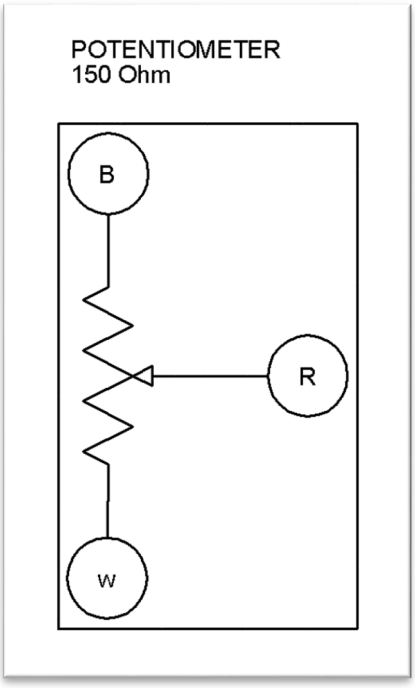


Figure 5

For manual control of the modulating motor

Manual / Auto toggle switch.

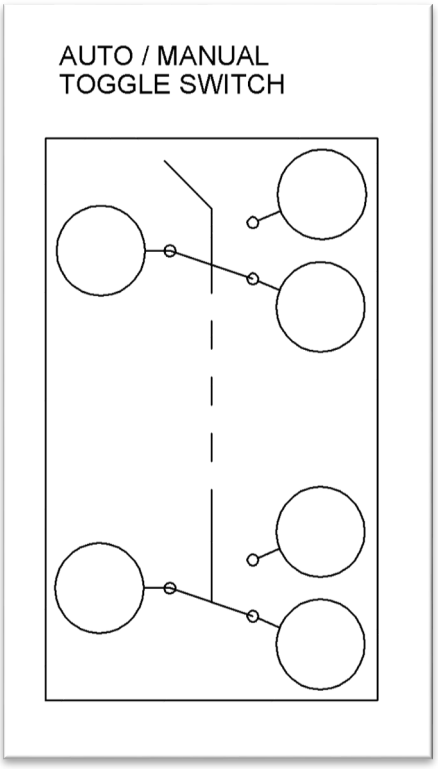


Figure 6

Two pole single throw

15Amp 120 volt

Controlling the Modulating Motor

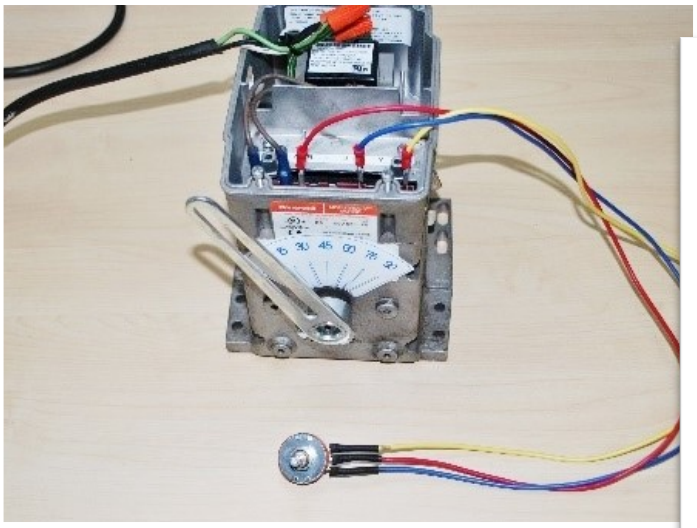
The modulating motor on a full modulating burner is controlled either automatically by the pressure transducer or manually by the potentiometer (rheostat).

It is both opened and closed and allowed to modulate by the flame safety relay.

In this section, we will learn how it works by understanding the mechanism of the basic system and adding each of the components in stages.

Basic System

The most basic of systems is the combination of a modulating motor and a rheostat. As the rheostat is moved through its sweep, the modulating motor works directly.



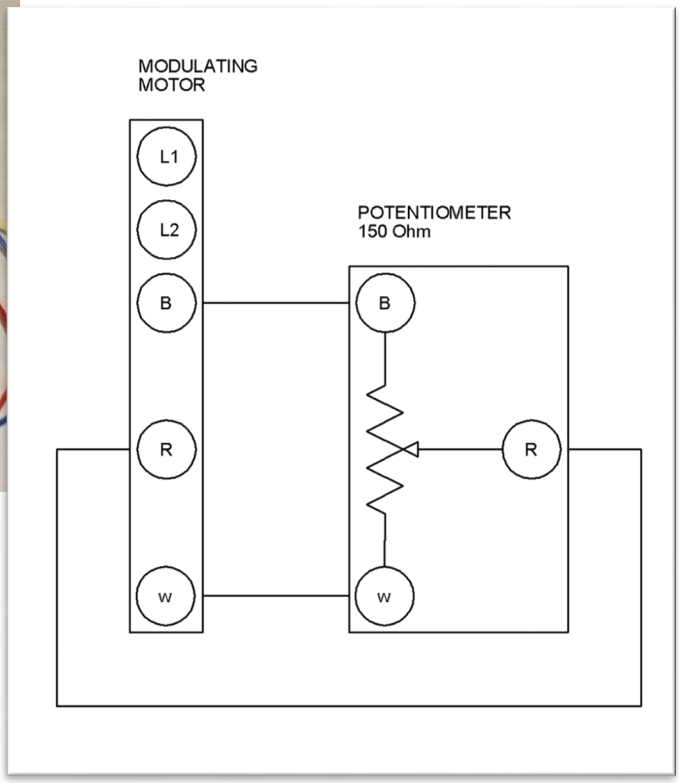


Figure 7

The modulating motor is attached to a 120 volt supply. Three wires run from the R, B, and W to the rheostat.

But having an operator move the modulating motor manually would be limiting.

The solution is to replace the potentiometer with an operating control—like a pressure transducer.

Add Operating Control

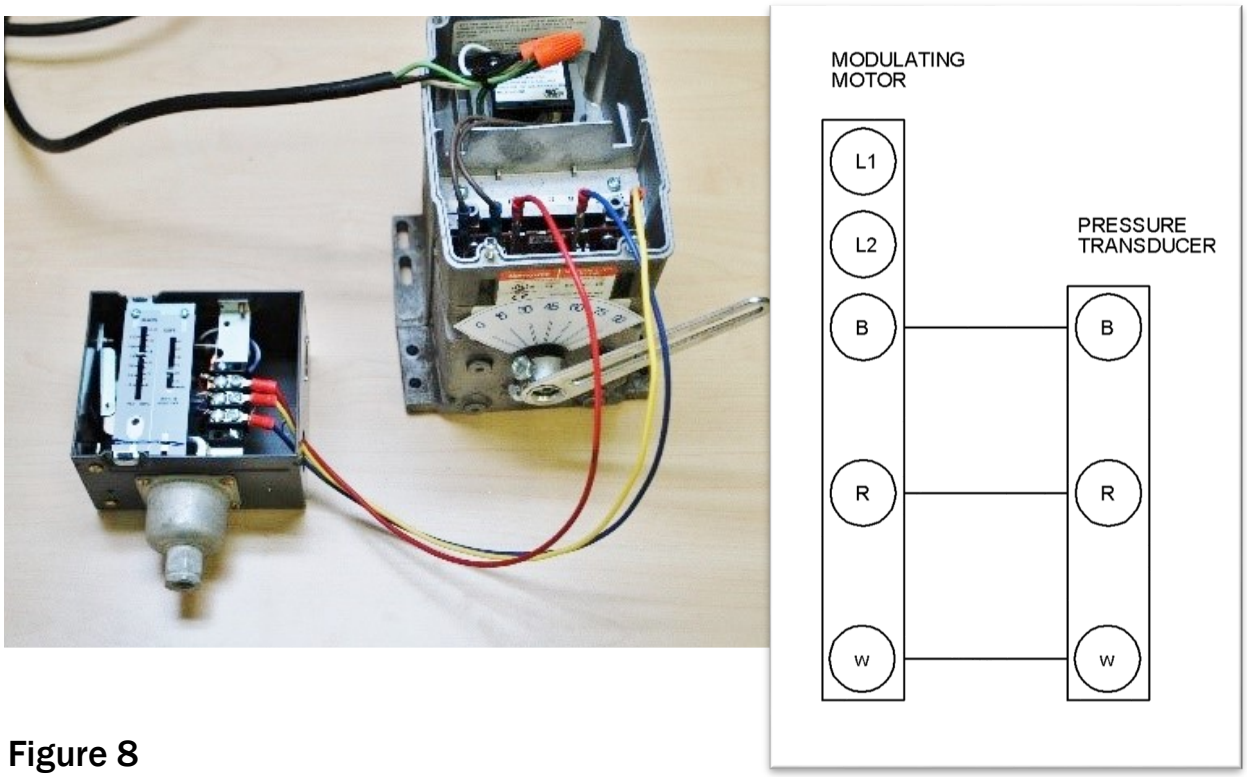


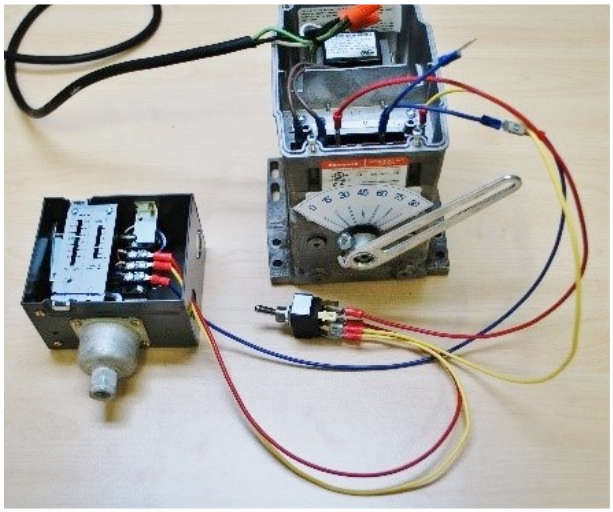
Figure 8

The pressure transducer is added using the same wires as before.

The modulating motor is still attached to 120 volt supply, and three wires run from the pressure transducer to the modulating motor.

Both a rheostat and a pressure transducer can be used to set the position of the modulating motor with the addition of a two pole single throw switch. There is no need to disconnect all three wires, only two at a time.

The blue wire is left connected.



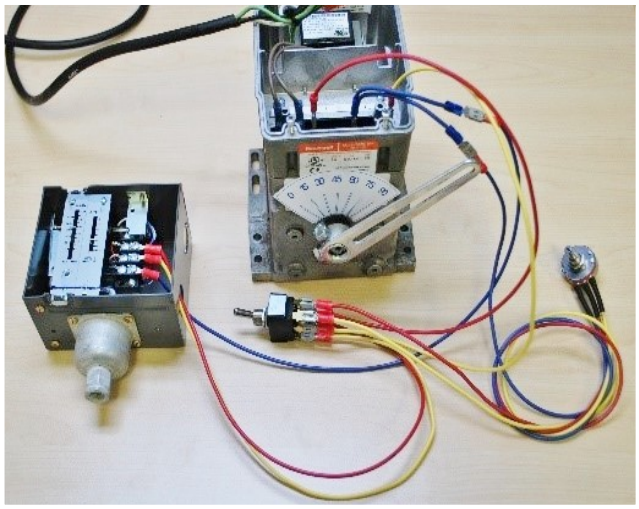
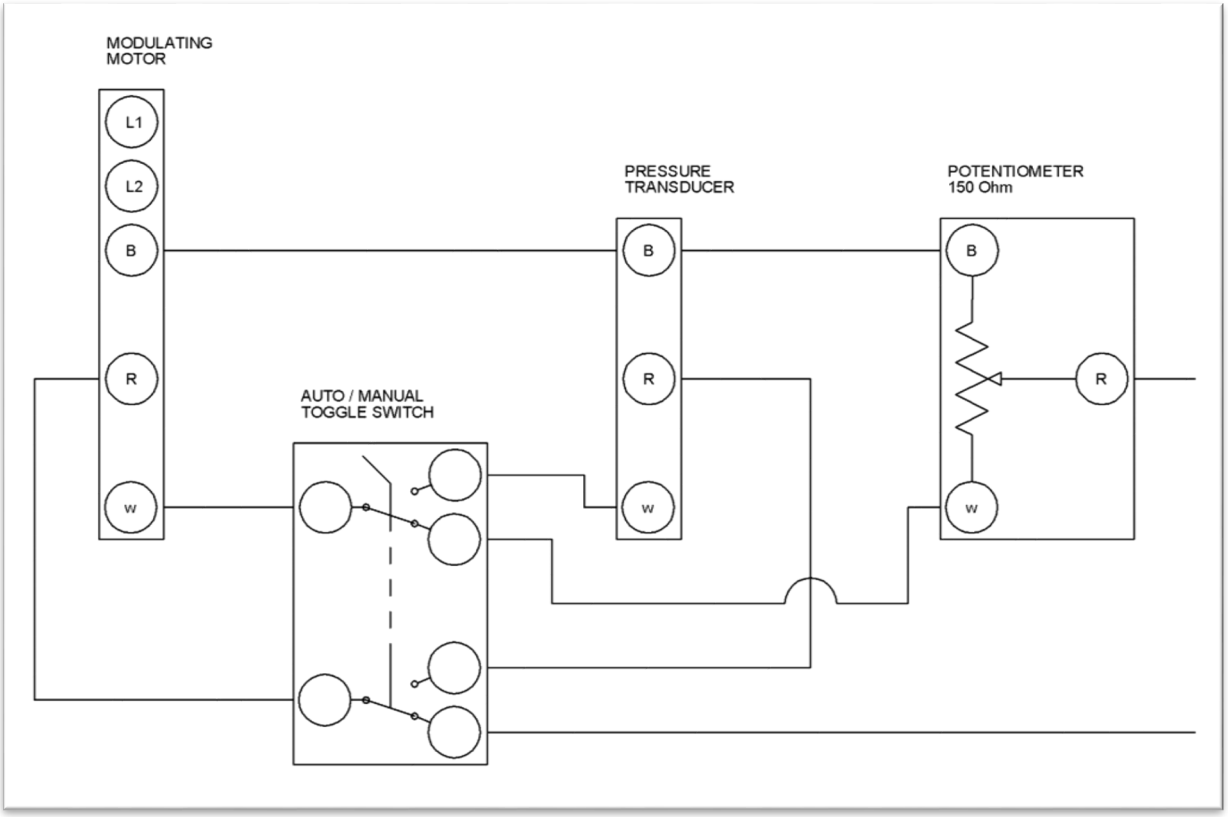


Figure 9 and 10



This combination allows for both an automatic and a manual control of the modulating motor.

But this combination does not ensure the air damper is open during a pre-purge or that the damper is closed for proper light off in low fire.

For that we need to add the flame safety relay.

Add Flame Safety Relay

Go back a step, to only one controller—the pressure transducer.

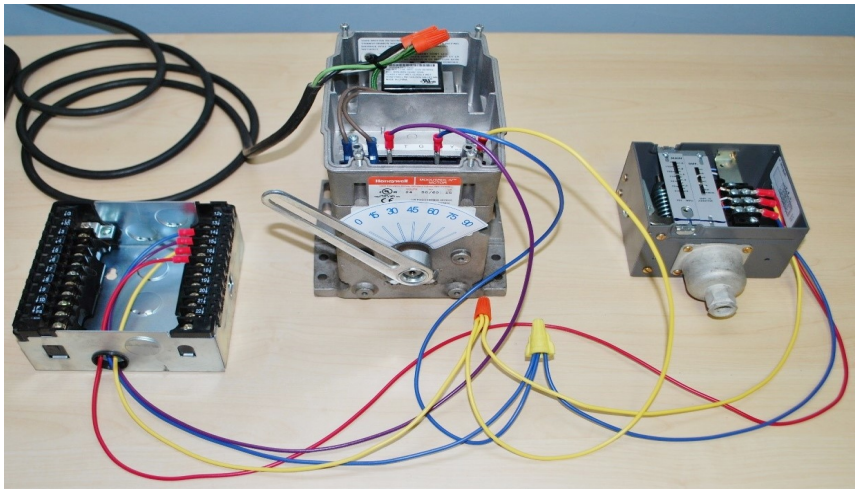
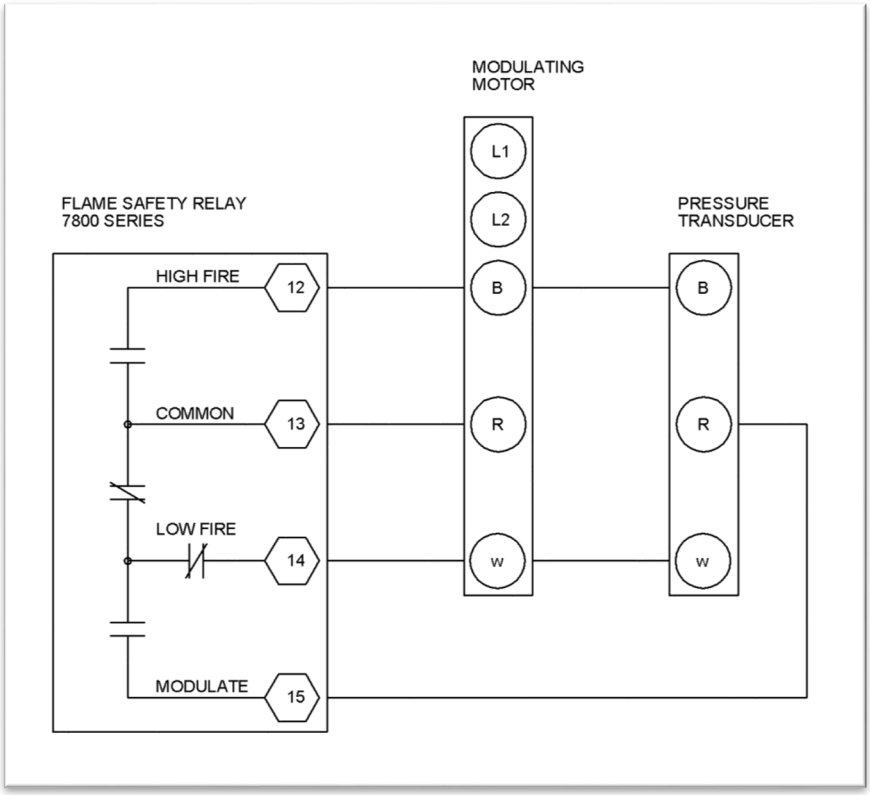


Figure 11

The safety relay interrupts the signal from the red wire of the pressure transducer, and is wired in parallel with the yellow and the blue.

This allows the safety relay to command three actions:

1. Close the modulating motor
2. Open the modulating motor
3. Allow the signal from the pressure transducer to pass through to the modulating motor.



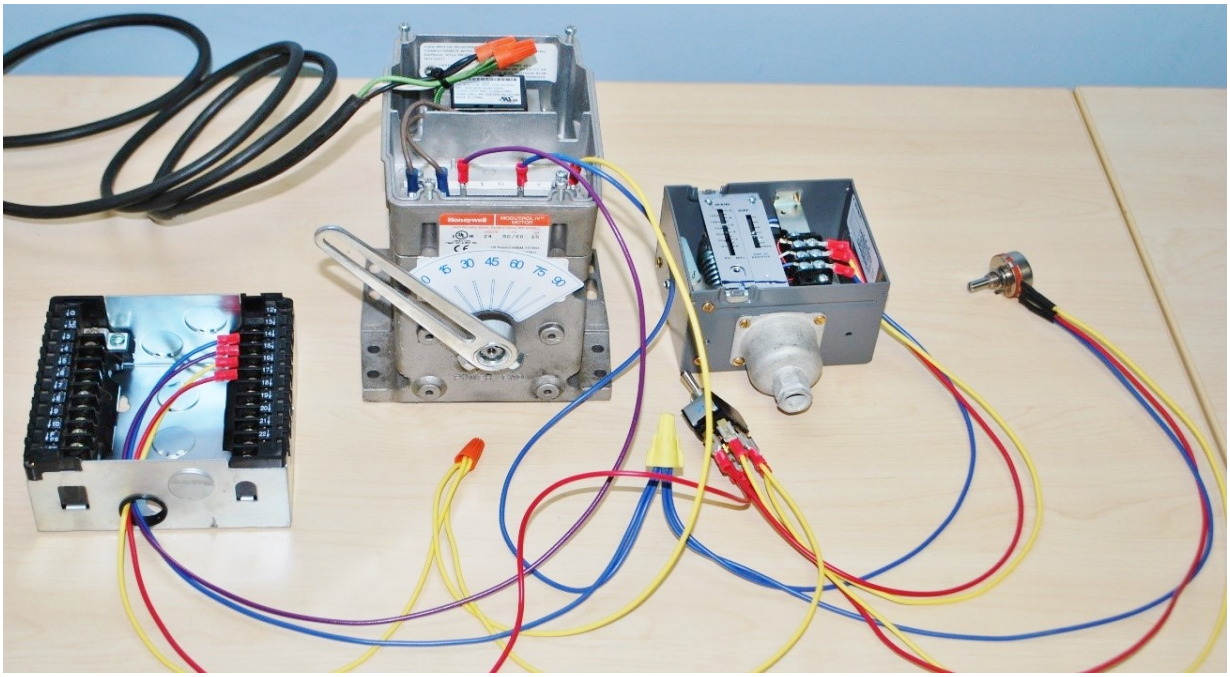
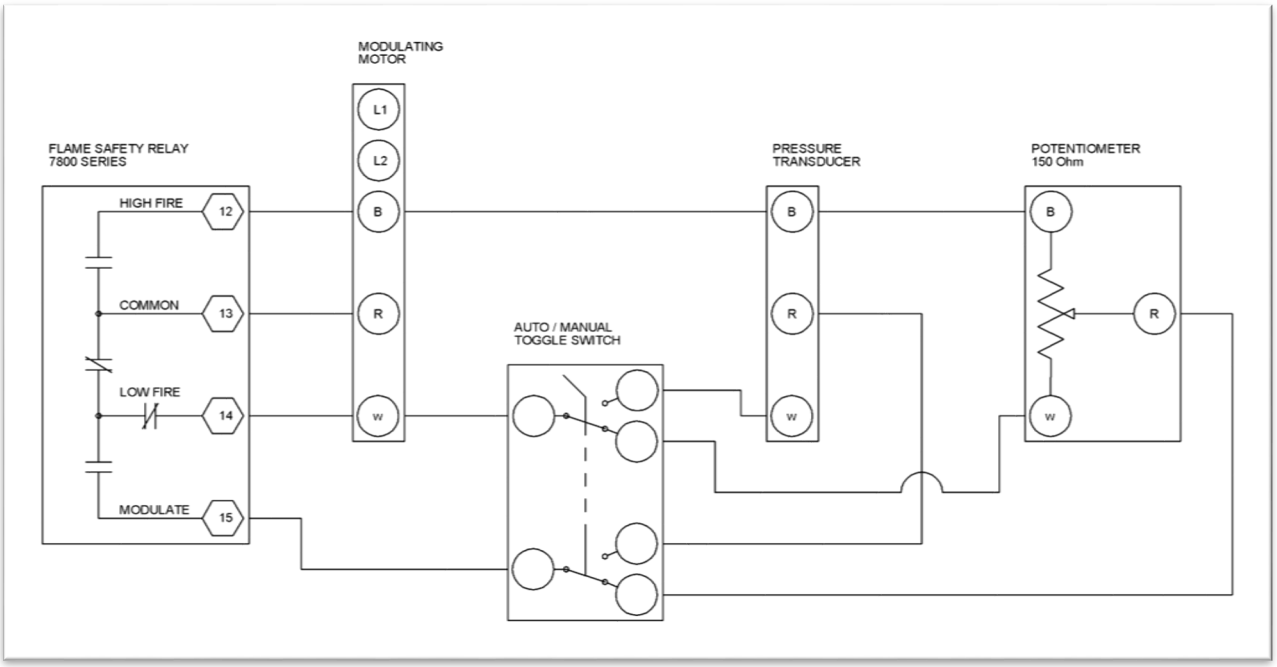


Figure 12

Add a rheostat and a double through single pole switch from the previous example and the system is complete. .



Testing the Pressure Transducer and Rheostat

The biggest challenge for a service technician is determining the point of failure. When you arrive on site, the item is broken and you may not know what the normal operation of the system is.

In my experience, the pressure transducer should be the first suspect when a system does not work in automatic mode. It can be manually actuated and tested in two ways—either with the control wires disconnected, or with it installed as a system.

Testing the device without the control wires connected is an excellent choice because the control power to the unit can be turned off and locked out, eliminating an electrocution hazard. This method also eliminates other potential problems in the system as causing the test to fail. But this method does have the shortcoming of not being practical in all instances. Also, it will only identify the status of the transducer, whereas with it connected to the system we can determine the status of the control wires and more importantly the connections.

Tests Without Power

Figure 13

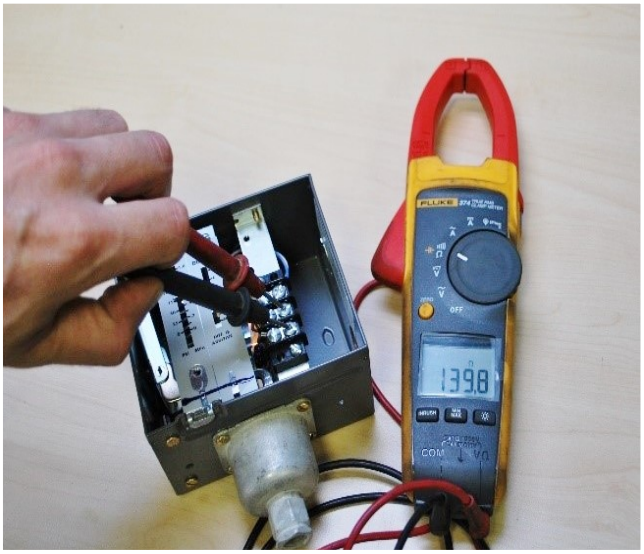
In this picture the terminal strip has been moved to the right for a better view of the mechanical wiper.

As the pressure builds against the diaphragm, the movement is transferred to the gold arm. The top of the arm, called a wiper, slides across a round cylinder. The cylinder has a fine wire wrapped around the outside creating a coil resistor.

As the wiper slides across the coil resistor, the resistance from the wiper to either side of the coil changes, forming a variable resistor in proportion to position.

Notice on both ends of the coil resistor it is a little darker. This is a nonconductive enamel that has been applied to stop the wire from unraveling. If the wiper is resting on the enamel, it will have an infinite resistance from the coil. Notice as well the cylinder can be adjusted left and right..

Figure 14



With no pressure pushing against the transducer and the meter set to Ohm, the bottom and middle connection should read 135 Ohm (+/- 5%). In this picture it is 139.8 Ohm and is normal.

This measure is the total resistance of the coil resistor. An infinite reading on the meter would indicate a broken wire or a failed resistor.

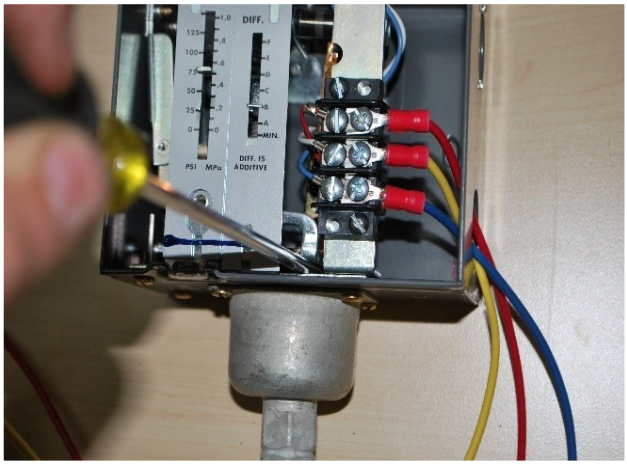
The bottom to the top screw should be 1 Ohm (+/- 3%). In this example it is 1.1 Ohm and is normal.

If the resistance is much higher, check to see if the wiper is on the right hand side of the coil resistor and no pressure is on the transducer. If the resistance is infinite, check to see if the wiper is in contact with the coil resistor between the nonconductive enamel.

The top screw to the middle screw should measure 136 Ohm (+/- 5%). In this example it is 141.5 Ohm and is normal.

The next test will simulate pressure being placed on the wiper arm from the diaphragm.

This test is not recommended by the manufacturer and can lead to a damaged control if the technician is forceful. However, without expensive testing equipment, this is the only option.



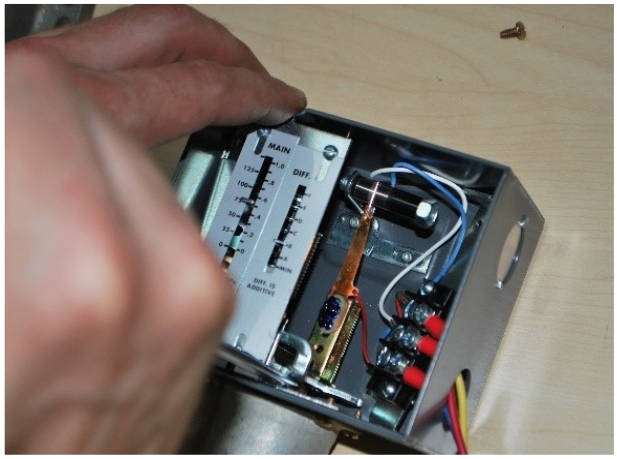
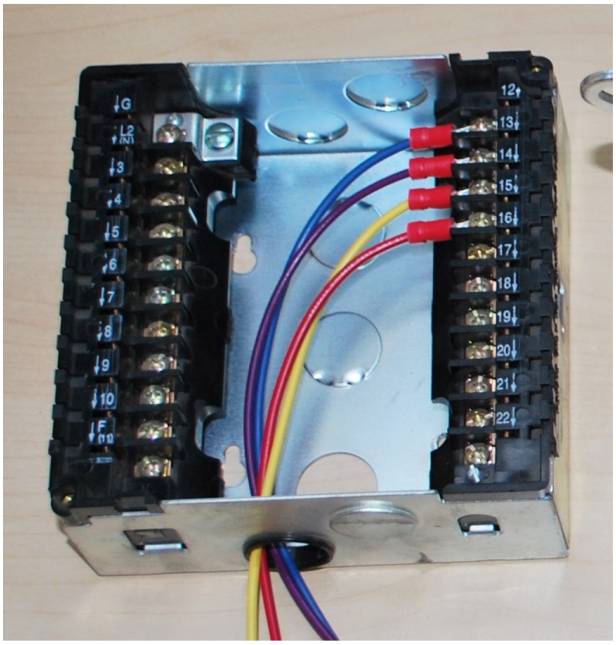


Figure 15 and 16

Place an appropriately sized flat blade screw driver under the arm. Rotate the screwdriver, moving the arm from the right to the left. Once the wiper reaches the end of travel across the coil resistor, do not apply any more force or the control will be damaged. With the meter set to Ohm, the top and bottom screw should range from 1 Ohm to 136 Ohm in a gradual fashion, as the wiper is moved. If the resistance is nonlinear the coil resistor may be damaged.

Figure 17



The wiring of the system and the pressure transducer can be checked in a similar way at the control panel.

With the power off, remove the flame safety relay from the base.

With no pressure pushing against the transducer, the Auto / Manual switch set to auto, and the meter set to Ohm, **Terminal 12 to 14** should read 135 Ohm (+/- 5%). This is the total resistance of the coil resistor.

Terminal 12 to 15 should read 1 Ohm (+/- 3%). This is the resistance from the wiper to the low side of the coil resistor.

Terminal 14 to 15 should read 136 Ohm (+/- 5%). This is the resistance from the wiper to the high side of the coil resistor.

Now that the wiring and operation of the pressure transducer has been verified, turn the Auto / Manual switch to manual and the potentiometer (rheostat) to low.

Again testing at the base of the flame safety relay, the resistance from **Terminal 12 to 14** should read 135 Ohm (+/- 10%).

Terminal 12 to 15 should read 1 Ohm (-3% /+ 10%), and Terminal 14 to 15 should read 136 Ohm (+/- 10%).

To check the sweep of the potentiometer (rheostat) connect the meter to **Terminal 12 and 15** and slowly turn the potentiometer. As the potentiometer turns, the resistance should gradually increase from 1 Ohm to 139 Ohm.

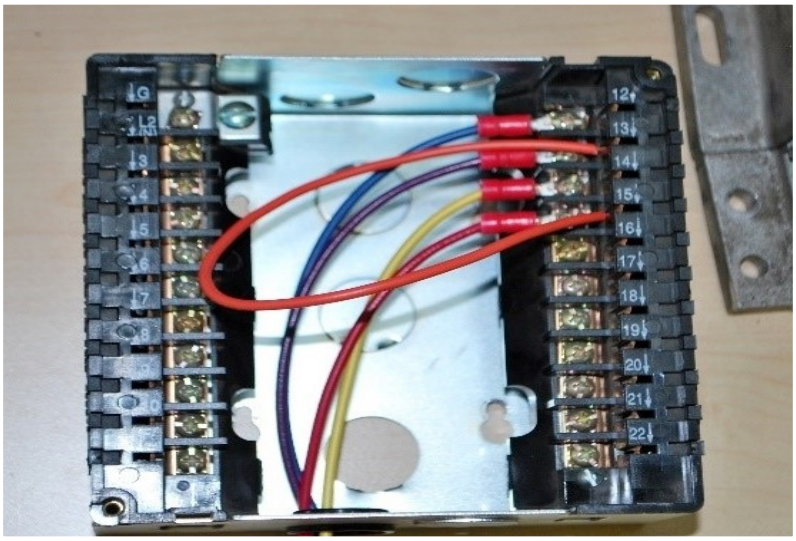


Figure 18

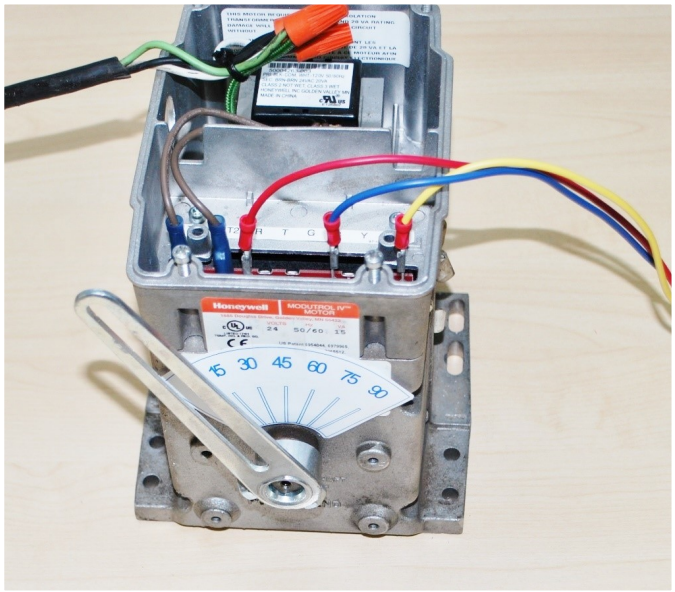
The wiring to the modulating motor can be checked in a similar fashion as the base. But first the connection from the center wiper to the modulating motor must be established in the safety relay base. Place a jumper wire from terminal 13 to 15.

Figure 19

With no pressure pushing against the transducer, the Auto / Manual switch set to auto, and the meter set to Ohm, terminal B to W should read 135 Ohm (+/- 5%). It is the total resistance of the coil resistor.

Terminal B to R should read 1 Ohm (+/- 3%). This is the resistance from the wiper to the low side of the coil resistor.

Terminal W to R should read 136 Ohm (+/-5%). This is the resistance from the wiper to the high side of the coil resistor.



This completes the testing without power.

Testing the Modulating Motor

All of the function tests that can be done without power have been done. Now the modulating motor and the flame safety relay still have to be tested.

The modulating motor is normally energized when the control system has power. With the **power turned off:**

- Remove the safety relay from the base.
- Turn all of the control switches off.
- Place the Auto / Manual switch into manual, turn the rate control rheostat down.
- Turn the power on.

Check the AC voltage at **terminal T1 and T2** (the brown wires) inside the modulating motor. The transformer should have 24 Volts (+/-10%) AC across the secondary.

If not, test the high side of the control transformer in the modulating motor. It should be 110 Volts (+/- 5%) AC.

Now that the power to the modulating motor has been verified, turn off the power. Just as before, place a jumper wire from terminal 13 to 15 in the safety relay base. This will connect the center wiper to the modulating motor.

Turn the power back on, reenergizing the modulating motor. With the Auto /Manual switch in manual, turning the rheostat should move the position of the modulating motor. If the system is controlled by the pressure transducer solely, use the manual simulation technique as outlined in testing of the pressure transducer.

The modulating motor can be made to go to full stroke, simulating a command from the safety relay by placing a jumper wire from terminal 13 to 14. The modulating motor can be made to go closed by placing a jumper wire from terminal 12 to 13, if the modulating motor is not equipped with a spring return.

With no jumper wires installed, it is normal for the modulating motor to go closed. Note that this information contradicts Figure 6 and Table 6 of the Honeywell 63-2190-3 operation booklet for the modulating motor; where it depicts the wiper being attached to W, not R, as in the photos.

Problems

With a complicated system, sometimes problems produce unexpected results. Quite often the person charged with fixing the system is not the first person to attempt the repair. This makes problem diagnosis all the more frustrating.

On the back of this page is a problem diagnosis checklist. It includes a comprehensive list of symptoms, the possible causes, and what to look for to verify the problem.

DESERT AIR RENTALS

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Symptom	Cause	What to look for
The modulating motor runs backwards—all the time	The B and W wires are reversed in the modulating motor	■ Check the wiring on the modulating motor.
The modulating motor runs backwards—after light off, in manual	The B and W wires are reversed on the rheostat	■ Check the wiring on the rheostat. ■ Check the wiring on the Auto / Manual switch.
The modulating motor runs backwards—after light off, in auto	The B and W wires are reversed on the pressure transducer	■ Check the wiring on the pressure transducer. ■ Check the wiring on the Auto / Manual switch.
The modulating motor opens up all the way—all the time	The B and the R connection in the modulating motor are shorted together	■ Check the wire from the modulating motor to the safety relay. ■ Check the flame safety relay contacts between Terminal 12 and 13.
The modulating motor opens up all the way— after light up, in auto	The B and the R connection in the pressure transducer are shorted together	■ Check the wire from the pressure transducer to the safety relay. ■ Check the wiring on the Auto / Manual switch.
The modulating motor opens up all the way—after light up, in manual	The B and the R connection in the rheostat motor are shorted together	■ Check the wire from the rheostat to the safety relay. ■ Check the wiring on the Auto / Manual switch.
The modulating motor only goes half the stroke—all the time	The B and the W wires are shorted together between the modulating motor and the safety relay.	■ Check the wire from the modulating motor to the safety relay. ■ Check the flame safety relay contacts between Terminal 12 and 13, and 12 and 14.
The modulating motor only goes half the stroke— after light off, in auto	The B and the W wires are shorted together between the pressure transducer and the safety relay.	■ Check the wire from the pressure transducer to the safety relay. ■ Check the wiring on the Auto / Manual switch.
The modulating motor only goes half the stroke—after light off, in manual	The B and the W wires are shorted together between the rheostat and the safety relay.	■ Check the wire from the rheostat to the safety relay. ■ Check the wiring on the Auto / Manual switch.
The modulating motor does nothing	The modulating motor may not have power or has no signal.	■ Check that the safety relay is fully inserted into the base. Refer to checking modulating motor.
While in auto, sometimes the modulating motor closes when it should be opening.	The connection between the wiper and the resistor in the pressure transducer is broken.	■ Clean the coil resistor on the pressure transducer. ■ Look for loose wires between the pressure transducer and the safety relay. ■ Look for loose wires between the safety relay and the modulating motor. ■ Test the linearity of the coil resistor as outlined in the tests.

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