Honeywell

TP970 and TP9600 Series Pneumatic Thermostats

ENGINEERING DATA

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INTRODUCTION

This Engineering Data sheet provides detailed information on the operation of TP970 and TP9600 Series Pneumatic Thermostats (Thermostats). These Thermostats use the force-balance design with high nozzle feedback for stability. The TP970 and TP9600 Series includes the following thermostat models:

— TP970A-D and TP9600A, B:
High capacity
Proportional control
Single temperature

— TP971A-C and TP9610A, B:
Dual temperature
Day/night control (automatic switchover through diaphragm logic)
Two sensing elements
Individual setpoint control

— TP972A and TP9620A, B:
High capacity
Heating/cooling control (automatic switchover through diaphragm logic)
Two sensing elements (one for heating control, one for cooling control)

— TP973A, B and TP9630A, B:
Low capacity
Proportional control
Single temperature

— TP974A:
Room temperature sensor
Used as a remote temperature transmitter for the RP920 Pneumatic Controller

This Engineering Data sheet describes the TP973A, B and TP9630A, B Thermostats first, because they are the simplest.

FUNDAMENTALS OF THERMOSTAT OPERATION

General

In force-balance design, two forces oppose each other until they are equal, or balanced. The TP970 and TP9600 Series Thermostats use the force of the bimetal to close the flapper over the nozzle and the opposing force of the air pressure in the nozzle chamber to lift the flapper (see the Flapper-Nozzle Operation section). When the forces are equal, a force-balance condition exists.

The throttling range setting and the calibration reference temperature determine the Thermostat span and calibration point. At control point the nozzle-flapper-bimetal assembly (acting through the calibration screw, setpoint cam, and the throttling range (TR) adjustment) has a fixed branchline pressure (BLP) for each temperature within the temperature and throttling range settings. The forces within the nozzle-flapper-bimetal assembly always seek a balanced condition; giving the same BLP for the same temperature regardless of fluctuations in main air or the relative positions of the nozzle, flapper, and bimetal.

Flapper-Nozzle Operation

Flapper-nozzle operation is generally the same for all TP970 and TP9600 Thermostats. The Thermostat provides a branchline air pressure that is a function of the ambient temperature in the room or controlled space. As shown in Figure 1, the force of the temperature-sensing bimetal acting on one side of the flapper (Force A) is balanced by the feedback force of the pilot pressure through the nozzle acting on the other side of the flapper (Force B).

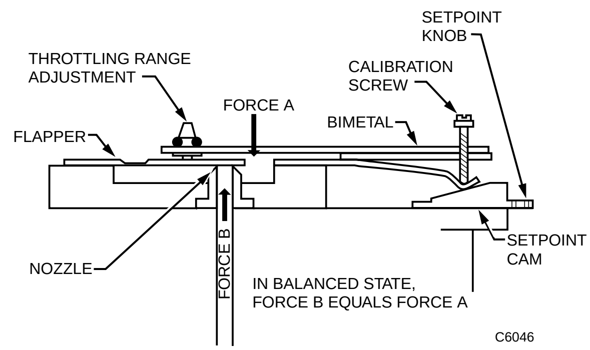


Fig. 1. Flapper-Nozzle-Bimetal Assembly.

The position of the flapper over the nozzle changes and creates a new pilot pressure when the bimetal force changes (through temperature or setpoint change). This pilot pressure feeds into the valve unit, which converts the low-capacity pilot pressure to a high-capacity branchline change (see the Valve Unit Operation section). Feedback at the nozzle regulates the pressure to negate the effect of normal main air supply fluctuations on the branch line.

Adjusting the throttling (proportioning) range changes the flapper lever position. Moving the setpoint cam changes the bimetal operating force and thus the setpoint.

Valve Unit Operation

TP970, TP9600, TP971, TP9610, TP972, and TP9620 Thermostats use force-balance valve units to amplify airflow and minimize air consumption without loss of required device capacity. Figure 2 is a cross-section of a TP970 and TP9600 Thermostat showing the relationship of the valve unit to the bimetal, nozzle, and other components.

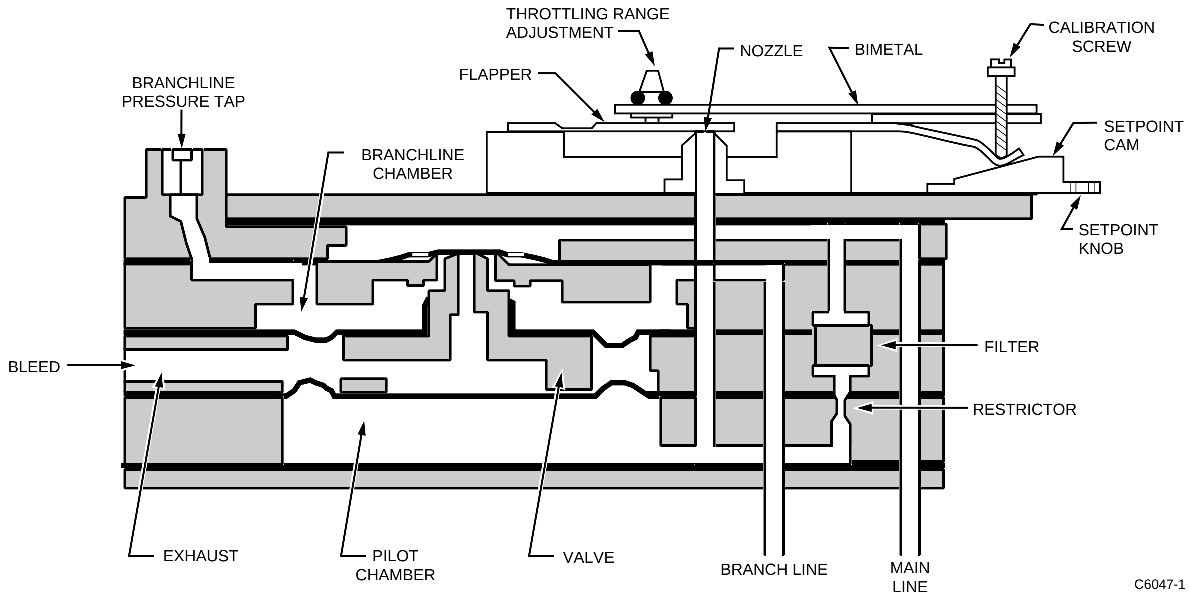


Fig. 2. Cross Section of TP970 and TP9600 Thermostat Showing Valve Unit and Airflow.

TP970, TP9600, TP971, TP9610, TP972, and TP9620 Thermostats are designed around a valve unit for flow amplification rather than conventional pressure amplification. Branchline chamber and pilot chamber design are such that branch pressure is equal to nozzle pressure at a higher capacity.

Figures 3, 4, and 5 are cross-sections of the valve unit only, showing air passages and the pilot-branch diaphragm relationship.

Figure 3 shows a valve unit in a strategic or balanced condition. All the forces are equal; BLP equals the pilot-line pressure.

No main air enters the branchline chamber and no exhaust air leaves the branchline chamber. In this static condition, the valve is sealed at both Points A and B, preventing airflow.

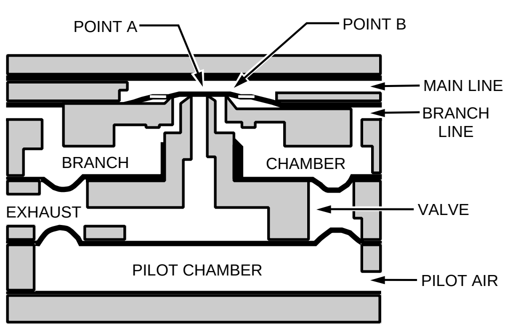


Fig. 3. Valve Unit Flow Amplifier in a Balanced (Static) Condition.

Figure 4 shows the valve unit supplying air to the branch line. This condition occurs when the bimetal sensing element forces the Thermostat flapper toward the nozzle, decreasing the nozzle-flapper gap and increasing the pilot pressure.

The increased pilot pressure against the pilot diaphragm overcomes the force of the BLP on the branchline diaphragm. This change opens the valve unit at Point B, allowing main air to flow into the branch line. BLP builds until the pressure against the branch diaphragm again equals the pressure against the pilot chamber diaphragm. The main airflow then shuts off, bringing the valve unit into a balanced condition at a new pressure.

With direct-acting bimetal sensors, a temperature increase closes the nozzle-flapper gap; with reverse-acting bimetal sensors, a temperature increase opens the nozzle-flapper gap. The arrows in the air passages in Figure 4 show the direction of airflow.

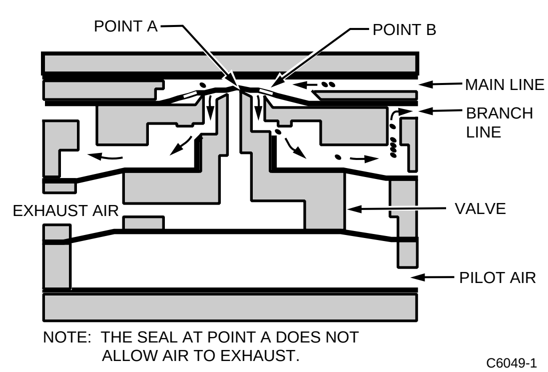


Fig. 4. Valve Unit Shown with Pilot Chamber Pressure Increased.

Figure 5 shows the valve unit bleeding down the BLP. This condition occurs when the bimetal sensing element relaxes its force against the flapper, allowing the nozzle-flapper gap to increase.

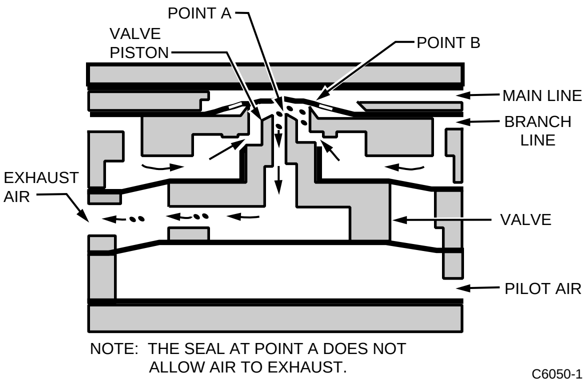


Fig. 5. Valve Unit Shown with Pilot Chamber Pressure Decrease.

The reduction in pilot pressure against the pilot diaphragm allows the BLP to overcome the pressure in the pilot chamber. This change moves the valve piston down, sealing off Point B and opening Point A. Branchline air bleeds off until the pressure against the branchline diaphragm equals the pressure against the pilot chamber diaphragm. When the pressures become equal, the exhaust air is shut off at Point A. The valve unit is again in a balanced condition at the new pressure. The arrows in the air passages in Figure 5 show the direction of airflow.

The preceding explanation of valve unit operation is very important to understanding TP970, TP9600, TP971, TP9610, TP972, and TP9620 operation. As can be seen from Figures 3, 4, and 5, pilot pressure changes affect BLP changes in the same ratio. There is no pressure gain to amplify errors as with other pneumatic Thermostats. Still, the main air supply being switched through the valve unit, provides fast, high capacity increase and decrease of BLP.

TP973A, B AND TP9630 A, B LOW-CAPACITY, SINGLE-TEMPERATURE THERMOSTATS

General

The TP973A, B TP9630A, B (Fig. 6) are the simplest Thermostats in the TP970 and TP9600 Series. Every other model includes the basic TP973 and TP9630 assembly with additions. Air going to the controlled device from the TP973 and TP9630 passes through an internal restrictor. The TP973A and TP9630A are direct acting (signal pressure increases as the temperature increases); the TP973B, reverse acting (signal pressure increases as the temperature decreases).

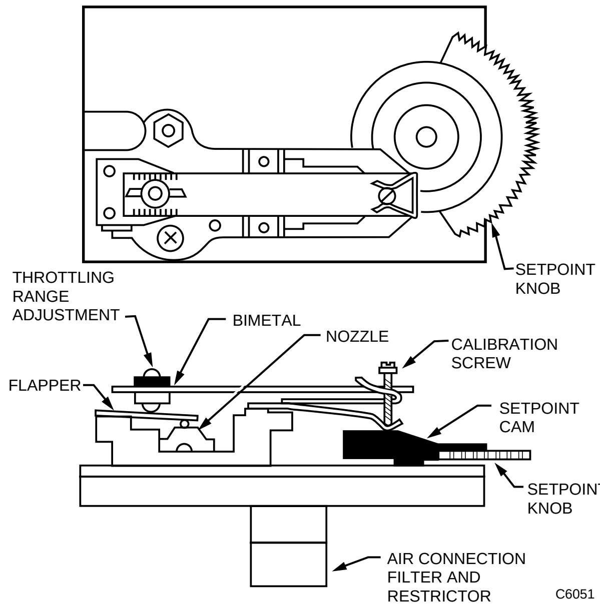


Fig. 6. Basic TP973 and TP9630 Thermostat.

The TP973 and TP9630 are used on one- or two-pipe systems. Connections are made to main and branch for two-pipe applications (see Fig. 7). The main air connector is plugged when used on one-pipe applications (Fig. 8). This causes the Thermostat to operate like any other bleed-type thermostat with a remote restrictor.

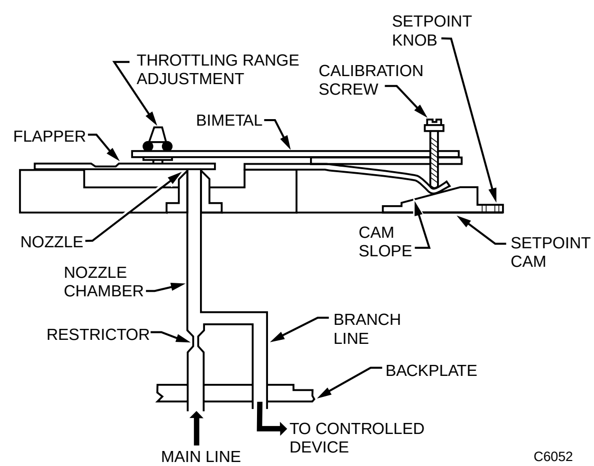


Fig. 7. TP973 and TP9630 Operating Section.

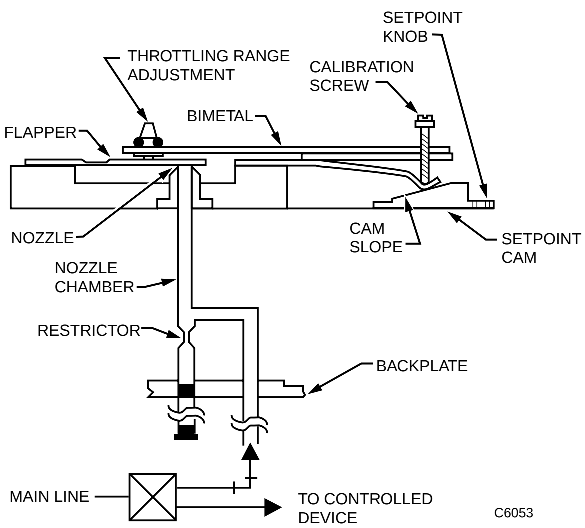


Fig. 8. TP973 and TP9630 Operating Section—Main Port Capped.

Operation

Direct Action

Refer to Figures 7 and 8. On a temperature rise, the flapper is forced toward the nozzle by the action of the temperature-sensing bimetal, which reduces the flapper-nozzle gap. The change in the flapper-nozzle gap allows less air to escape from the nozzle, thus increasing the pressure in the nozzle chamber as well as the branch line. The controlled device is thereby positioned to maintain the controlled space to the desired temperature.

The Thermostat provides a BLP that is a function of ambient temperature. The force from the bimetal acting on the flapper is balanced by the feedback force of the BLP acting on the opposite side of the flapper through the nozzle. If the setpoint knob is changed to a new setting, the opposing forces in the lever system go out of balance and the room ambient temperature changes to rebalance the lower system.

For example, if the setpoint cam is moved to a higher temperature setting, the point of the lever system that rides the slope of the cam lowers (direct-acting device) due to this cam slope. As a result, the bimetal reduces its force applied to the flapper. The reduced force causes the BLP to bleed down and a heating valve to open. Heat is introduced to the space until the forces of the bimetal are again in equilibrium with the opposing force (8 psi [55 kPa] times the area of the nozzle at the flapper). A reduction in setpoint causes the reverse to happen.

The calibration screw allows for matching the bimetal start position with the indicated setting on the setpoint cam to achieve an 8 psi (55 kPa) BLP at the indicated setpoint.

The TR adjustment (Fig. 9) provides a means for changing the effective length of the bimetal. When the TR adjustment is moved over the nozzle, the force from the bimetal is exerted directly over the nozzle and a narrow TR, or very high sensitivity, results. For example, a 1°F (0.56°C) change in temperature results in a 5 psi (34 kPa) BLP change.

When the TR adjustment is moved toward the end of the bimetal away from the nozzle, the effective force output of the bimetal is reduced. This reduction requires a greater temperature change at the bimetal to throttle the flapper over the nozzle. The result is a wider TR or very low sensitivity; for instance, a 1°F (0.56°C) change in temperature results in only a 1 psi (7 kPa) BLP change.

Reverse Action

Refer to Figures 7 and 8. On a temperature rise, the flapper is forced away from the nozzle by the action of the temperature-sensing bimetal, which increases the flapper-nozzle gap. The change in the flapper-nozzle gap allows more air to escape from the nozzle, thus decreasing the pressure in the nozzle chamber as well as the branch line. The controlled device is thereby positioned to maintain the controlled space to the desired temperature.

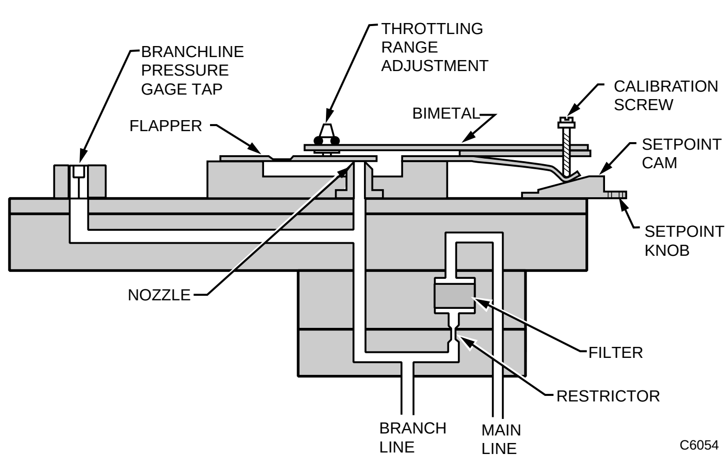


Fig. 9. Cross Section of TP973 and TP9630 Thermostat.

The Thermostat provides a BLP that is a function of ambient temperature. The force from the bimetal acting on the flapper is balanced by the feedback force of the BLP acting on the opposite side of the flapper through the nozzle. If the setpoint knob is changed to a new setting, the opposing forces in the lever system go out of balance and the room ambient temperature changes to rebalance the lower system.

For example, if the setpoint cam is moved to a higher temperature setting, the point of the lever system that rides the slope of the cam rises (reverse-acting device) due to this cam slope. As a result, the bimetal increases its force applied to the flapper. The increased force causes the BLP to build up and a cooling valve to open. Cooling is introduced to the space until the forces of the bimetal are again in equilibrium with the opposing force (8 psi [55 kPa] times the area of the nozzle at the flapper). A reduction in setpoint causes the reverse to happen.

The calibration screw allows for matching the bimetal start position with the indicated setting on the setpoint cam to achieve an 8 psi (55 kPa) BLP at the indicated setpoint.

The TR adjustment provides a means for changing the effective length of the bimetal. When the TR adjustment is moved over the nozzle, the force from the bimetal is exerted directly over the nozzle and a narrow TR, or very high sensitivity, results. For example, a 1°F (0.56°C) change in temperature results in a 5 psi (34 kPa) BLP change.

When the TR adjustment is moved toward the end of the bimetal away from the nozzle, the effective force output of the bimetal is reduced. This reduction requires a greater temperature change at the bimetal to throttle the flapper over the nozzle. The result is a wider TR or very low sensitivity; for instance, a 1°F (0.56°C) change in temperature results in only a 1 psi (7 kPa) BLP change.

TP970A-D AND TP9600A, B HIGH-CAPACITY, SINGLE-TEMPERATURE THERMOSTATS

General

The TP970 and TP9600A, B Thermostats (Fig. 10) are the basic TP973 with a valve unit added for greater capacity to control valve or damper actuators in heating or cooling systems.

TP970A, B, C, D and TP9600A, B devices are bimetal-element, pilot-operated, two-pipe, proportioning pneumatic Thermostats. The TP970A, C and TP9600A are direct acting (BLP increases as temperature increases). The TP970B, D and TP9600B are reverse-acting (BLP decreases as temperature increases).

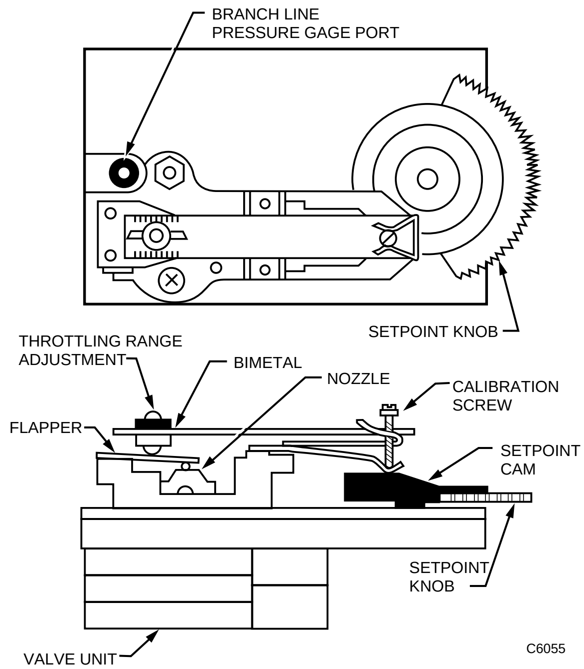


Fig. 10. TP970 and TP9600 High Capacity Pilot Operated Thermostat.

NOTE: TP970C1000 (direct acting) and TP970D1008 (reverse acting) Thermostats have extended throttling ranges of 5 to 20°F (2.5 to 10°C) for energy conservation applications. The extended throttling range allows for a Zero Energy Band (ZEB) between sequenced heating and cooling modes.

Operation

Direct Action

Refer to Figure 11. On a temperature rise, the flapper is forced toward the nozzle by the action of the bimetal. The force of the bimetal acting on the flapper is balanced by the feedback force of the pilot pressure in the nozzle chamber acting in an opposing direction. This action varies the flapper-nozzle gap, which in turn causes an increased pressure in the pilot line. The change in pilot pressure is routed to the flow amplifier that converts the low capacity pilot pressure signal to a high capacity branchline flow at the same pressure.

For a more detailed discussion, refer to the Valve Unit Operation section.

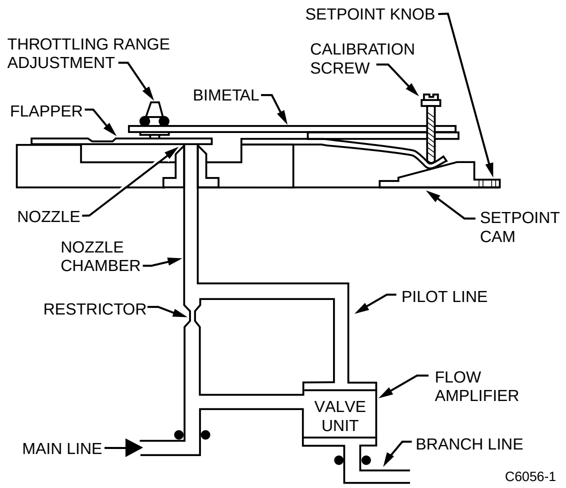


Fig. 11. Operating Sections of TP970A, C and TP9600A (Direct Acting).

Reverse Action

Refer to Figure 11. On a temperature rise, the flapper is forced away from the nozzle by the action of the bimetal. The force of the bimetal acting on the flapper is balanced by the feedback force of the pilot pressure in the nozzle chamber acting in an opposing direction. This action varies the flapper-nozzle gap, which in turn causes a decreased pressure in the pilot line. The change in pilot pressure is routed to the flow amplifier that converts the low capacity pilot pressure signal to a high capacity branchline flow at the same pressure.

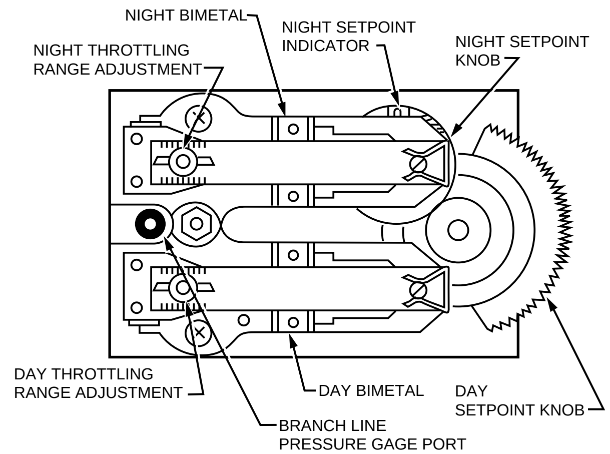
For a more detailed discussion, refer to the Valve Unit Operation section.

TP971A-C AND TP9610A, B HIGH-CAPACITY, DUAL-TEMPERATURE THERMOSTATS

The TP971A, B, C and TP9610A, B Thermostats feature day and night sensing elements with individual setpoint adjustments for day/night control of heating and air conditioning systems. The Thermostat cover is removable for adjusting the nighttime setpoint. All TP971 and TP9610 Thermostats have a manual override lever (DAY/AUTO) which allows the occupant to change the Thermostat operation from night cycle to day cycle. The Thermostat can be made tamper proof by cutting off the manual override lever with a side cutter. The complete manual override lever assembly can be removed and replaced if desired (see TP970 and TP9600 Series Pneumatic Thermostats Service Data 75-7134).

TP971A and TP9610A

On the TP971A and TP9610A direct-acting Thermostats (Fig. 12), the daytime bimetal controls the system when the main air pressure is 13 psi (90 kPa). The nighttime element controls the system when the main air pressure reaches 18 psi (124 kPa). Models are available with switchover pressures of 16 to 21 psi (110 to 145 kPa) and 20 to 25 psi (138 to 172 kPa).



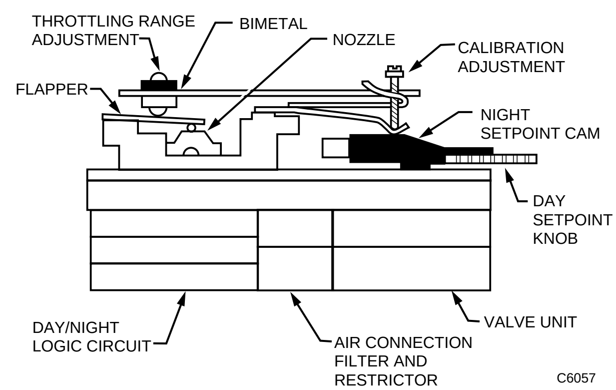


Fig. 12. TP971 and TP9610 Day/Night Thermostat.

TP971B and TP9610B

The TP971B and TP9610B are the same as the TP971A and TP9610A except that they are reverse acting.

TP971C

The TP971C is a direct-acting, three-pipe Thermostat. The third pipe, a secondary branch line, is a switched line providing pilot control of auxiliary equipment. Switchover pressure is 13 psi (90 kPa) for daytime operation and 18 psi (124 kPa) for nighttime operation. The TP971C is typically used in conjunction with unit ventilator systems requiring Day/Night/Warm-up cycles.

The secondary branch line is used with a pneumatic/electric (P/E) switch to start and stop the supply fan on the night cycle. The secondary branch line has full main air pressure on the night cycle and daytime main air pressure on the day cycle.

Daytime Operation

Figure 13 shows airflow through the Thermostat during daytime operation. The main air pressure is at the lower, daytime operating pressure of 13 psi (90 kPa).

Air enters the Thermostat through the main line, passes through a screen, then diverts into the valve unit and through the multistage filter. The arrows in Figure 13 show main air traveling to Logic Module A, which is closed because the adjustable spring is set to open only at the higher nighttime pressure. Main air passes through the integral restrictor, into the pilot chamber of the valve unit, and in to Logic Module B. The spring holds Port B1 open because there is no air pressure against the top of the diaphragm of Logic Module B. This action allows air to pass through Port B1 to the 13 psi (90 kPa) (DAY) nozzle-flapper. The Thermostat now operates on a daytime cycle at the daytime setpoint. The valve unit operation is identical to that described in the Valve Unit Operation section.

Nighttime Operation

In Figure 14, the main air pressure is at 18 psi (124 kPa) for nighttime operation. The airflow, shown by arrows, is the same as the daytime cycle up to Logic Module A and Logic Module B. The main air pressure, 18 psi (124 kPa), is now enough to overcome the spring-loaded diaphragm in Logic Module A. Because the manual override lever is in the AUTO position, the air passes through Logic Module A, and then through Logic Modules C and D. This air pressure forces the diaphragm of Logic Module B downward, closing Port B1 and allowing air to pass through Port B2. The airflow then passes to the 18 psi (124 kPa) (NIGHT) nozzle-flapper. In this condition, the Thermostat operates on a nighttime cycle. Valve unit flow amplifier operation is identical to that described in the Valve Unit Operation section.

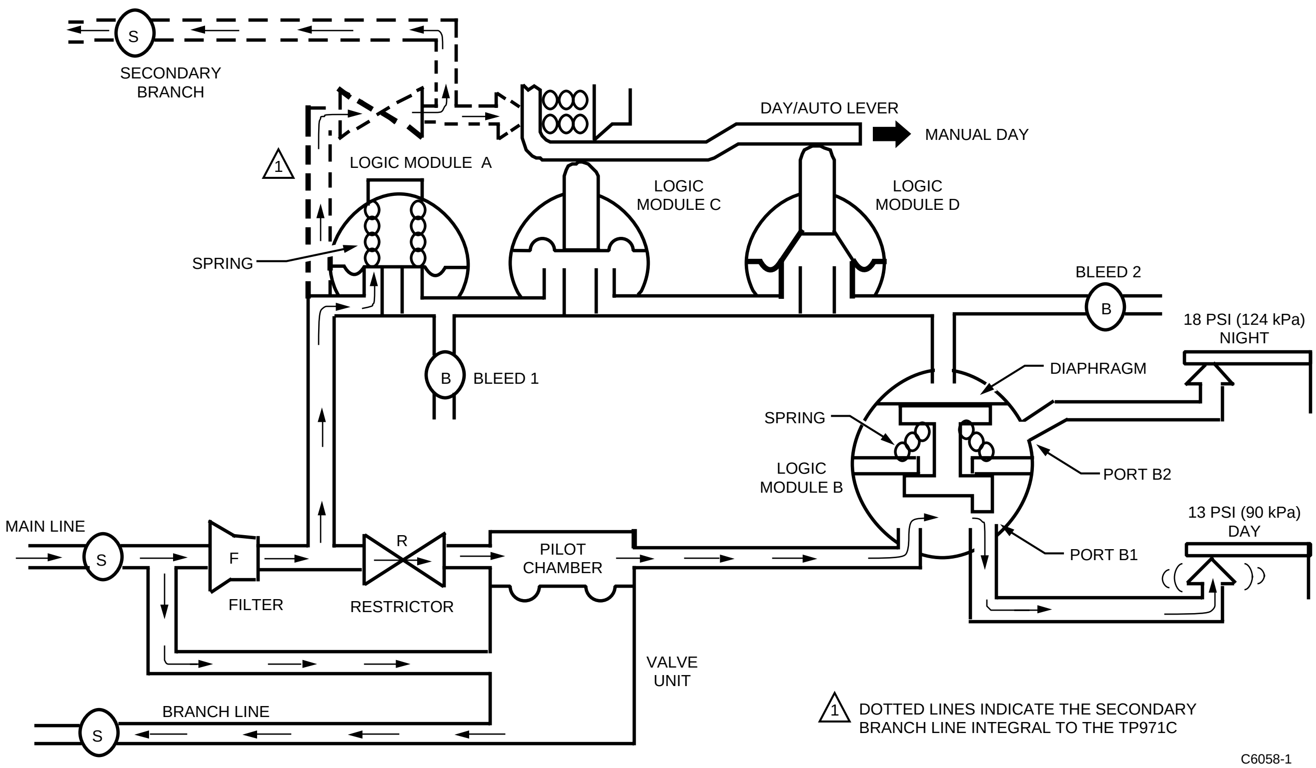


Fig. 13. TP971 and TP9610 Operation on Day Cycle—Main Air Pressure 13 psi (90 kPa).

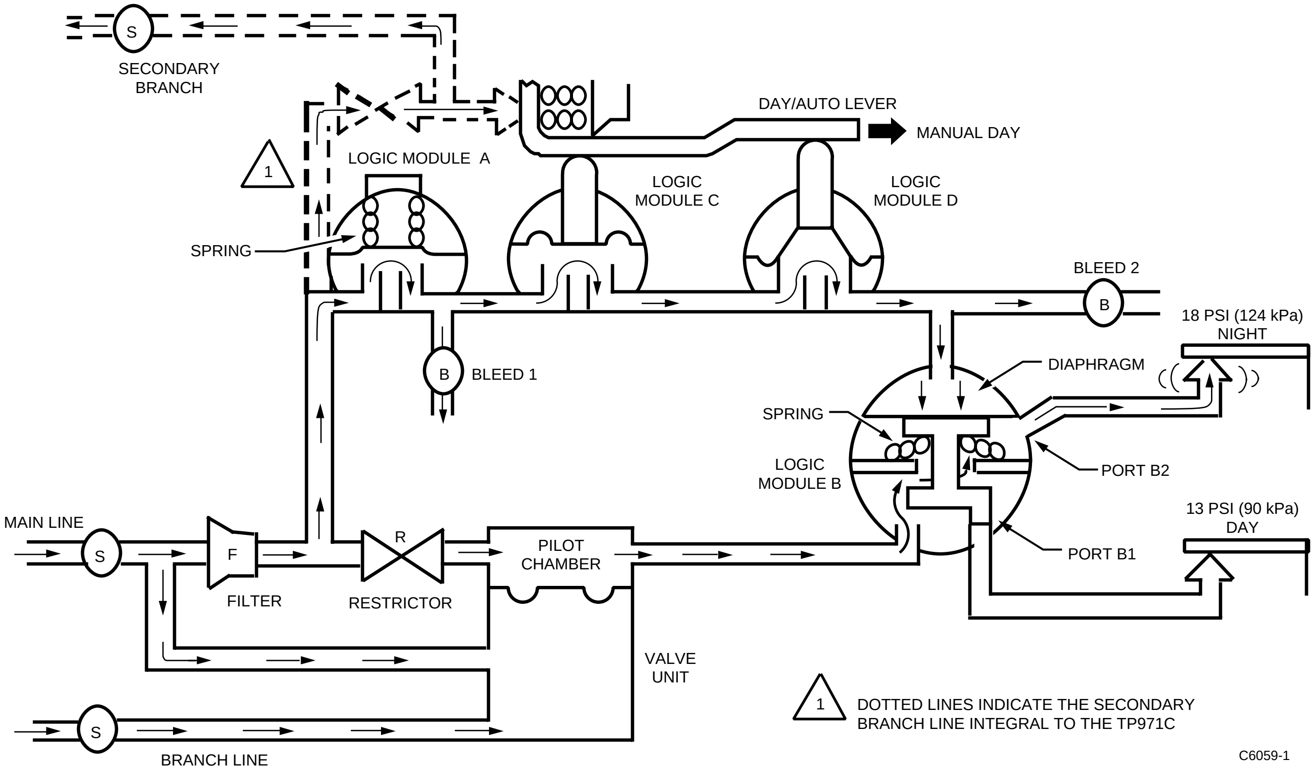


Fig. 14. TP971 and TP9610 Operation on Nighttime Cycle—Main Air Pressure 18 psi (124 kPa).

Manual DAY Override

Manual DAY Override is shown in Figure 15. With main air pressure at the 18 psi (124 kPa) (NIGHT) setting, airflow applies pressure to Logic Modules A, C, and D. However, because the DAY/AUTO lever has been manually positioned to DAY, Logic Module D is shut off, stopping airflow. Air pressure is bled from Logic Module B through Bleed 2, and the diaphragm moves up to open Port B1 and close Port B2. This condition allows an airflow path to the 13 psi (90 kPa) (DAY) nozzle-flapper and closes the airflow path to the 18 psi (124 kPa) (NIGHT) nozzle-flapper. Thus, the Thermostat works on a daytime cycle even though the main air supply pressure is at its normal night cycle main air pressure of 18 psi (124 kPa).

The 18 psi (124 kPa) pressure on the diaphragm of Logic Module C holds the manual DAY/AUTO lever in position. If the occupant fails to return the override lever, the lever returns automatically when the system main air pressure is reduced to 13 psi (90 kPa). This change returns the Thermostat to its normal operation and automatic logic switchover.

The secondary branch line operates with the manual DAY/AUTO lever position as follows:

1. System in normal daytime operation, 13 psi (90 kPa) main air pressure (Fig. 13 dotted lines).

2. Move the manual DAY/AUTO lever to the DAY position. It snaps back to AUTO because there is no air pressure on logic switch C (Fig. 13).

The secondary branch line is always at the main air pressure when the system operates in a daytime mode; the P/E switch contacts are closed and the supply fan is operating.

During normal nighttime operation conditions (Fig. 14):

1. The system is in normal nighttime operation mode; main and secondary branchline air pressure is at 18 psi (124 kPa). The secondary branch line is also at 18 psi (124 kPa).

2. Since the P/E switch contacts open at any pressure over 15 psi (103 kPa), the supply fan is off.

3. The manual DAY/AUTO lever is in the AUTO position because operation is under normal nighttime conditions (Fig. 14).

The secondary branch line is at the night main air pressure of 18 psi (124 kPa) when the system is operating in a normal nighttime mode. The P/E switch contacts are open and the supply fan is off because the pressure in the secondary branch is over 15 psi (103 kPa).

For night occupancy and daytime control:

1. Push the DAY/AUTO switch to the DAY position. This opens the nozzle-bleed on the secondary branch line (Fig. 15).

2. The DAY/AUTO lever stays in the DAY position because of the air pressure on Logic Module C (Fig. 15).

3. The main air pressure in the secondary branch line bleeds down through the secondary branch nozzle. The secondary branchline restrictor maintains normal night system pressure in the rest of the Thermostat. However, airflow is now diverted to operate the nozzle-flapper on the DAY mode sensing element (Fig. 15).

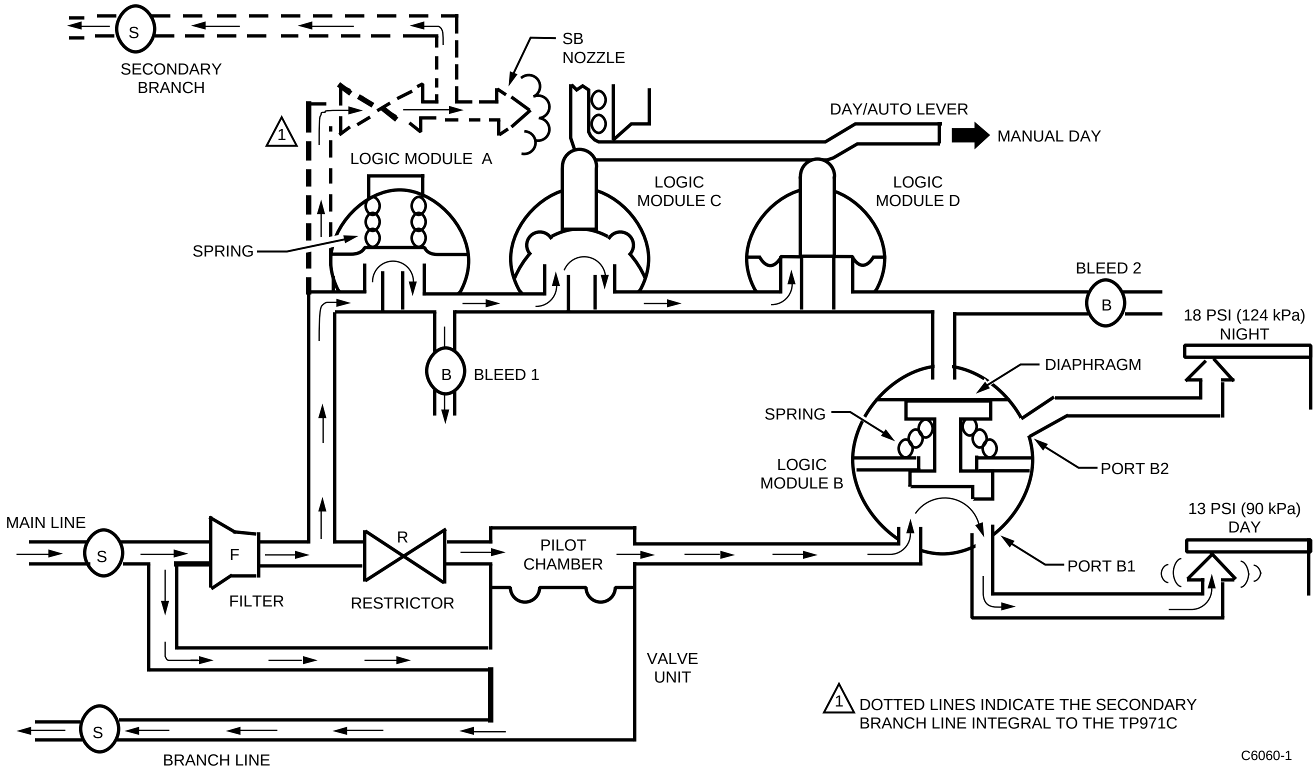


Fig. 15. TP971 and TP9610 Operation, DAY/AUTO Lever Manually Set to DAY Position—Main Air Pressure 18 psi (124 kPa).

When the air supply system returns to its normal daytime pressure, the DAY/AUTO lever is spring returned to the AUTO position and the Thermostat returns to normal operation. The occupant can also return the system to normal operation by manually switching the DAY/AUTO lever to AUTO.

In the preceding situation, the P/E switch contacts are closed. This is because the secondary BLP is under 15 psi (103 kPa); the DAY/AUTO lever is held in the DAY position by pressure on Logic Module C; and the Thermostat uses its daytime bimetal because the airflow through Logic Module D is closed off.

TP972A AND TP9620A HIGH-CAPACITY, HEATING/COOLING THERMOSTAT

General

The TP972A and TP9620A (Fig. 16) are high-capacity, two-pipe, proportioning pneumatic Thermostats with two bimetal sensing elements.

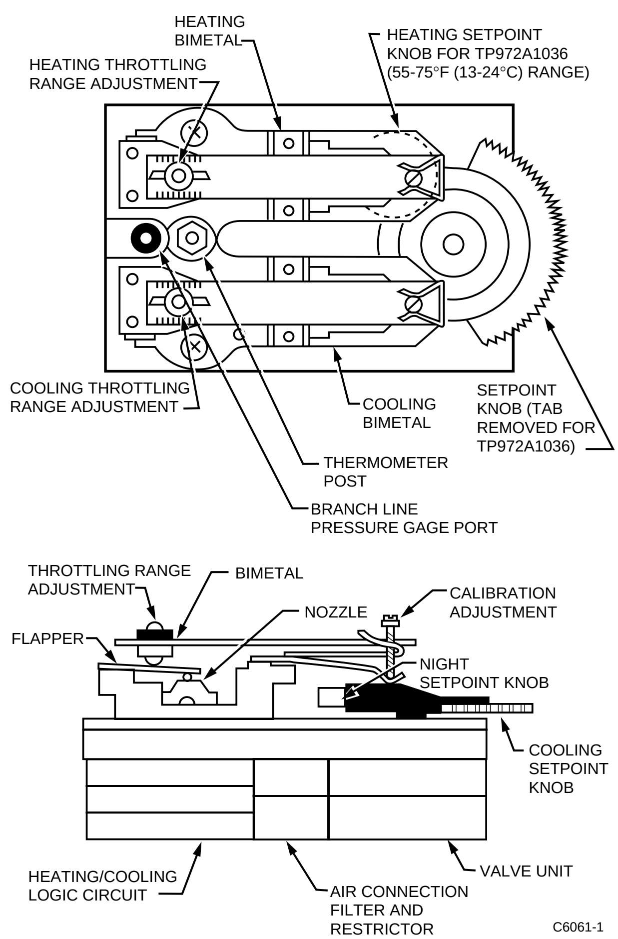


Fig. 16. TP972A and TP9620A Cross Section Showing Adjustments and Modular Construction.

The TP972A and TP9620A have one setpoint adjustment knob that controls both heating and cooling bimetals. Each bimetal has an independent throttling range adjustment (Fig. 16). The cooling bimetal of the TP972A and TP9620A controls when the two-pressure air supply is at the lower of the two pressures; the heating bimetal of the TP972A and TP9620A controls when air supply pressure increases to the higher of the two pressures. Typical values for the two-pressure supply systems are 13/18 psi (90/124 kPa), 16/21 psi (110/145 kPa), and 20/25 psi (138/172 kPa).

Figures 17 and 18 are schematic representations of the TP972A and TP9620A airflow paths for heating and cooling control. Operation is the same as that for the TP971 and TP9610 except for the logic modules, the manual override, and the independent setpoint adjustment. Cooling control requires a lower pressure in the main air supply. Figure 17 shows the workings and traces the air path within the TP972A and TP9620A when it is controlling with the cooling bimetal.

NOTE: The TP972A2036, A2168, and A2176 and TP9620A limited-control-range Thermostats have separate, concealed setpoints for heating and cooling and limit the heating control point to a maximum of 75°F (24°C).

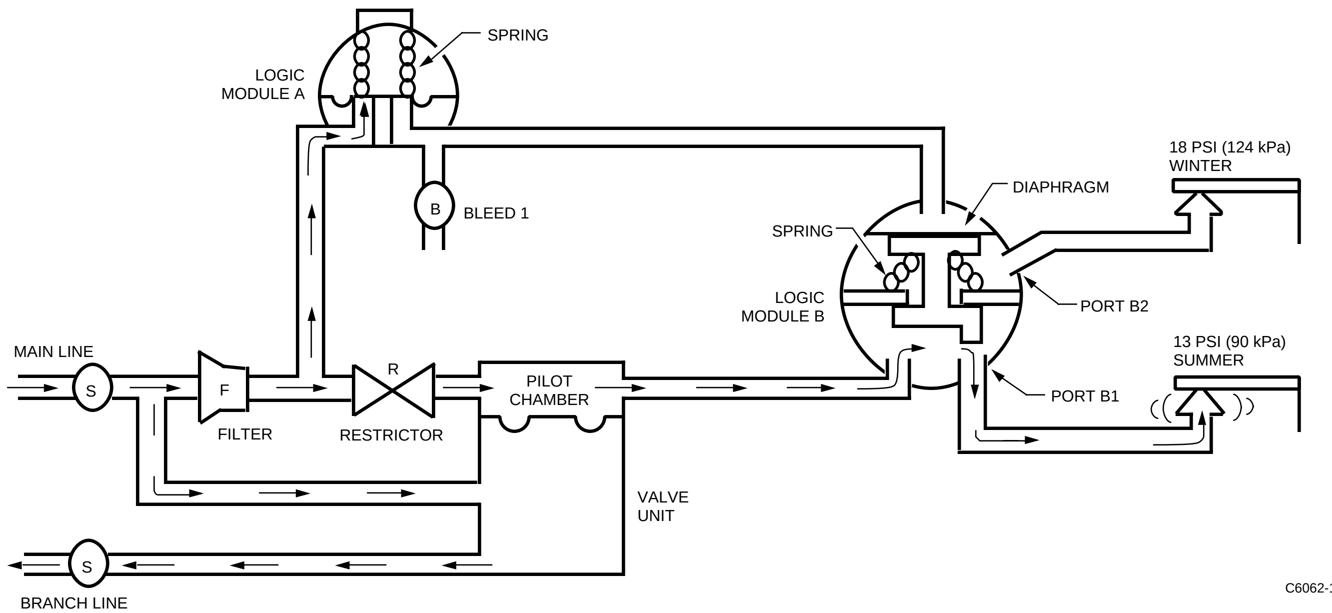


Fig. 17. TP972A and TP9620A Operation on Cooling Cycle—Main Air Pressure 13 psi (90 kPa).

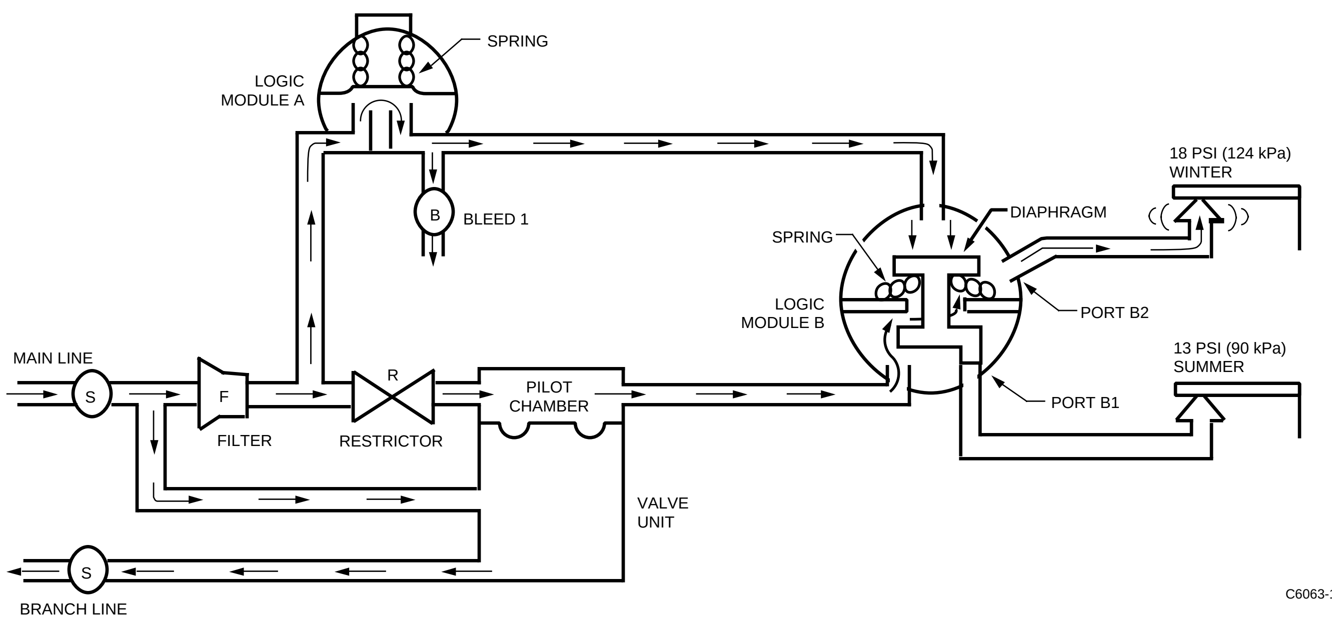


Fig. 18. TP972A and TP9620A Operation on Heating Cycle—Main Air Pressure at 18 psi (124 kPa).

Operation

Main air enters through the main air passage. Filtered air goes to Logic Module A and into the pilot chamber of the valve unit flow amplifier (see arrows in Fig. 17). When the air reaches Logic Module A, it cannot pass because the spring-loaded diaphragm is adjusted to pass only 18 psi (124 kPa) of air. In this condition, no air pressure is applied to the diaphragm of Logic Module B and it stays in the up position, allowing air to pass from the pilot chamber through Port B1. This air is routed on to the flapper-nozzle of the cooling bimetal and the Thermostat operates in a cooling mode. The spring-loaded diaphragm of Logic Module B stays open until air pressure is applied from Logic Module A.

When main air enters the Thermostat at 18 psi (124 kPa), as previously described for the cooling cycle, the spring of Logic Module A is overcome and air passes through the Module. The air pressure is applied to the diaphragm of Logic Module B, closing off Port B1, and opening Port B2. Now the air is directed to the flapper-nozzle of the heating bimetal and the Thermostat controls in the heating mode.

TP974A ROOM TEMPERATURE SENSOR

General

The TP974A (Fig. 19, 20) is a bimetal-element, proportioning temperature sensor for either two- or one-pipe applications. The sensor bimetal is direct acting (signal pressure increases as the temperature increases). The TP974A is factory calibrated for 50 to 100°F (10 to 38°C), for a fixed span of 50°F (28°C). This span is equal to a corresponding pressure change of 12 psi (83 kPa) for 3 to 15 psi (21 to 103 kPa). The TP974A has no setpoint adjustment and the TR is factory preset.

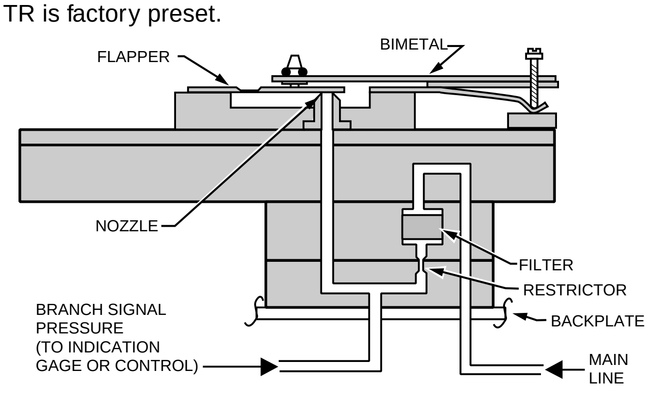


Fig. 19. Cross Section of TP974A—Two-Pipe Application.

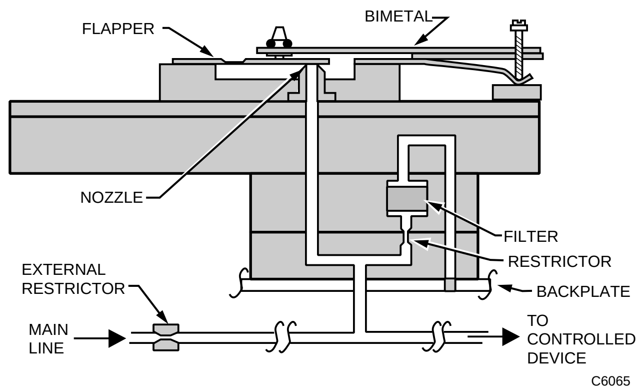


Fig. 20. Cross Section of TP974A—One-Pipe Application.

Operation

Figure 21 shows a TP974A used with a direct-acting RP920A Controller for control of a normally open heating valve. A fall in temperature at the TP974A lowers the signal to the RP920A. The RP920A responds by decreasing the BLP to the valve to admit more hot water to the heating coil.

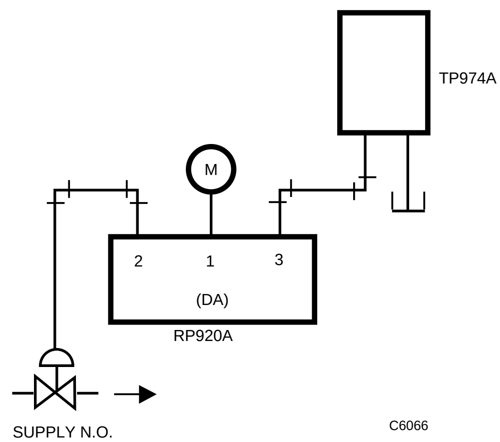


Fig. 21. Typical TP974A Operation.

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