Philip D. Sutherlin 3/12/64

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GLOSSARY OF CONTROL TERMS AND DEFINITIONS

CONTROL ACTION is that manner in which a controller sends its varying output to an operator in response to the controlled variable changes imposed upon its measuring element.

CONTROL AGENT is a source of energy such as steam, water, etc., which is regulated by the controlled device.

CONTROL POINT is the actual value of the controlled variable which the controller is causing to be maintained at a given time.

CONTROL PRESSURE is the output air pressure of a controller.

CONTROLLED DEVICE is the final control element which is actuated by the controller and regulates the flow or effect of the control agent. A valve, damper, relay, etc.

CONTROLLED MEDIUM is the material (such as air in a space) in which a controlled variable such as temperature is controlled.

CONTROLLED VARIABLE is the variable such as temperature, humidity or pressure which is being measured and controlled.

CONTROLLER is an instrument that measures variations in the controlled variable and transmits energy to produce an appropriate corrective control action.

CONTROLLING ELEMENT is the part of a controller which transmits the effect produced by the measuring element for the operation of the controlled device.

CUMULATOR is an auxiliary control device actuated by the pressure from one or more controllers and used to produce a variety of special effects.

DIRECT ACTING applies to a pneumatic controller when an *increase* in the controlled variable results in an increased control pressure.

DIFFERENTIAL is the difference in values of the controlled variable which will activate a two-position controller to change an output of either maximum or zero to the opposite extreme, with no intermediate steps.

FEEDBACK is the transmission of information about the results of an action back to its origin.

FLOATING ACTION moves the controlled device either toward its open or its closed position until the controller is satisfied, or until the controlled device reaches the end of its travel or until a corrective movement in the opposite direction is required. Generally there is a neutral zone in which no motion of the controlled device is required by the controller. When the controlled variable gets outside the differential of the controller, the controlled device is moved in the proper direction.

MASTER CONTROLLER is an instrument whose variable output is used to change the set point of a submaster controller. It may be a thermostat; humidostat, pressure controller, manual switch, etc.

MASTER PRESSURE is the variable output air pressure from the master controller, which changes the submaster controller's set point.

MEASURING ELEMENTS are those elements which ascertain and communicate the value of the controlled variable.

NORMALLY CLOSED applies to a controlled device which closes when all operating force, (control pressure, electric energy) is removed.

NORMALLY OPEN applies to a controlled device which opens when all operating force is removed.

OFFSET is the sustained difference between the set point and the actual control point of the controlled variable. This is also sometimes called drift, deviation, or droop.

OPERATOR is the device which responds to the output of the controller and positions the controlled device.

PROPORTIONAL BAND is the change in controlled variable required to move the controlled device from one extreme limit of travel to the other. It is normally used with respect to recording and indicating controllers and is expressed in per cent of the chart or scale range. (See Throttling Range)

GLOSSARY OF CONTROL TERMS AND DEFINITIONS
(continued)

PROPORTIONAL ACTION is when the output of the controller changes in proportion to the amount of change in the controlled variable.

PROPORTIONAL PLUS AUTOMATIC RESET ACTION is proportional action with the addition of a response which continually resets the control point back toward the set point to reduce the offset. (See Reset Rate)

PROPORTIONAL PLUS RATE ACTION is the combination of proportional action plus a response which precedes the normal proportional response. This response is proportional to the rate of change, or speed, with which the controlled variable deviates from the set point.

RANGE is the limitation between maximum and minimum values within which a device is designed to function.

RANGE OF REMOTE READJUSTMENT the change in set point of a submaster controller for full change in pressure from the master controller.

RATE TIME is the time in minutes that rate action response precedes normal proportional action response.

RELAY is a device where the control of energy flowing in one circuit governs the application of energy flowing in another circuit.

RESET RATE is the number of times per minute that the correction made by the proportional action is duplicated by the reset action. It is usually expressed in "repeats per minute".

REVERSE ACTING applies to a pneumatic controller when an increase in the controlled variable results in a *decreased* control pressure.

SENSITIVITY in pneumatic output control systems, is the number of psi that the control pressure changes per unit change in the controlled variable (psi per degree *temperature;* psi per per cent *relative humidity;* psi control pressure change per psi *pressure change* of control agent).

SET POINT is the point at which a controller is set to maintain a certain controlled variable value. It is the target value which a controller attempts to maintain. It may differ from the control point. (See Offset).

SPRING RANGE is the range through which the control pressure must change to produce total movement of the controlled device from one extreme position to the other.

Nominal Spring Range describes the control pressure range, which applies when there is no load opposing the operator.

Actual Spring Range describes the control pressure range, which will operate the controlled device under actual conditions where it must overcome forces due to fluid flow, friction, etc. in addition to the nominal spring pressures.

SUBMASTER CONTROLLER is a controller whose set point is automatically readjusted from a remote location. The set point is changed over a predetermined range by variations in output from a master controller.

A. *Direct Readjustment:* An increase in master pressure increases the set point.

B. *Reverse Readjustment:* An increase in master pressure decreases the set point.

SUPPLY PRESSURE is the force per unit area (psi) of the compressed air supplied to a controller. It is usually constant at 15 or 20 psig, but it may have some other value in special cases.

THROTTLING RANGE is the change in controlled variable required to move the controlled device from its one extreme limit of travel to the other. (See Proportional Band).

TIMED TWO-POSITION ACTION is a variation of two-position action wherein the "On" periods are prematurely shortened. This may be done by a cam mechanism although it is usually accomplished in electric room thermostats by means of a heat element which is energized during the "On" periods.

TWO-POSITION ACTION is the type wherein the controlled device can be positioned only to either a maximum or minimum position, with no intermediate steps.

PNEUMATIC
TEMPERATURE
CONTROL
SYSTEMS

for Heating—Cooling
Ventilating
Air Conditioning
Industrial Processing

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Pneumatic Temperature Control

A control system is a grouping of instruments or devices that regulate or control a variable and maintain it at a predetermined value. The variable may be temperature, humidity or pressure.

A pneumatic control system, Fig. 1, consists of four essential parts:

(1) Air compressor, filter and reducing station

(2) Air piping and distribution system

(3) Controllers (thermostats, humidostats, pressure regulators, etc.)

(4) Controlled devices (valves, damper operators, etc.)

Air from the compressor is supplied to each controller at a constant pressure, usually 15 psi, and the controller in turn is connected by air pressure piping to the valve or damper operator it actuates. The function of the controller is to apply a varying air pressure to the controlled device. The controller acts as an automatic pressure reducing valve regulating the air pressure to the controlled device in accordance with the controlled variable.

COMPRESSORS AND ACCESSORIES

The air compressors furnished for these systems vary in size and capacity and usually operate in a range of 70 to 80 psi. The size of the compressor depends on the size of the control system and the number of control units that must be supplied with air.

All air compressors are equipped with a filter and reducing valve assembly. The filter will remove any moisture or impurities that may be present in the air. Air pressure is reduced from the 80 psi to a usable constant supply by the reducing valve.

A typical air filter and reducing valve station for single pressure systems using single temperature controllers is shown in Fig. 2.

In cases where two-temperature thermostats are used, a dual supply pressure system is incorporated, Fig. 3. The normal dual supply pressures are 15 psi and 19 psi. The lower supply pressure is used for the "day" cycle of dual thermostats and the "heating" cycle of heating-cooling thermostats. The higher supply pressure is used for the "night" cycle of dual thermostats and the "cooling" cycle

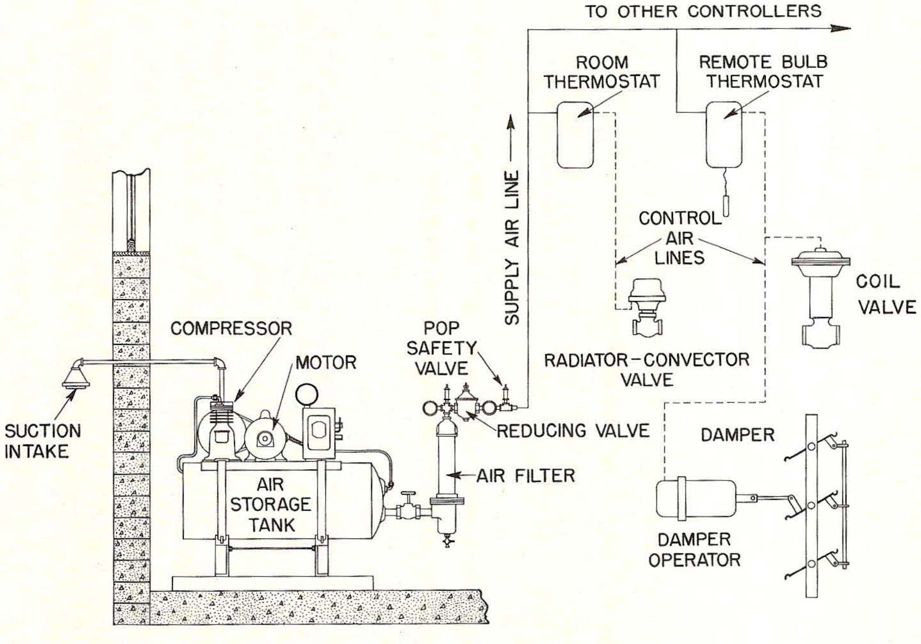


Fig. 1: Typical Pneumatic Control System Showing The Various Components

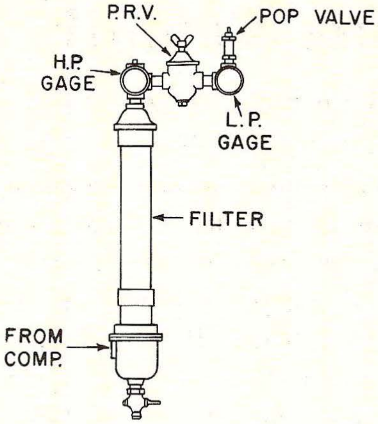


Fig. 2: Single Pressure System

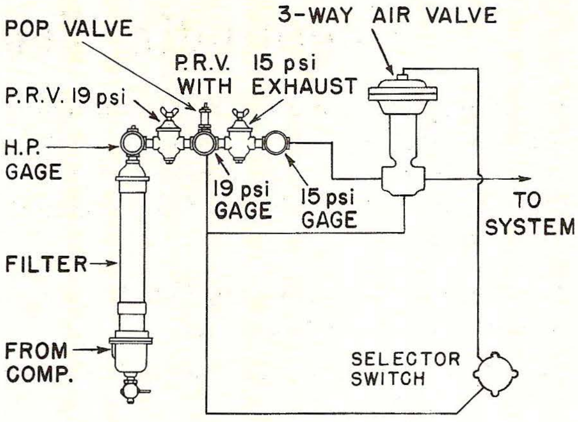


Fig. 3: Dual or Two Pressure System

of heating-cooling thermostats. Switching from one pressure to the other is accomplished by using three-way valves and pneumatic switches.

Air piping is usually galvanized iron pipe or copper tubing. In some cases where complete protection is assured plastic tubing is used. Most air piping for the control system is concealed within the building structure.

CONTROLLERS

A controller is an instrument that measures variations in temperature, humidity or pressure and changes its output pressure or control pressure accordingly.

Controllers are classified as either direct or reverse acting. A direct acting controller increases its control pressure with an increase in temperature, humidity or pressure, (controlled variable) and a reverse acting controller decreases its control pressure with an increase in the controlled variable.

In order for the control system to function properly each controller must react in a specified manner. Controllers are furnished for two types of action.

Two-Position (Positive) Action

The control pressure is either at a maximum or minimum with no intermediate steps. This type of controller produces "on-off" control with the controlled device in either of two positions — open or closed.

Proportional (Gradual) Action

The control pressure varies in proportion to the change in the controlled variable. This type of controller produces gradual action of the controlled device, with the controlled device positioned to any intermediate position between fully open and fully closed.

Since the controller acts as an automatic pressure reducing valve it must operate in a manner similar to that of a reducing valve. Figure 4 shows a typical reducing valve. Turning the adjusting screw to compress the adjusting spring causes the main valve to open, allowing the output pressure to increase. The output pressure acts on the diaphragm to oppose the spring and when this pressure is equal to the pressure from the spring the main valve closes. Turning the adjusting screw to reduce the spring force allows the output pressure, acting on the diaphragm, to open the exhaust valve. For every value of spring force there is a corresponding value of output pressure.

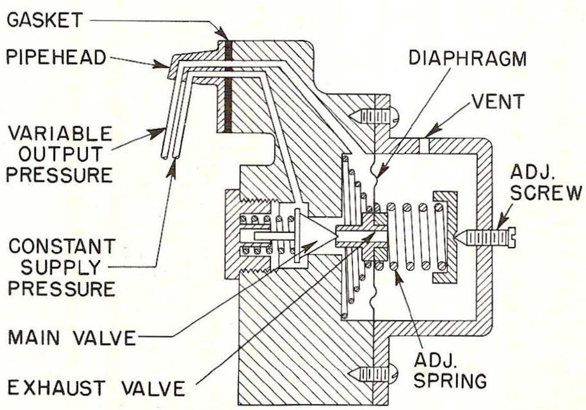


Fig. 4: Pressure Reducing Valve

From Fig. 5 it can be seen how this reducing valve principle is applied to the relay of a thermostat. The lower diaphragm is the same as the diaphragm shown in Fig. 4. The spring and adjusting screw have been replaced by the upper diaphragm. Supply air pressure which is connected to the pin valve, passes through the chamber to the upper diaphragm and to atmosphere through the control port.

The pin valve is adjusted so that when the control port is wide open, only a slight pressure exists in the upper diaphragm chamber. When the control port is closed, full supply pressure exists in this chamber. Any intermediate opening of the control port results in a proportionate pressure between minimum and maximum. Thus the variable pressure in the upper diaphragm chamber replaces the spring and adjusting screw of Fig. 4.

The control port in the room thermostat is opened and closed by the action of the bimetal element which bends as the temperature changes.

Most Johnson controllers use the relay as described above, and a suitable measuring element arranged to operate the control port. Figures 6 thru 13 show typical controllers with all important components labeled. Most of these controllers have an adjustable sensitivity. Sensitivity is defined as the psi change in control pressure per unit change in the controlled variable.

The non-relay thermostat, Fig. 14, uses the control port pressure directly as the control pressure. The rod and tube element regulates the control port lid which decreases the control pressure by opening the control port or causes the control pressure to increase by closing the control port.

This type of thermostat is limited in air capacity and is used only in certain applications.

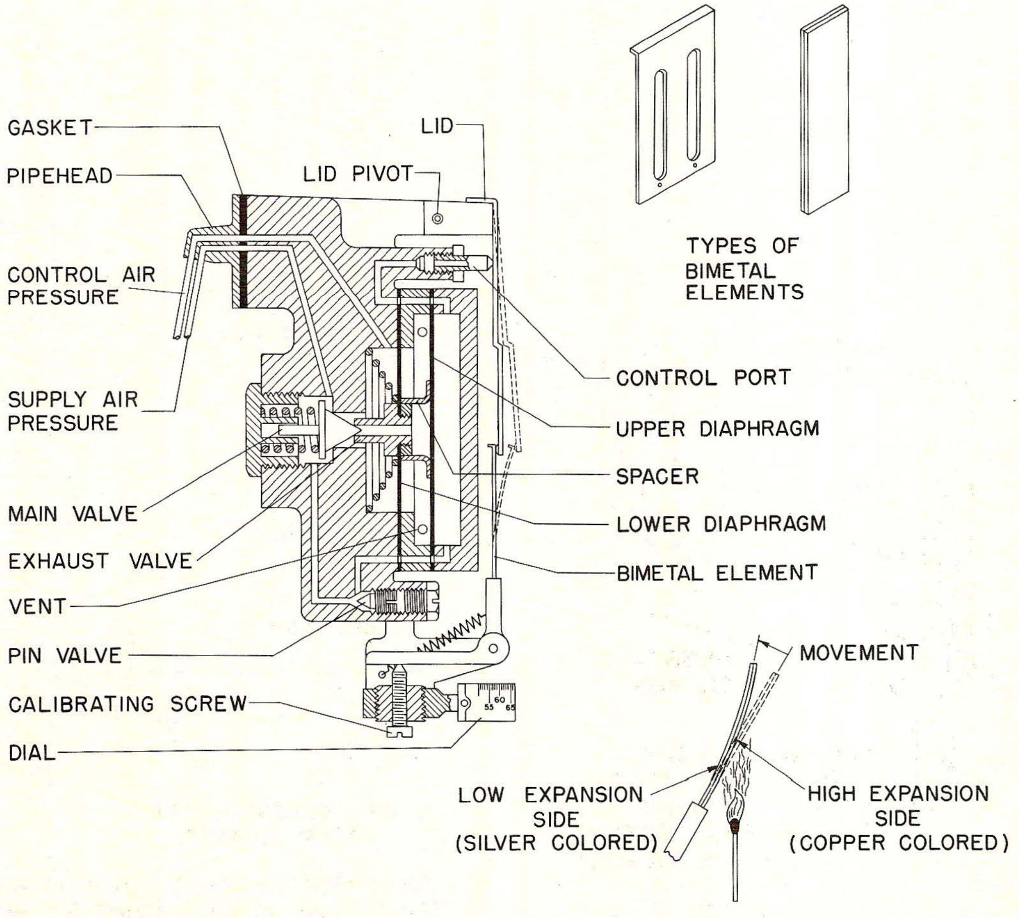


Fig. 5: Room Thermostat and Bimetal Elements

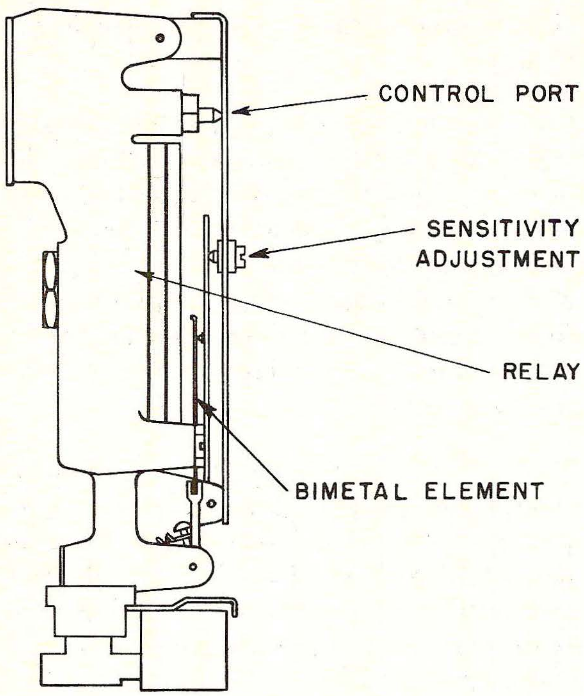


Fig. 6: Bimetal Thermostat With Sensitivity Adjustment

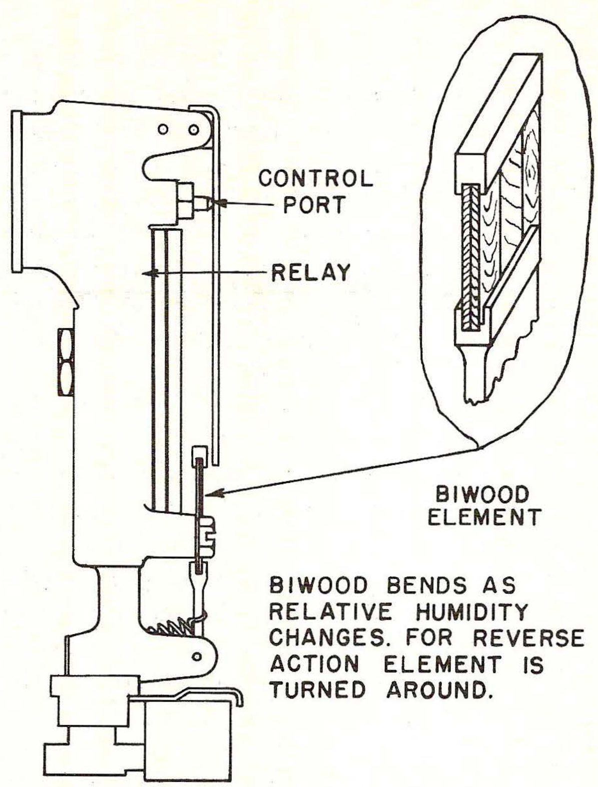


Fig. 7: Biwood Humidostat

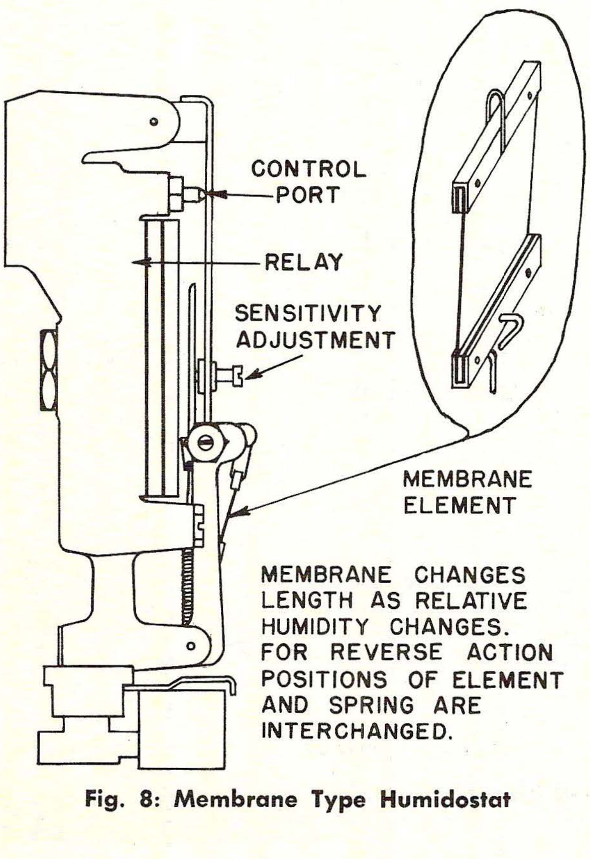
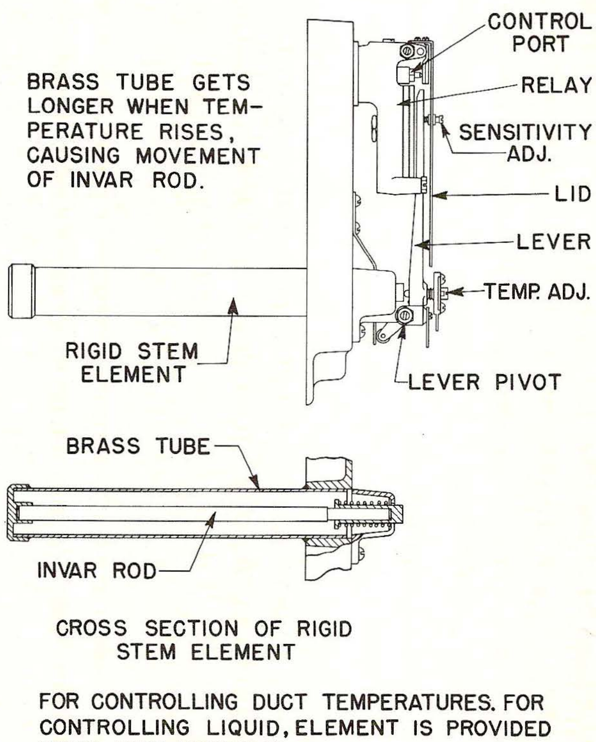


Fig. 8: Membrane Type Humidostat



FOR CONTROLLING DUCT TEMPERATURES. FOR CONTROLLING LIQUID, ELEMENT IS PROVIDED WITH PIPE THREADS.

Fig. 9: Rigid Stem Insertion Thermostat

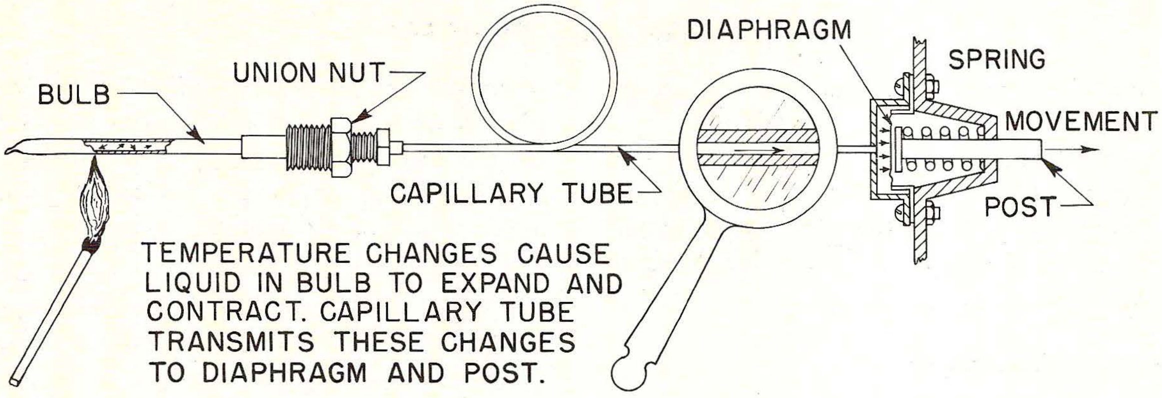


Fig. 10: Liquid Filled Remote Bulb Element

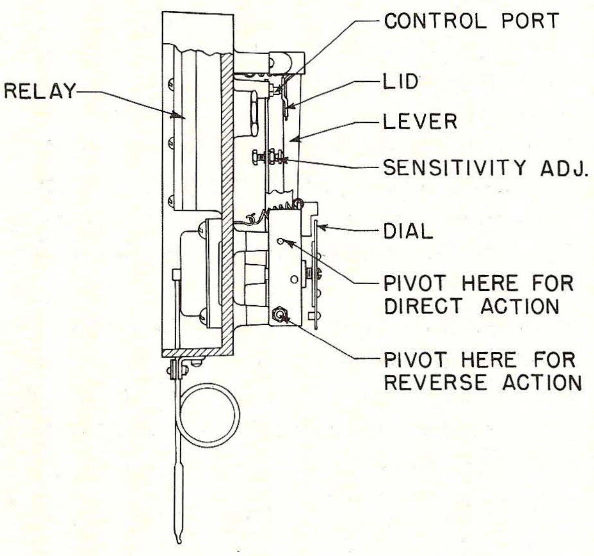


Fig. 11: Thermostat With Remote Bulb Element

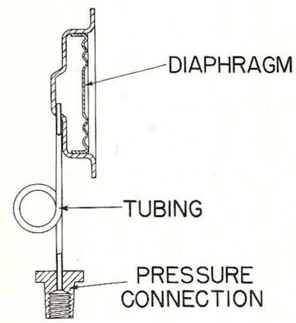


Fig. 12: Pressure Element

(RELAY NOT SHOWN) FOR PRESSURES OR VACUUMS UP TO 10" WATER GAGE

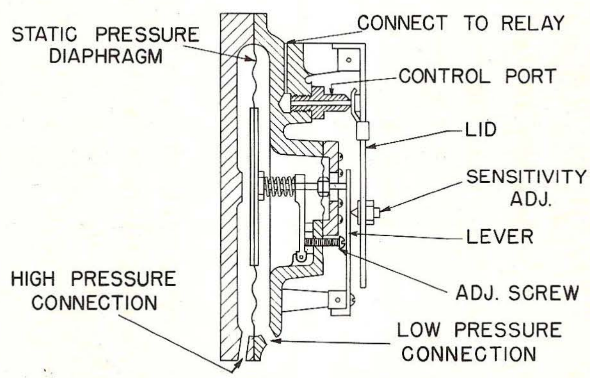


Fig. 13: Static Pressure Regulator

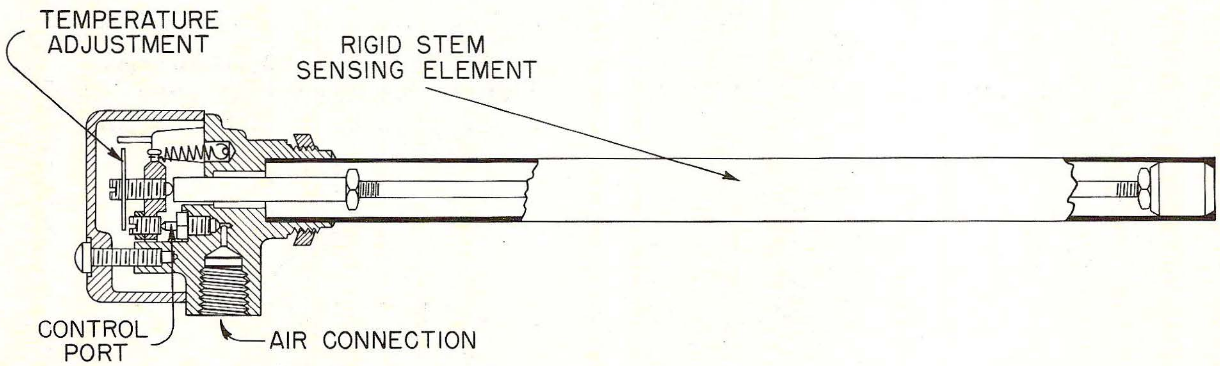


Fig. 14: Non-Relay Thermostat

CONTROLLED DEVICES

A controlled device is the final piece of equipment in a control system that regulates the controlled variable in accordance with the demands of the controller. This device is usually a valve controlling the flow of water or steam or a damper operator regulating a damper to control air flow.

Damper Operators

Damper operators are available in two styles, the metal bellows type and the piston type. The majority of damper operators are of the piston type.

This operator has a long powerful straight stroke which requires no lever arrangements. Air from the controller is applied to the molded diaphragm which has a positive seal to prevent air leakage, Fig. 15. This air pressure expands the diaphragm forcing the piston and stem outward against the force of the spring. The movement of the piston varies proportionally with the air pressure applied to the diaphragm. This air pressure, from the controller, varies over the full pressure range.

The spring returns the operator to its normal position when the air pressure is removed from the diaphragm. Full movement of the operator can be restricted to set limits by using various spring ranges. The most common spring range is 5 to 10 psi. With this spring the operator is in its normal position when the air pressure applied to the diaphragm is 5 psi or less. Between 5 and 10 psi the stroke will be proportional to the air pressure in the diaphragm. Above 10 psi the operator will be at its maximum stroke.

Piston operators can be mounted on the damper frame and coupled directly to the damper blades. In some cases the operator is mounted on the ductwork and coupled to the damper blade axis through a crank arm and linkage arrangement. Reversal of the action of the operator on the damper is obtained by mounting the operator in the opposite direction.

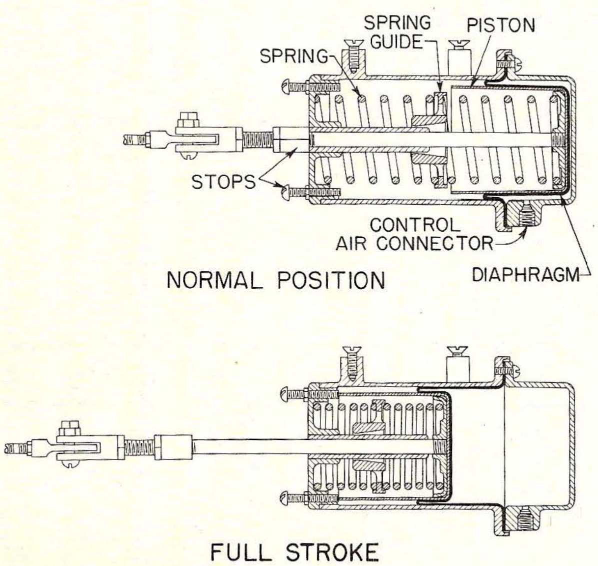


Fig. 15: Piston Damper Operator

Dampers

There are many sizes and styles of dampers each depending on the installation and purpose. However, there are four basic types. Figure 16 shows a proportioning type with the blades rotating in the opposite directions. A damper with parallel blades is shown in Fig. 17. A mixing damper can be seen in Fig. 18 and Fig. 19 is a volume type damper. Depending on the function of the damper the blades may be normally open or normally closed. The mixing damper, Fig. 18, has one set of blades normally open and the other set normally closed.

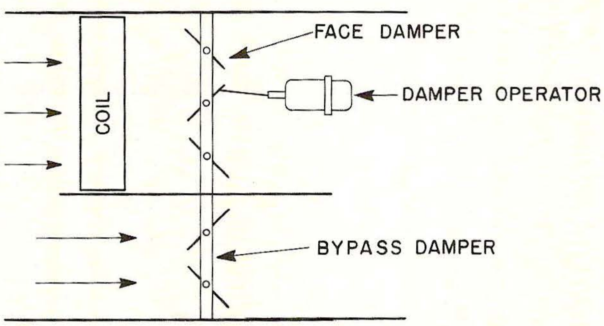


Fig. 16: Face and Bypass Damper Proportioning Type With Opposed Blades

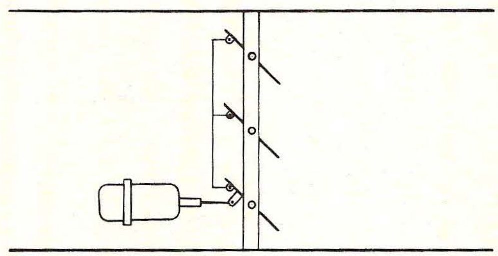


Fig. 17: Damper With Parallel Operating Blades

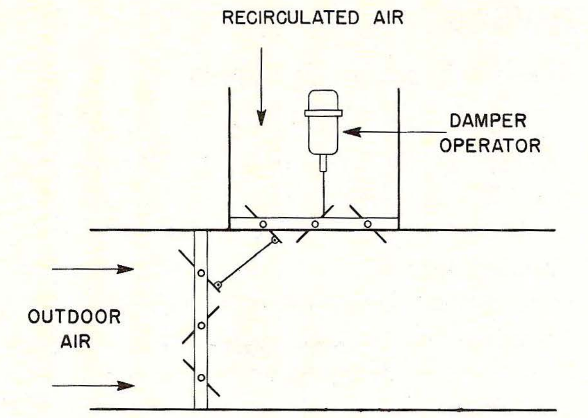


Fig. 18: Outdoor and Recirculated Air Mixing Damper Proportioning Type

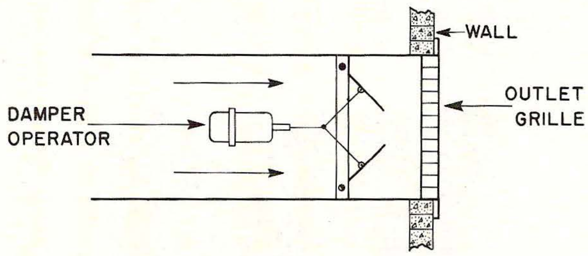


Fig. 19: Volume Damper

Valves

Johnson valves are available in two types, "sylphon" or metal bellows operated and diaphragm operated. Sylphon bellows operated valves are used mainly on radiators, convectors and unit ventilators where mounting space is limited. Diaphragm valves are used on larger heating and cooling coils of central or zoned systems.

There are many body patterns available to meet the various piping arrangements. Also there are a great number of inner valves available each with a different flow characteristic.

The valves function in the same manner as the piston damper operators. Air from the controller is applied to the reinforced rubber diaphragm which expands and opposes the force of the spring. This causes the valve stem and disc to move toward the seat of a normally open valve. When air is removed from the diaphragm the spring will return the stem and disc to their normal position.

There are many valve body patterns available to suit all applications and installations. However, there are only three basic body styles and all patterns fall into one of these styles: normally open, normally closed and three-way.

The normally open valve will close when air pressure from the controller is applied to the diaphragm. A normally closed valve will open when the air pressure from the controller is applied to the diaphragm. The other type is the three-way valve. This may be called a mixing, a diverting or a bypass valve. There are three connections on this type, common, normally open and normally closed. The mixing valve has two inlets and one common outlet. Air pressure from the controller regulates the inner valve so that the entire flow is from either one of the two inlets or a portion from both. Bypass or diverting valves have one inlet and two outlets. The flow is directed to either one of the two outlets when air pressure from the controller is applied to the valve operator. Any portion of the flow can be directed to both outlets by an intermediate air pressure in the operator.

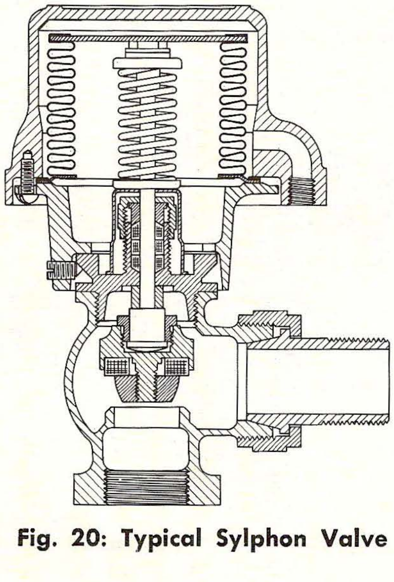


Fig. 20: Typical Sylphon Valve

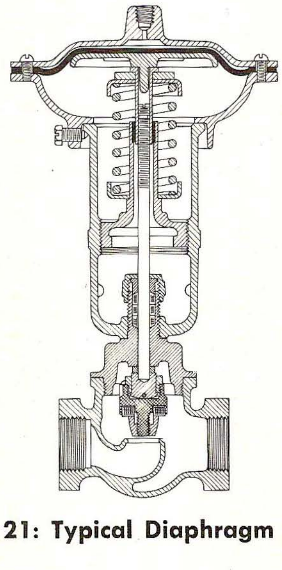


Fig. 21: Typical Diaphragm Valve

Cumulator

A cumulator is a device that is used to accumulate the effect of two or more controllers operating a single controlled device. It can also be used to reverse the action of a controller or to convert from proportional to two-position action. Cumulators are similar to relays except that they have no restrictor or control port. The variable pilot pressure which determines the control pressure is received from another controller. Figure 22 illustrates the use of a cumulator where it is desired to have either controller open the single controlled device but both must be satisfied in order to close it.

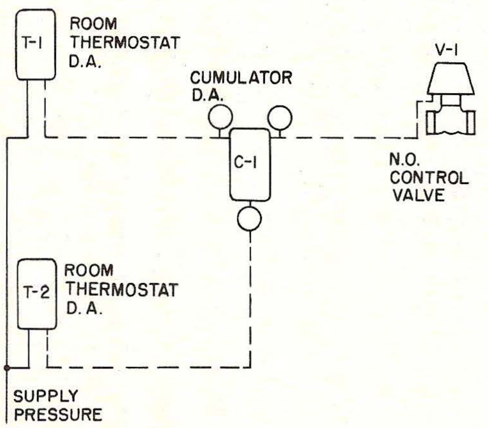


Fig. 22: Cumulator Used With Two Associated Controllers and One Controlled Device

Pressure Electric Switches

Pressure electric switches, Fig. 23, are actuated by air pressure from a controller to open or close an electric circuit. Starting and stopping fans, compressors or pumps are common applications of these switches. All air compressors, which were referred to on page 1, use a pressure electric switch to start and stop the motor to maintain a constant supply pressure.

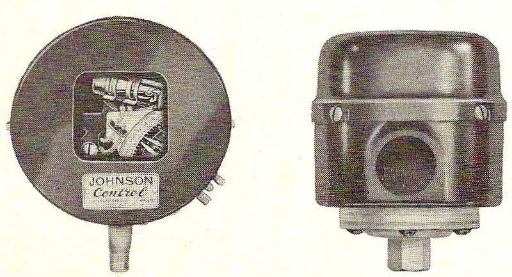


Fig. 23: Pressure Electric Switches

Electric Pressure Switches

Electric pressure switches or solenoid air valves, Fig. 24, are installed where the control of a pneumatically operated device is dependent on an electric circuit. When the electro-magnetic coil is energized by an electric circuit the solenoid air valve will be positioned to allow air to pass. This will then supply air to the pneumatic devices. When the electric circuit and the coil are de-energized air will be exhausted and the pneumatic devices will return to their normal position. A common use is to close an outdoor air damper whenever the fan stops running.

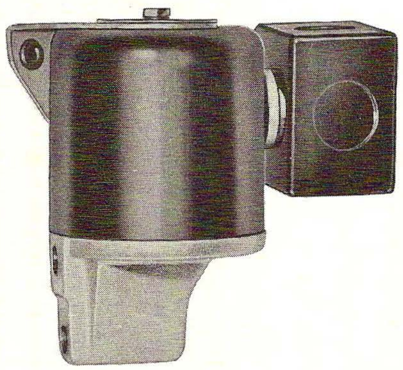


Fig. 24: Three-Way Solenoid Air Valve

Three-Way Air Valves

For installations where large volumes of air must be switched from a remote point, three-way air valves are used. The valve, Fig. 25, may be actuated by a manual pneumatic switch or a two-position controller. Three-way valves are also used on dual systems to switch from one pressure to the other.

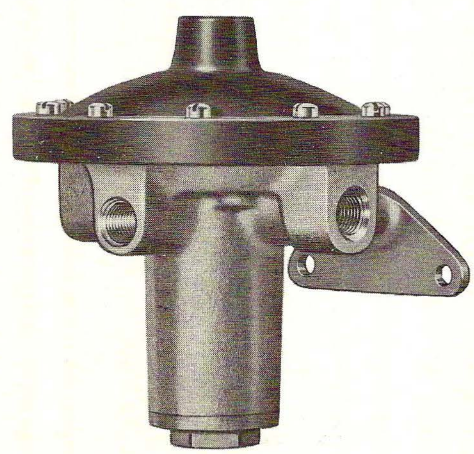


Fig. 25: Three-Way Air Valve

Manual Pneumatic Selector Switches

In many pneumatic control applications it is necessary to provide manual settings of control equipment, or to provide a manual means of switching. For this purpose manual switches such as the one shown in Fig. 26, are furnished. These are available in two, three or four position selector models.

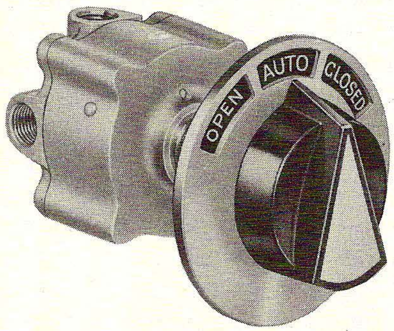


Fig. 26: Three-Position Selector Switch

Pneumatic Gradual Switch

Proportional manual control is necessary many times. For these applications a gradual switch, Fig. 27, is used. This is a very accurate pressure reducing valve that can be adjusted conveniently by turning a knob. A graduated dial makes it possible to set the gradual switch at the proper setting each time.

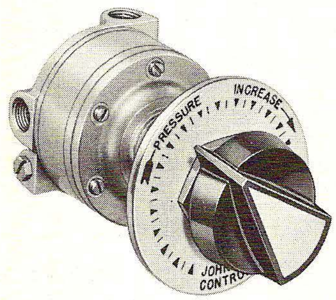


Fig. 27: Gradual Switch

TYPICAL APPLICATIONS

It has previously been explained that the source of power for a pneumatic system of temperature and humidity control is an air compressor and an air storage tank. On some large industrial and commercial installations, a source of air under pressure is already available and no additional air compressor is needed. For explanation purposes, however, an air compressor and storage tank are used as illustrated in Fig. 1, page 1.

Some of the basic control arrangements, which are suitable to a large variety of installations, will be discussed briefly. These basic arrangements, with a few minor changes and additions, can be used to cover a wide range of applications.

Individual Room Control

The most familiar of all temperature control installations is the single temperature room thermostat and radiator valve, Fig. 28, controlling direct radiation.

It often is advantageous from the standpoint of economy, to use a two-temperature or dual thermostat for the control of direct radiation and other applications. This type of thermostat is used where two different temperature levels are desired, usually "day" and "night".

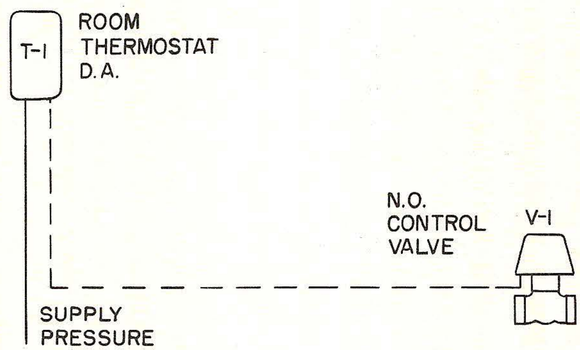


Fig. 28: Simple Control Combination

The changeover, from day to night, may be accomplished either manually through a selector switch, Fig. 29, or automatically by a clock as shown in Fig. 30. Another familiar two-temperature room thermostat is the "heating-cooling" thermostat used in conjunction with year 'round air conditioning systems. This thermostat is arranged to control as a direct acting thermostat during the winter heating cycle and as a reverse acting thermostat during the summer cooling cycle. The changeover from one cycle of control to the other may be either manual, from a selector switch, or automatic from another thermostat located either in the outdoor or return air. In both dual and heating-cooling systems, changeover is accomplished by changing the air pressure supplied to the thermostats.

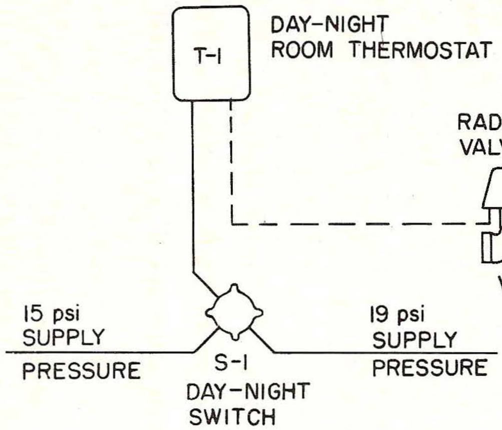


Fig. 29: Day-Night Thermostat and Radiator Valve Manual Change Over

Air Distribution Systems

Air distribution systems, whether used for ventilating only, for heating and ventilating combined or for year 'round air conditioning, require more control equipment and control combinations than do the ordinary direct radiation control installations. Central fan systems consist of many individual parts designed to perform the following functions:

1. Ventilating
2. Heating
3. Humidifying
4. Cooling
5. Dehumidifying
6. Air Distribution

There are, of course, many ways in which equipment may be arranged to perform any or all of the above functions. The way in which the equipment is arranged will determine the type of controls and the arrangement of those controls which should be used.

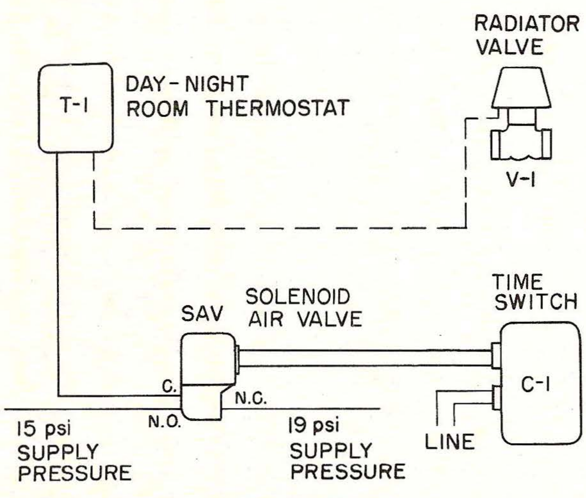


Fig. 30: Day-Night Thermostat and Radiator Valve Automatic Change Over

However, only basic control arrangements can be discussed here.

Damper Control

100% Outdoor Air

Many systems, used for ventilation only, require 100% opening of the outdoor air dampers whenever the fan is in operation. This is accomplished by the use of a solenoid air valve, interconnected with the fan motor circuit. Whenever the fan is started, the solenoid air valve is energized and supplies control pressure to the damper operator, opening the outdoor air damper. Whenever the fan is stopped, the solenoid air valve is de-energized, exhausting the control pressure line and providing automatic closing of the outdoor air damper. Figure 31 shows typical outdoor air damper control of this type.

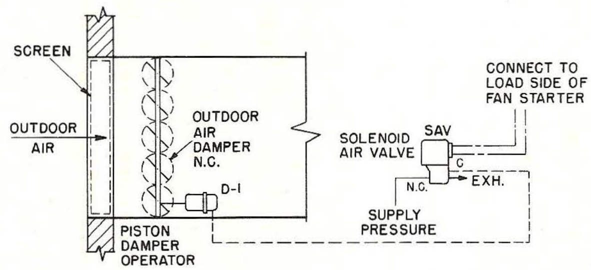


Fig. 31: Outdoor Air Damper Control (100% O.A.)

Manual Control of Outdoor Air Damper

If manual positioning of the outdoor air damper is required, whenever the fan is running, a gradual switch, as shown in Fig. 32, is installed in the control pressure line of the solenoid air valve. This gradual switch controls the amount of air supplied to the damper operator and limits the maximum opening of the outdoor air damper whenever the fan is in operation.

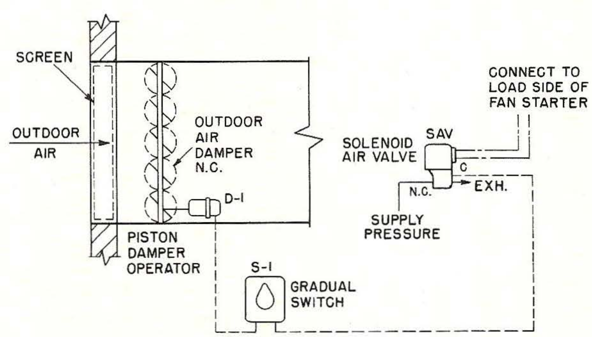


Fig. 32: Outdoor Air Damper Control (Manual Selection of Damper Opening)

Mixture of Outdoor and Return Air

Many systems are designed to provide a mixture of outdoor and return air, in order to maintain a constant entering air temperature to the heating coil. Figure 33 illustrates a system where minimum outdoor air is supplied at all times except when overheating occurs. Whenever an overheated condition occurs, the maximum section of the outdoor air and return air dampers are modulated by a thermostat located in the mixture of outdoor and return air. Because of stratification, the problem of locating the mixing chamber thermostat properly is a difficult one, and unless there is assurance that stratification will not occur, an averaging type element, which can be strung back and forth across the entire mixing chamber, should be used.

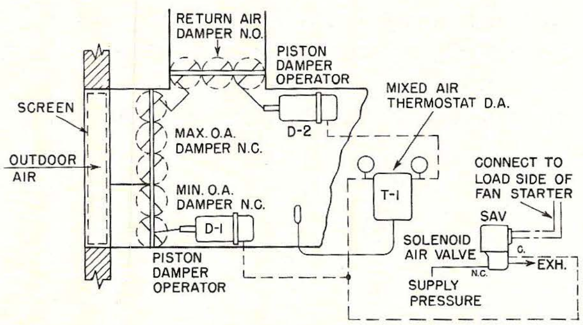


Fig. 33: Outdoor Air Damper Control (Mixing Chamber Control)

Outdoor Air and Return Air Damper Control From Fan Discharge

Another method of admitting additional outdoor air to the space, whenever an overheated condition exists, is to transfer the control to the discharge thermostat which might operate as a submaster.

Figure 34 illustrates a control system in which return air thermostat T-1 readjusts submaster thermostat T-2, in the discharge air, in accordance with the heat demands of the space. T-2 in turn controls heater steam valve V-1 in sequence with outdoor and return air damper operator D-2. As the return air temperature rises, T-1 readjusts T-2 to control the discharge temperature at a lower value. T-2 then modulates steam valve V-1 toward the closed position, lowering the discharge temperature. On a further demand for decreased discharge temperature, T-2 modulates maximum outdoor damper toward the open position and return air damper toward the closed position. The reverse operation takes place on a decrease in return air temperature.

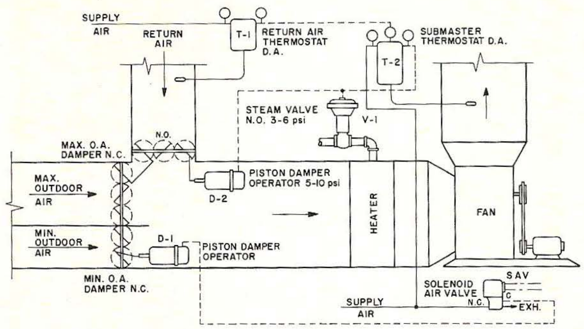


Fig. 34: Outdoor Air Damper Control From Fan Discharge Thermostat

Heating Coil Control

Fan systems, used for ventilating purposes only, require a tempering coil. The control of this coil is usually accomplished by a thermostat located in the fan discharge. In systems used for both heating and ventilating, such as blast systems, the heater coil generally is controlled from the return air or space temperature, through a low limit discharge thermostat. There are a number of different methods used in controlling heating coils, the most common of which is the coil valve. Figure 35 shows a discharge thermostat controlling a coil valve on a heating coil.

The face and bypass damper method of control is preferred, in some installations. In this type of hook-up, as shown in Fig. 36, the coil is supplied with steam or hot water at a constant temperature and the discharge temperature is controlled by positioning the face and bypass dampers.

Some engineers prefer the operation of the coil valve and bypass damper to control heat delivery to a space. Figure 37 shows a system in which the steam valve and bypass damper

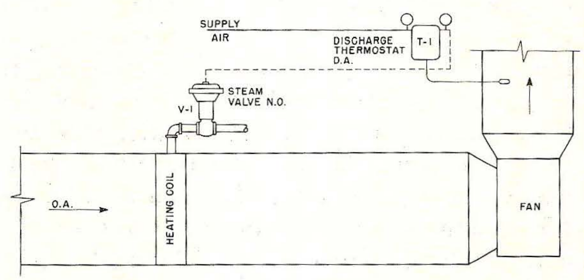


Fig. 35: Heating Coil Control From Fan Discharge

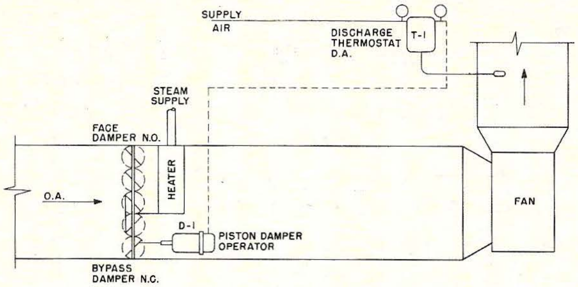


Fig. 36: Control of Heat Supply Using Face and Bypass Dampers

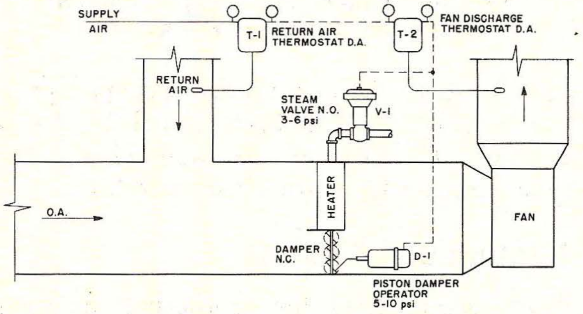


Fig. 37: Control of Heat Supply Using Sequence Operation of Coil Valve and Bypass Damper

are operated in sequence by a return air thermostat, through a low limit discharge thermostat. As the return air temperature rises, the steam valve is throttled to the closed position and the bypass damper opens, thus reducing the heat delivery to the space. Still others prefer to combine the control of the face and bypass dampers with the control of the coil valve. In this application, the return air thermostat controls the valve and the face and bypass dampers in sequence, through low limit discharge thermostat. On rising air temperatures, the return air thermostat first throttles the valve, then opens the bypass damper and closes the face damper. The reverse action takes place on falling temperature.

In the cooler climates it is almost always necessary to preheat the incoming outdoor air. Where an arrangement of minimum and maximum outdoor air dampers is used, only the air passing through the minimum section need be preheated. In 100% outdoor air systems, all incoming air must be preheated. It is general practice to locate the control for the preheater coil in the outdoor air, arranged to start to open the coil valve at about 40 F and to have the valve fully open at 33 F to 35 F. Some systems are designed to supply a constant temperature of air leaving the preheaters. These systems will have the preheat control located in the preheater discharge.

Figure 38 shows a 100% outdoor air system, with control located in the outdoor air, and Fig. 39 indicates a system employing minimum and maximum outdoor air dampers, with control located in the preheater discharge.

Humidification

Systems used for heating require the addition of moisture to the air, to maintain the proper relative humidity conditions. The relative humidity controller is located either in the space proper or the return air. Pan humidifiers, water sprays, and steam grid humidifiers are the most common types of humidifying equipment. The limited capacity of pan humidifiers makes their use advisable only on installations where moisture requirements are low. Steam grid humidifiers should be used only on installations where there will be no objections to odors of boiler compound and where low pressure steam is available. Water sprays in all probability will be found most satisfactory in comfort air conditioning work. Humidity controls always are arranged so that the valve

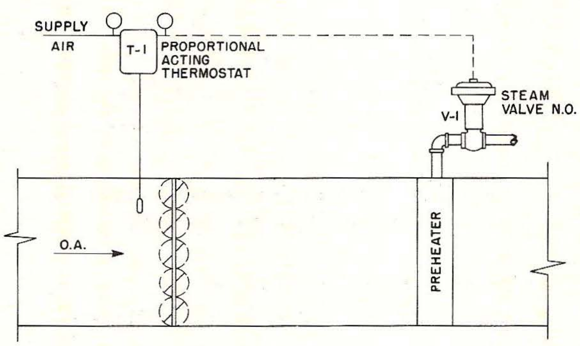


Fig. 38: Typical Preheater Control For 100% Outdoor Air System

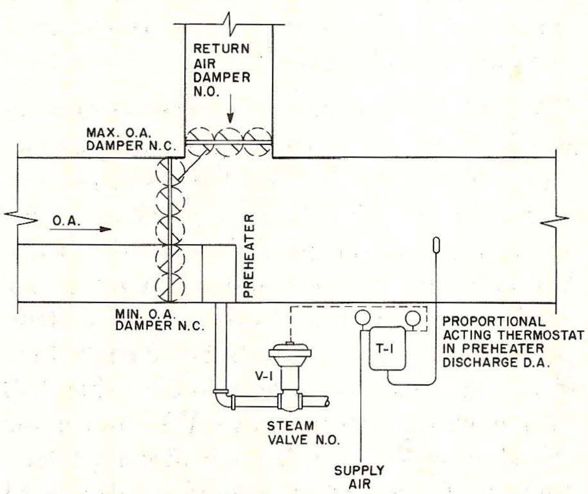


Fig. 39: Typical Preheater Control (Minimum Outdoor Air)

controlling the steam to the grid or pan humidifier or the water to the spray nozzles will close whenever the fan is stopped.

Two-position controllers are used to regulate valves on spray humidifiers because throttling valves on most types of spray equipment will cause improper atomization of the water from the spray nozzles. Either two-position or proportional action controllers may be used with pan or steam grid humidifiers. Figure 40 illustrates a typical steam grid humidifier

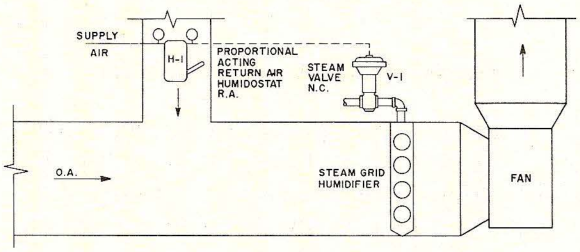


Fig. 40: Typical Control of Steam Grid Humidifier

installation. A proportional action room or return air humidostat controls the normally closed steam valve in the steam supply to the humidifier. The supply pressure to the humidostat is furnished from the control pressure of a solenoid air valve, which is interconnected with the fan motor starter so that the controller operates only when the fan is running and the valve is closed when the fan is stopped. Figures 41 and 42 show typical applications of pan and water spray humidifiers.

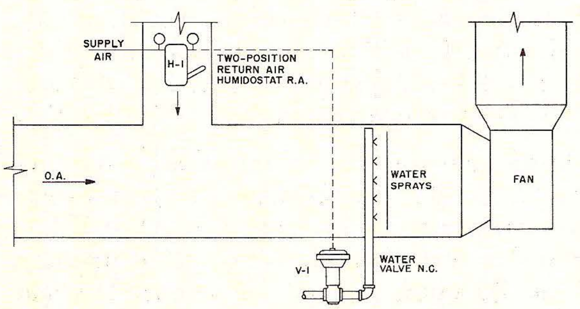


Fig. 41: Typical Humidity Control Using Water Sprays

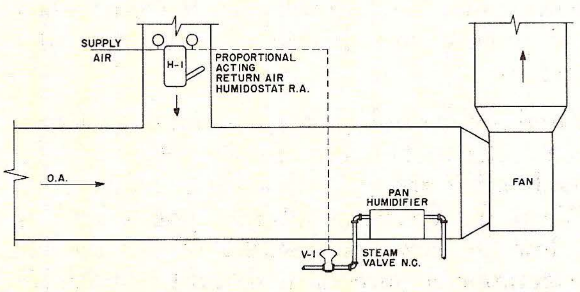


Fig. 42: Typical Control of Pan Humidifier

Cooling Control

The simplest, and one of the most frequently used control systems for small and medium sized cooling installations is starting and stopping the cooling compressor from a thermostat located in the conditioned space or return air duct. Figure 43 illustrates such a hook-up. On rising room temperature, room thermostat T-1 increases its control pressure to position-pressure electric switch PE-1, to start the cooling compressor. The reverse action takes place on falling temperature.

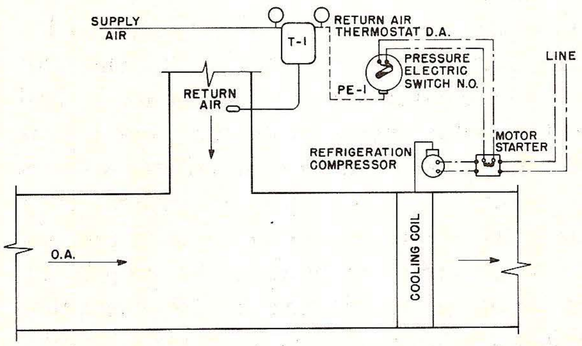


Fig. 43: Typical Cooling Control by Starting and Stopping Cooling Compressor

There are a number of different methods for controlling direct expansion coils in cooling installations. One of the more common, especially on small installations, is to control the flow of refrigerant to the coil, either by the operation of a solenoid liquid valve, or through the use of a modulating attachment on the thermostatic expansion valve. Figure 44 shows a control system employing the use of the solenoid valve while Fig. 45 shows a modulating attachment applied directly to the expansion valve.

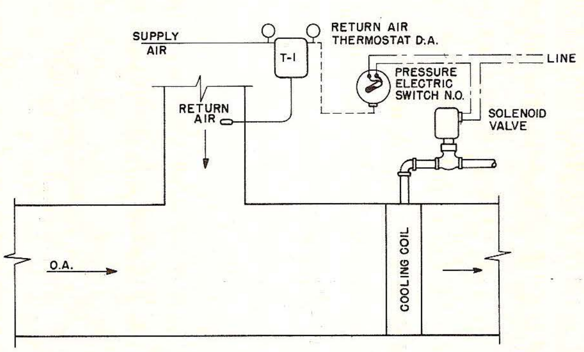


Fig. 44: Typical Cooling Control when Refrigerant Flow to Coil is Controlled by Solenoid Valve

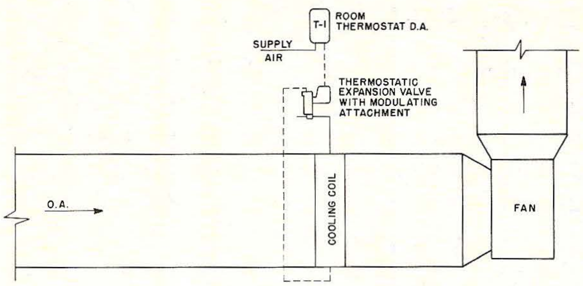


Fig. 45: Typical Control of Thermostatic Expansion Valve Equipped with Modulating Attachment

In many systems which use a direct expansion or chilled water coil, the control is accomplished by the operation of the face and bypass dampers as shown in Fig. 36. The most common control, where chilled water is used as the cooling media, is the three-way bypass or mixing valve. In those installations where a mixing valve is employed, chilled water from the cooler and return water from the coils are mixed to produce the proper coil temperature, as dictated by the controller. When a bypass valve is used, the controller positions the valve to allow chilled water either to pass through the coil or to be bypassed around the coil, in order to maintain the required temperature. Figure 46 illustrates a typical mixing valve application.

Many large, year 'round air conditioning systems, which require independent control of temperatures and relative humidity, employ air washers. In these systems, the air is cooled to the dew point temperature, which is required to maintain the desired relative humidity, and then is reheated to the proper dry-bulb temperature. Figure 47 illustrates a typical air washer system with reheater control. Air washer systems are used for humidification during the heating season and for dehumidification during the cooling season.

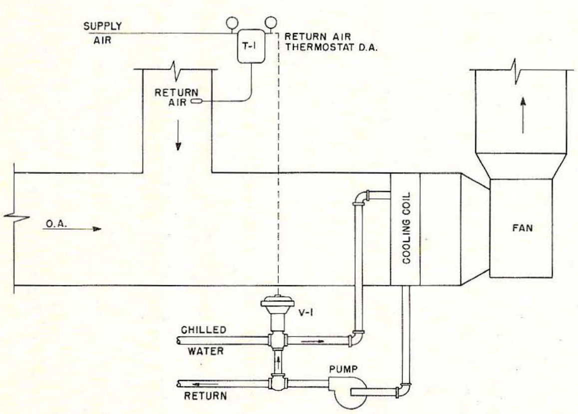


Fig. 46: Typical Three-Way Mixing Valve Control

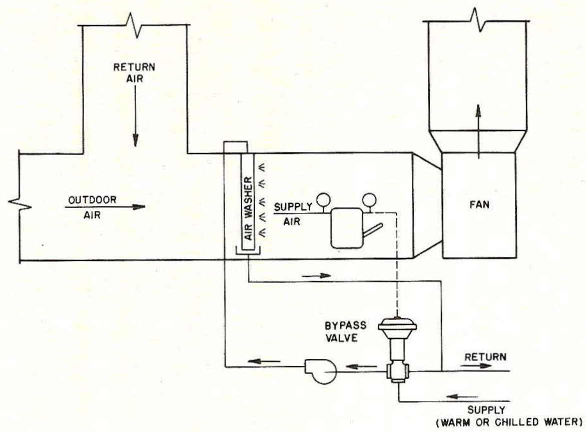


Fig. 47: Typical Dewpoint Control

Year Round Air Conditioning System

By combining some of the simple basic control systems it is possible to make a complete control system for a year 'round air conditioning system. This system is shown in Fig. 48. Assuming a control condition of 50% relative humidity and a space temperature of 75 F the operation is as follows:

Heating Cycle

When the fan starts, solenoid air valve SAV is energized and passes maximum air pressure to open the minimum outdoor air damper D-1. The SAV also switches three-way air valve VA-1 so that preheat discharge thermostat T-1 can operate dampers D-2, D-3 and D-4. T-1 also operates preheat coil valve V-1.

On an increase in temperature after the preheat coil, T-1 increases its control pressure proportionately to shut off V-1. After V-1 is closed a further increase in control pressure from T-1 opens outdoor air damper D-3 and exhaust air damper D-4 and closes return air damper D-2. D-4 operates in direct proportion to D-3. The reverse cycle occurs when the preheat coil discharge temperature decreases.

Humidity controller H-1 maintains a 50 per cent relative humidity in the return air by modulating the grid humidifier valve V-2. When the discharge of the cooling coil is below the dew point setting of T-2 the refrigeration compressor is shut off by pressure electric switch PE-1.

Cooling Cycle

When the outdoor temperature increases to 50 F two-position summer-winter switchover thermostat T-3 exhausts its control pressure which cuts off the supply air to:

1. H-1 allowing V-2 to close
2. T-1 which allows D-3 and D-4 to close and D-2 to open

As the cooling coil discharge temperature increases because of the additional return air, T-2 will start the refrigeration compressor through PE-1 and modulate bypass valve V-3 to maintain a dew point temperature of 55 F.

When the fan is shut off, SAV exhausts the air from its common line and closes D-1, D-3 and D-4 and opens D-2 during the heating cycle. During the cooling cycle D-1 only closes because D-3 and D-4 are closed and D-2 is open due to the action of T-3.

Room Control

Room thermostat T-4 acting as a master, resets submaster thermostat T-5 to a lower discharge temperature as the room temperature increases, and to a higher discharge temperature as the room temperature decreases. T-5 modulates V-4 to maintain the desired discharge temperature as dictated by T-4.

Induction System

An induction air conditioning system may be described as one in which a supply of conditioned primary air is distributed from a central source through high velocity ducts to room induction units where it induces a flow of recirculated room air through the unit coil, discharging the mixture into the space to be conditioned. From this definition, it is apparent that the induction system consists of three major components:

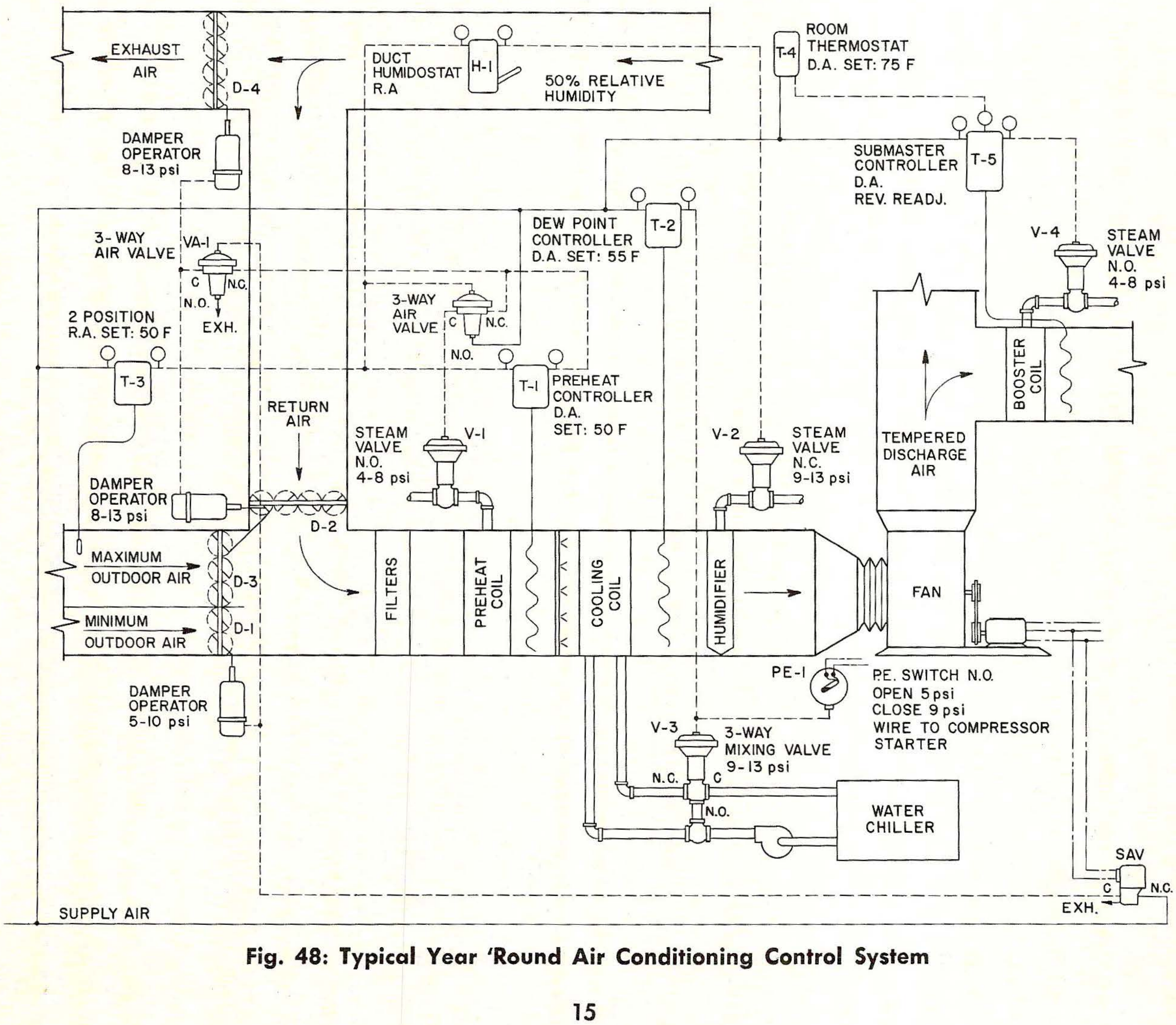


Fig. 48: Typical Year 'Round Air Conditioning Control System

1. The primary air system
2. The individual room induction units containing a secondary coil
3. A source of primary and secondary water supplied to the primary air unit and the individual unit coils, respectively

Induction systems are designed to provide year around air conditioning to the perimeter zones of multi-room, multi-story buildings, with individual temperature control in all spaces of these zones. Because perimeter exposures present difficult problems relating to solar and transmission factors, they must be given special consideration.

The transmission factor may be either positive or negative. The solar factor may change from maximum to zero within a few minutes. These factors may be greatest at different times of the day in different parts of the building. To provide uniform comfort conditions in all areas simultaneously, it may be necessary to divide a building into zones so that each zone may be handled individually.

With induction systems, heating and/or cooling is available for any and all units whenever required, so that accurate, individual room control is provided throughout the year.

Typical Operation

During the "heating" season, for instance, warm water is supplied to the secondary or induction unit coils. Some areas of the building may require cooling at this time due to internal or solar gain. The cooling required to offset this gain is provided by cool primary air supplied to the units.

When the room thermostat calls for cooling, the secondary coil valve closes and the cool primary air, mixed with induced recirculated air, discharges into the conditioned space. When cooling requirements exceed the cooling available with primary air, the system is changed to cooling operation and chilled water, rather than warm water, is supplied to the secondary unit coils.

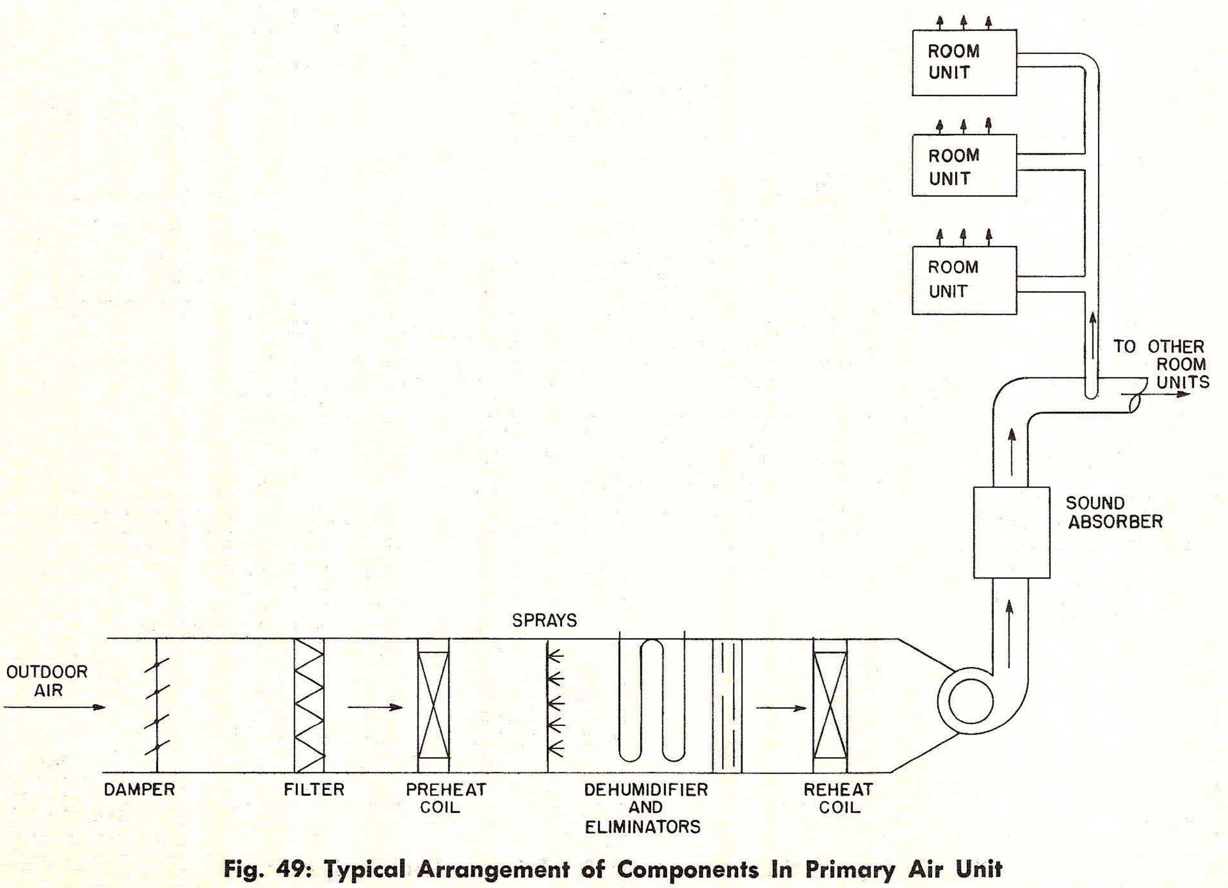


Fig. 49: Typical Arrangement of Components In Primary Air Unit

The Primary Air Unit

The primary air unit performs several functions:

1. Outdoor air, and occasionally recirculated air, is drawn into the primary air unit and is distributed throughout the system for ventilation. This constitutes approximately 20 to 25 per cent of the total air circulated in the conditioned space.
2. The primary air unit is designed to handle the entire latent load of the area served by the system.
3. The primary air system distributes its air at high velocity to the room units. This air provides the motive force for inducing room air through the room unit and for circulating the mixture throughout the room.

The primary air is heated by preheat (if necessary) and reheat coils. Cooling and dehumidification or humidification is done by cooling coils, sprays or a combination of both.

All primary air is filtered in the central unit. Figure 49 shows one arrangement of the various components required to perform the above functions.

This type of system is particularly adaptable to office buildings, hotels or other structures with a similar type of occupancy since the ventilation requirements are relatively small and the latent load is a relatively small percentage of the total cooling load.

Water Circuits

In general, the water performs two functions, both of which are indispensable to proper operation of the systems:

1. The water must be chilled to provide dehumidification and cooling for the primary air system during the cooling cycle.
2. It must be heated or cooled to provide hot or chilled water for the room induction unit coils.

Chilled water may be supplied to the system by conventional mechanical chilling equipment.

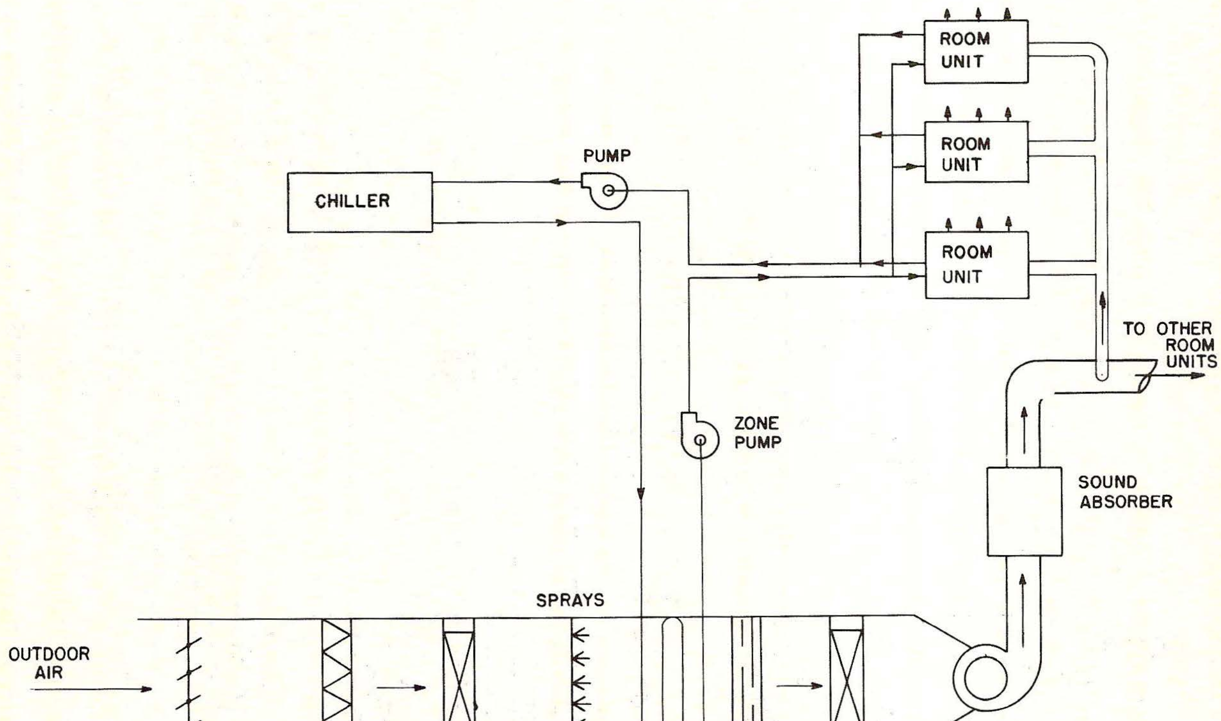


Fig. 50: Chilled Water Flow Diagram for a Typical Induction System

Figure 50 shows a typical water flow diagram for an induction system. Note that the chilled water flows through the dehumidifier before entering the secondary coils. This provides the dehumidifier with the coldest water, thus giving it sufficient capacity to maintain the required dew point temperature.

In Fig. 51, hot water is supplied only to the secondary units. The preheat and reheat coils could also be supplied with hot water but usually use steam. The hot water is supplied through the same piping as the chilled water. Proper valving of the water circuit prevents hot water from entering the chiller during the heating cycle.

Primary Air Unit Components

The primary air unit is composed of several sections. The functions of each are described briefly below.

Damper Section

One hundred per cent outdoor air is usually used in the primary air unit; however, there are occasions when a certain percentage of recirculated air may be used either continuously or at certain times.

For 100 per cent outdoor air systems, the controls are so arranged that the fan cannot start until the outdoor air damper is open. This precaution is unnecessary if there is a recirculated air connection to the unit.

Preheat Coil Section

During heating operation, the preheat coil performs a dual function. It prevents freezing air from entering the dehumidifier and provides heat to regulate humidification if used.

Filtering Section

The filtering section is used the conventional way.

Dehumidifier Section

Generally, the dehumidifier section consists of one bank of sprays and a cooling coil. The sprays operate continuously during cooling operation, insuring a wetted coil for better heat transfer. The cooling coil is usually of the chilled water type, but a direct expansion coil is sometimes used.

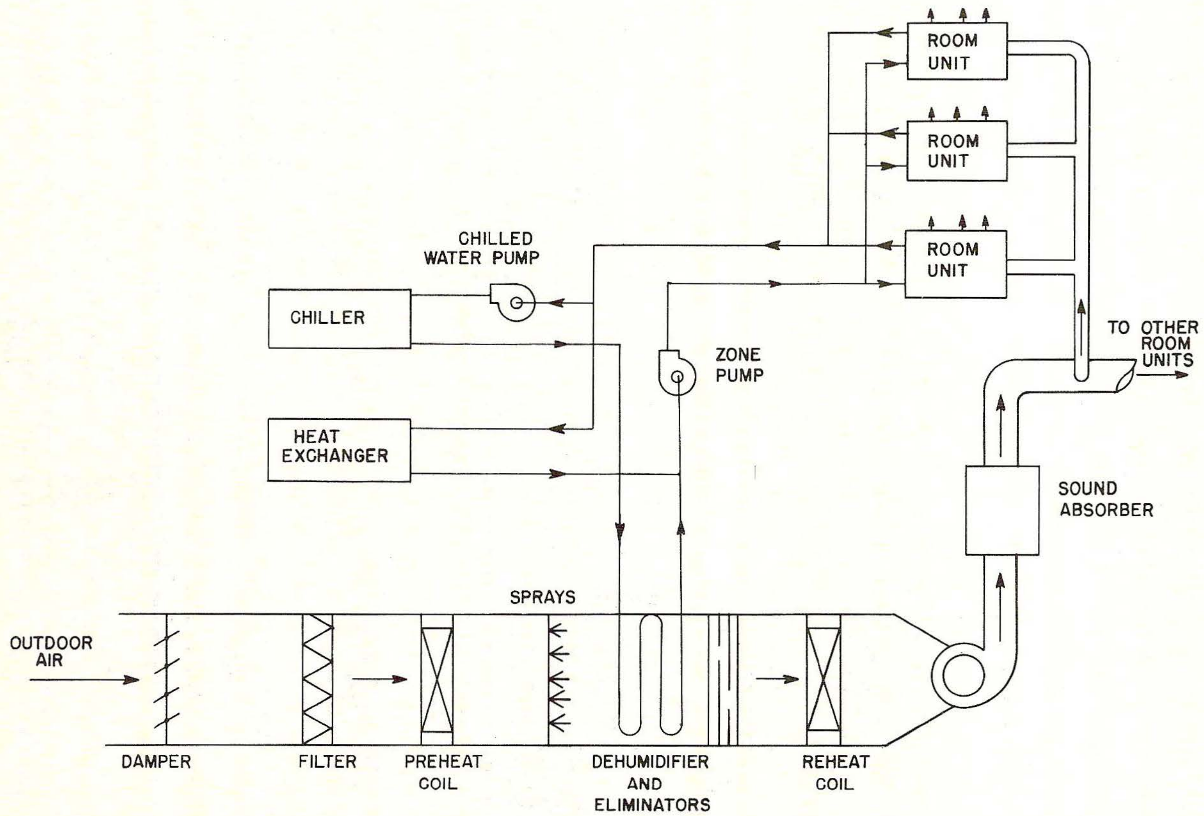


Fig. 51: Hot and Chilled Water Flow Diagram for a Typical Induction System

The sprays provide humidification during the heating operation. In extremely cold weather, however, they may be shut off to prevent frosting the windows.

The moisture content of air leaving the dehumidifier section can be controlled by maintaining the desired dew point temperature in this section.

Reheat Coil Section

When required, the reheat coil raises the primary air temperature to a value above the temperature of the air leaving the dehumidifier. The reheat coil is not used at all times. When the primary air system is zoned, one reheat coil is required for each zone. In this case, a reheat coil is placed in the fan discharge to each zone. Air, at proper temperature and moisture content, enters the primary air fan and is discharged at high velocity through a sound absorber into ducts for distribution to room units throughout the building.

This air is introduced at high velocity into the room units through nozzles or jets so located that their discharge induces room air through the coil. The primary air and recirculated air mix before entering the conditioned space. Depending on the season, the room air induced through the room unit will be either heated or cooled by the secondary water coil which handles only the sensible load of the room.

The temperature settings of the submaster controllers, which control both the secondary water temperature and the primary air discharge temperature, are of paramount importance for proper control of the system.

During the "heating" season, the secondary water supplied to the room unit coils is at a relatively high temperature (150 F) when the outdoor air is at, or below, design temperature. (Design temperature in this example is 0 F. The primary air temperature is 40 F.)

The hot water must supply sufficient heat to the room unit coils to handle room losses as well as the load added by the cooler primary air. As outdoor air temperature increases, the secondary water temperature decreases proportionally. The primary air temperature remains constant at 40 F until the outdoor air temperature reaches 40 F. At this time, primary air temperature increases with the outdoor temperature.

During this period, cool primary air is available at all secondary units. Heating is supplied by the secondary water. Switchover to the "cooling" cycle should take place when the cool primary air can no longer satisfy cooling requirements in areas having cooling demands. This may occur at any temperature between approximately 45 F and 65 F outdoors, depending on internal heat gains, solar gains, etc.

The changeover to cooling operation is at 55 F outdoors. The secondary water temperature reduces to 55 F and remains at this value during cooling operation. The primary air temperature is increased to 80 F.

As the outdoor air temperature increases above 55 F, the primary air temperature is reduced until at 80 F outdoors, the primary air temperature is 55 F. The primary air temperature remains at 55 F during the period when outdoor temperatures are above 80 F.

By gradually decreasing the primary air temperature from 80 F to 55 F, while the outdoor air temperature increases from 55 F to 80 F, warm primary air is available for heating during the mild part of the "cooling" season.

If the system is changed over at an outdoor temperature of 65 F, for example, the primary air temperature, *before* changeover from heating to cooling, would be 65 F while the secondary water temperature would be 79 F. Under these conditions limited amounts of heating and cooling are available. If these amounts are not sufficient, the relationship of primary air temperature and water temperature to outdoor air temperature should be changed accordingly.

The example illustrates only one of many possible relationships for control of primary air and secondary water. Another possible arrangement would be to gradually decrease the secondary water temperature from 160 F at design conditions to 100 F at the changeover temperature. During this period (the "heating" cycle) the primary air temperature would remain constant at 80 F. After changeover the secondary water temperature is decreased and is supplied at 55 F throughout the "cooling" cycle. The primary air temperature after changeover is gradually decreased until, at approximately 80 F outdoor temperature, it is reduced to 55 F. It remains at this temperature during the "cooling" cycle.

In any event, the primary air must be cool enough during the "heating" cycle to satisfy any space requiring cooling. If not, the water system must be so zoned that chilled water is available to any area requiring cooling at this time.

These are but two of many possible control variations and are intended only as a guide in understanding how to schedule temperature relations for specific systems.

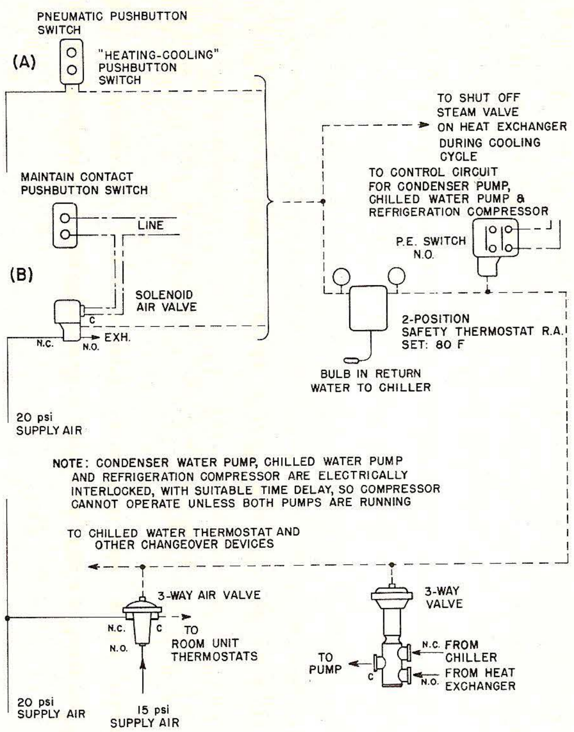


Fig. 52: Changeover Control

Typical Control System

The following control diagrams show some of the recommended arrangements of the various components of a primary air system as used on induction systems.

Changeover Control

System changeover, Fig. 52, must be provided when the same individual room unit coils are used for both heating and cooling. Suggested changeover arrangements follow:

A. When the pushbutton switch is positioned to "cooling" the heat exchanger steam valve closes fully. The changeover is not complete, however, until the return water temperature falls below the setting of the safety thermostat, its bulb located in the return water line. The safety thermostat then positions a three-way valve to admit water into the chiller. The three-way air valve indexes the room thermostats to "summer" cycle. A pressure electric switch provides automatic starting of the condenser water pump and, through an electrical interlock and time delay, the chilled water pump. The refrigeration compressor then is in a position to start upon a demand for chilled water from the chilled water thermostat.

B. The basic arrangement of "A" is again used but in this case the condenser water pump is manually started by a conventional electrical start-stop station. Pneumatic switchover is accomplished with a solenoid air valve energized when the condenser pump starts.

The above description illustrates manual changeover which is most common. If automatic changeover is required it can be provided by an outdoor thermostat with its bulb located in a solar compensator. It therefore responds to outdoor temperature plus solar radiation. This thermostat would be substituted for the pushbutton switch of method "A".

Damper Control

Two methods of opening the outdoor air damper and starting the fan are shown in Fig. 53.

A. Whenever the fan motor start button is engaged, the solenoid air valve is energized to open the outdoor air damper. This

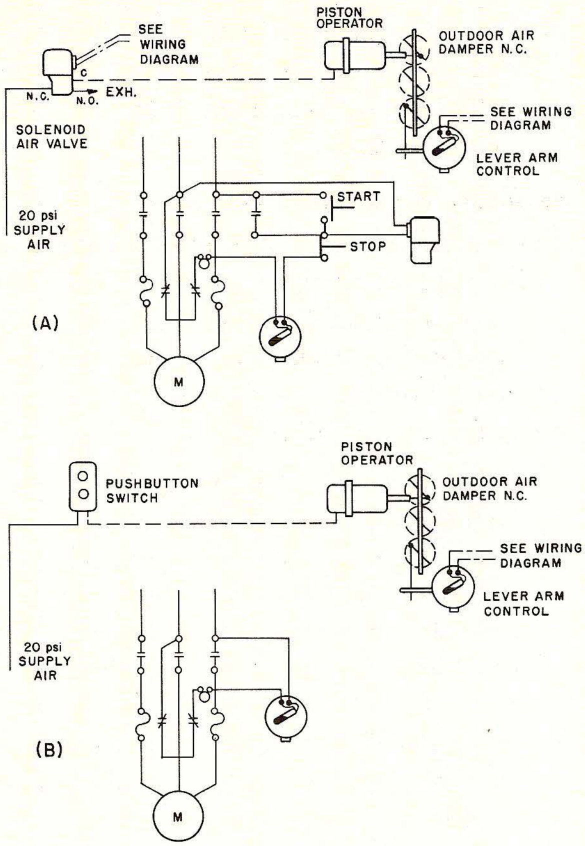


Fig. 53: Damper Control

button must remain engaged until the outdoor air damper is open sufficiently to cause the lever arm control to energize the holding coil of the fan motor starter.

B. In this arrangement, a pneumatic pushbutton switch is indexed to the start position and the outdoor air damper begins

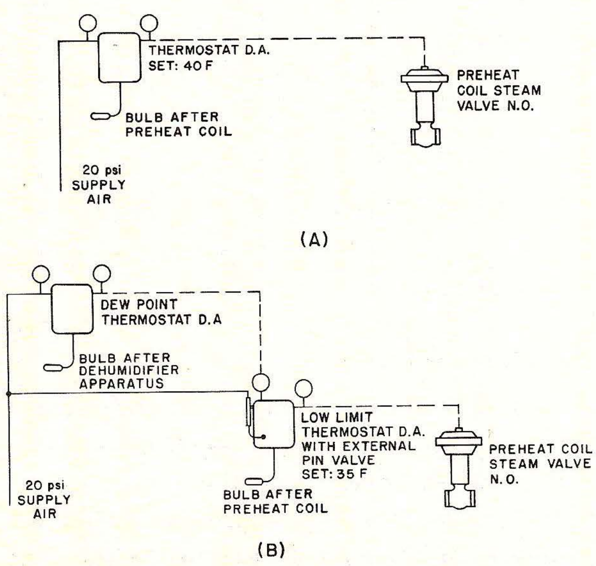


Fig. 54: Preheat Control

to open. A lever arm control starts the fan motor as described in "A".

Both of these methods provide for opening the outdoor damper before the fan can start.

Preheat Control

The main function of the preheat coil is to prevent freeze-up. It also provides heat for proper humidification when required. Two methods of preheat control are shown in Fig. 54.

A. A thermostat, its bulb located after the preheat coil, controls the valve in the preheat coil supply line.

B. A thermostat, its bulb located after the dehumidifier apparatus, operates the preheat coil valve to maintain the desired dew point. The safety thermostat, its bulb located after the preheat coil and set for approximately 35 F, provides freeze protection.

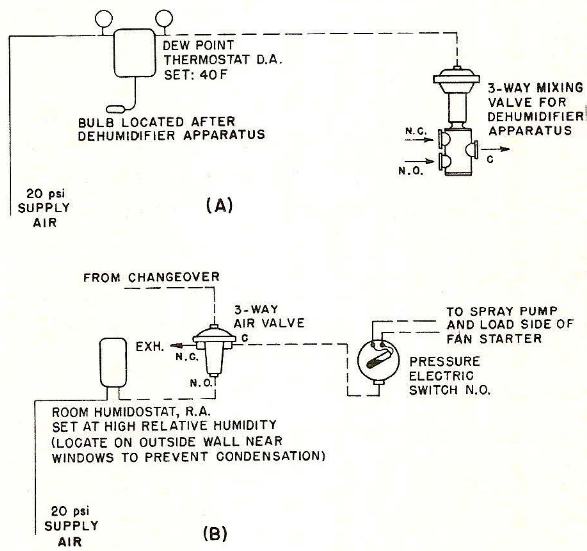


Fig. 55: Dehumidifier Control

Dehumidifier Control

The dehumidifier section, Fig. 55, does not require special control in most cases. The dehumidifier requires the coldest water available in the system, and the chilled water temperature controls on the mechanical chilling equipment are usually sufficient to provide proper control. Sometimes, however, it may be necessary to provide control on the dehumidifier. This can be accomplished as described in the following:

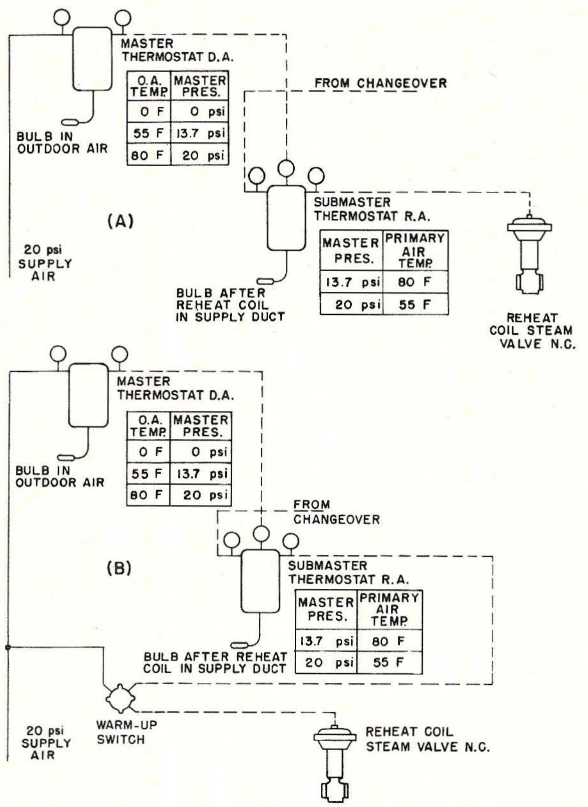


Fig. 56: Reheat Control

A. The dew point thermostat, its bulb located after the dehumidifier apparatus, controls a three-way mixing valve in the dehumidifier supply.

B. This provides an optional feature used only during the heating cycle to provide control of winter humidification by starting and stopping the spray pump. It can be used to prevent condensation on windows by locating the humidostat on an outside wall, preferably near a window.

Reheat Control

Two recommended arrangements for reheat control, Fig. 56, are described below:

A. An outdoor master thermostat resets a reheat submaster thermostat which modulates the reheat coil valve to maintain a predetermined schedule.

   Since reheat control is used only during the mild part of the "cooling" cycle, provision is made to fully close the coil valve when the system is changed over to the "heating" cycle.

B. This arrangement is similar to "A" except that a warm-up switch provides a means to fully open the reheat coil valve for early morning warm-up.

Secondary Water Control — Heating

Hot water must be furnished to the room unit coils during the heating season, Fig. 57. Since primary air is used for cooling during this season, heating requirements must be satisfied by the room unit coils. Three methods of doing this are described below:

A. This method provides a variable hot water temperature. An outdoor master thermostat resets a hot water submaster thermostat to modulate the heat exchanger steam valve according to a predetermined schedule. Since hot water is not needed during the "cooling" cycle, a three-way air valve is positioned from the central changeover to fully close the steam valve during cooling.

B. For a constant water temperature, a hot water thermostat modulates the steam valve to maintain the desired temperature. The changeover switch fully closes the steam valve during the "cooling" cycle.

C. Sometimes it is necessary to furnish a higher schedule of hot water temperature when the units operate as convectors at night. Method "C" provides two submaster thermostats, one set higher than the other. The day-night switch can be positioned to maintain either schedule. A three-way air valve fully closes the steam valve during the "cooling" cycle.

Primary and Secondary Chilled Water Control

Water can be chilled with any of the conventional mechanical refrigeration machines. The control diagram, Fig. 58, shows only the temperature controller.

The chilled water thermostat, its bulb located in the chilled water supply line for centrifugal compressors or in the chilled water return line for reciprocating compressors, modulates compressor capacity devices to maintain the design chilled water temperature.

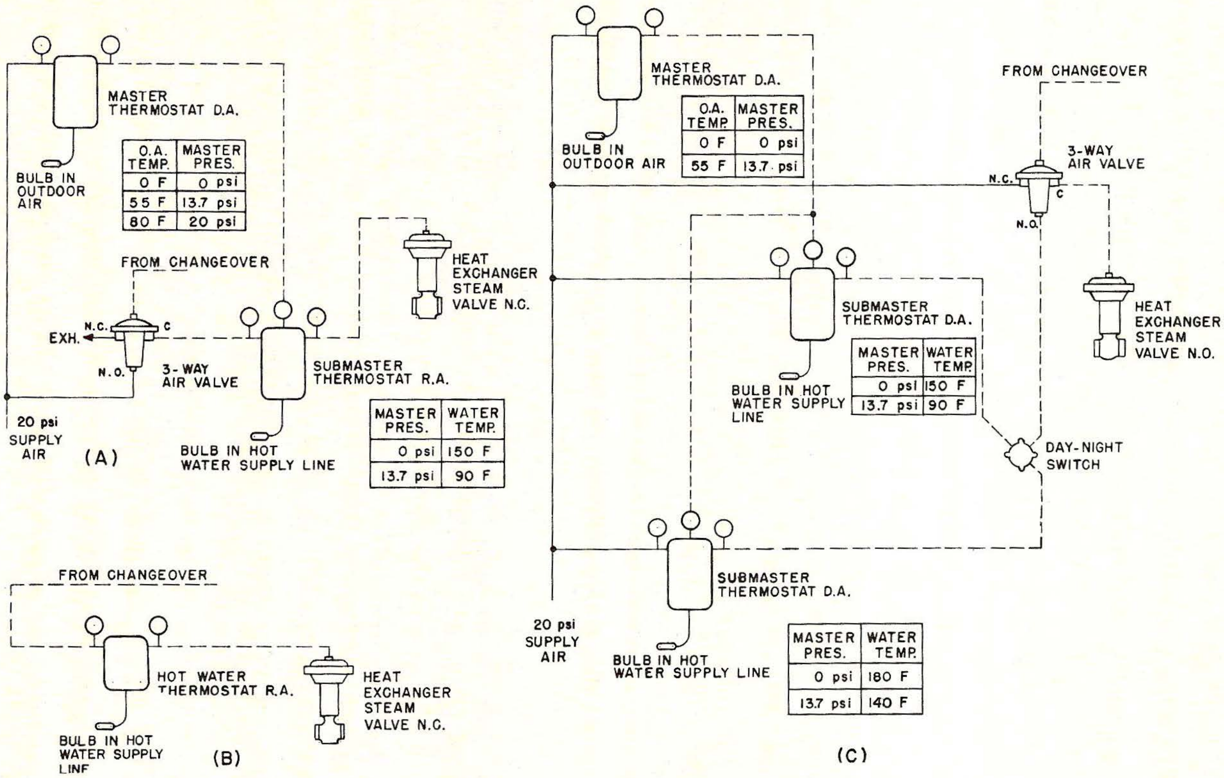


Fig. 57: Secondary Water Control (Heating)

Water Pressure Control

When using two-way throttling valves in the individual room units, pressure control between the main water supply and the return lines must be provided, Fig. 59, unless the pump characteristics are such that no appreciable pressure rise results as flow decreases. This also insures a constant flow of water through the chiller when the valves close. If three-way throttling valves are used, this control can be eliminated.

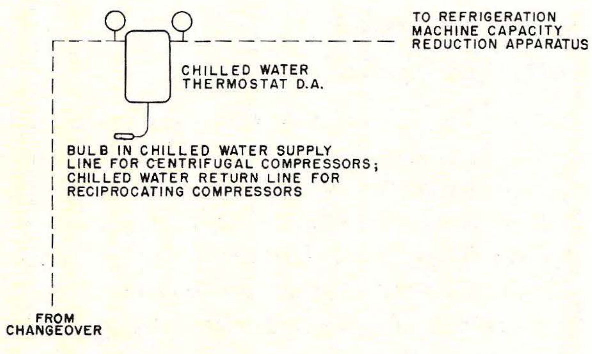


Fig. 58: Primary and Secondary Chilled Water Control

A pressure regulator maintains a constant pressure differential between the supply and the return water lines by modulating the bypass valve.

Complete System

In the preceding paragraphs several ways of controlling each section of an induction system are discussed.

Figure 60 is a typical flow diagram for two induction zones and one primary air unit. The diagram represents the combination of the individual sections from the preceeding paragraphs. It should be understood that this illustrates only one method of achieving proper control.

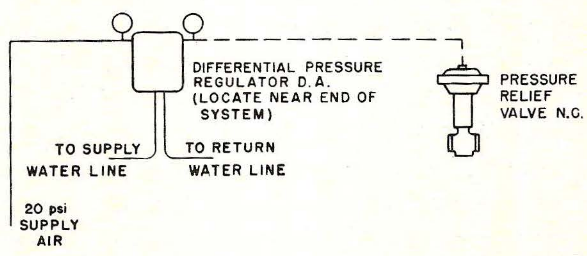


Fig. 59: Water Pressure Control

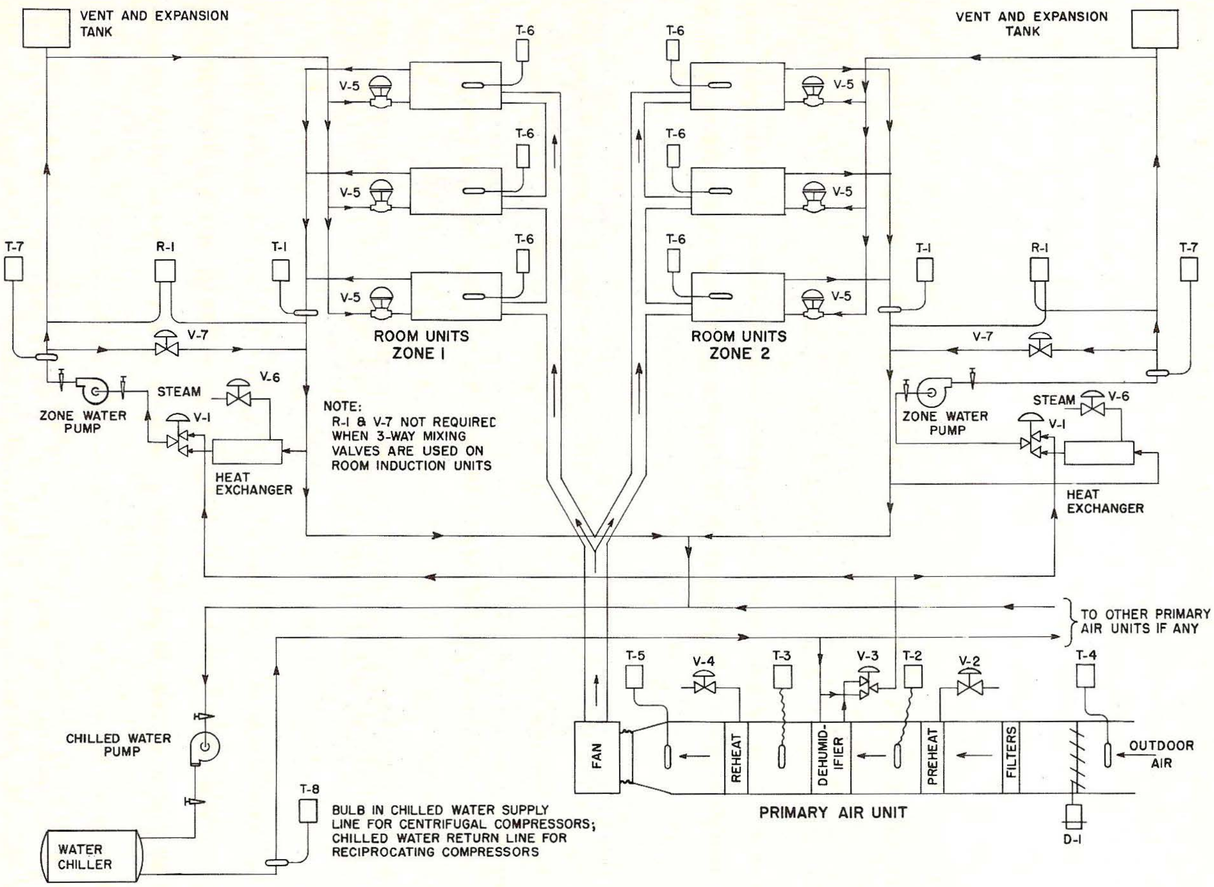


Fig. 60: Flow Diagram for Two Induction Zones and One Primary Air Unit

Fan Coil Units

Fan and coil units like induction units are located around the perimeter of a building. They consist of a water coil, usually for both hot and cold water and a fan. Air for ventilation purposes is usually taken directly from outdoors by means of a manually positioned damper.

Hot water which is supplied during the heating season is varied in accordance with the outdoor temperature. Cold water for cooling is usually supplied at a constant temperature that is low enough to provide for dehumidification.

These units can be used with a primary air system which will supply the outdoor ventilation air and also handle the latent heat load. The temperature of the space served by the fan coil units can be controlled by a standard heating-cooling thermostat mounted on the wall in the space or by a heating-cooling thermostat mounted in one of the end compartments of the unit.

Control pressure from the thermostat operates an offset globe, an angle valve or a three-way mixing valve to control the flow of water through the coil.

Typical System Controls

Figure 61 is a flow diagram for a typical zoned air conditioning system. The control arrangement illustrated utilizes common sources of chilled water and hot water for all zones.

Control Description

Water Chiller Controls

Thermostat T-1 controls the chilled water at a fixed temperature to provide maximum dehumidification at all times during the cooling season. The typical refrigeration compressor shown in the diagram is started manually whenever a need for cooling exists. T-1 controls the chilled water temperature by operating the inlet vanes of a centrifugal compressor to vary its capacity. A load limiting relay prevents overloading of the compressor motor. Thermostat T-2 starts the cooling tower fan whenever natural draft will not produce a sufficiently low condensing water temperature.

Water Heater Controls

Submaster thermostat T-4 controls the hot water temperature by operating steam valves V-1 and V-2 in sequence. Outdoor master thermostat T-3 resets T-4 in accordance with outdoor temperature so that the water temperature is gradually reduced as the outdoor temperature rises. The bulb of T-3 should be located on the coldest exposure of the building. Thermostat T-4 should be reset to provide hot water at a temperature which is always 10 to 15 degrees higher than normally required, to permit the unit thermostats to provide individual space control under all conditions.

Controls For Each Zone

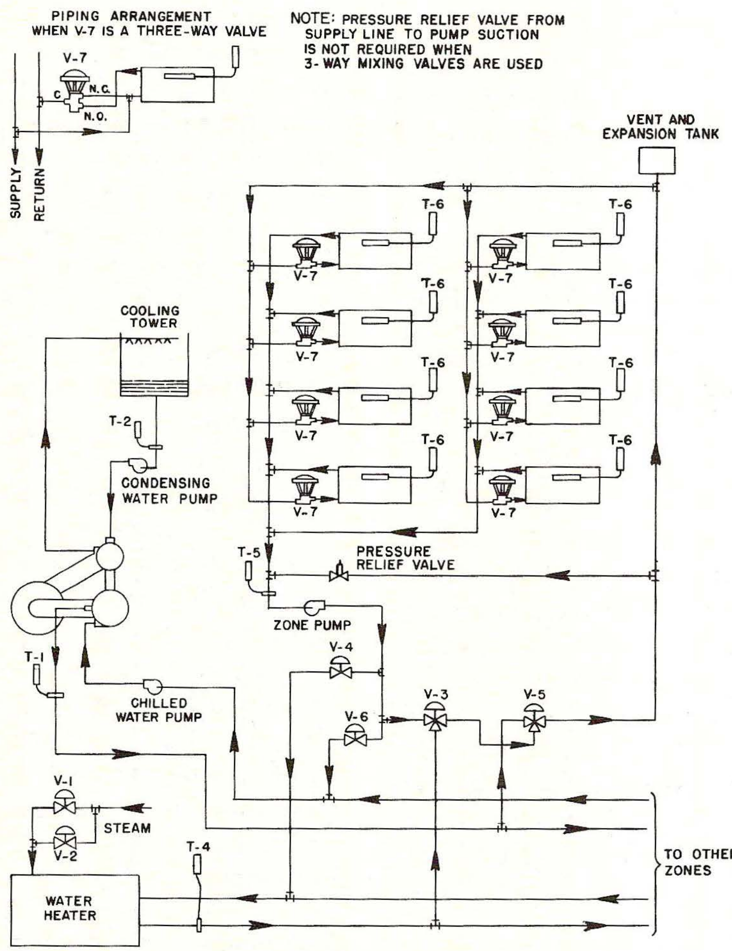
Any zone can be placed on heating or cooling operation by means of a switch. The refrigeration compressor must be running whenever any zone is placed on cooling operation.

Heating

When in the "heating" cycle, zone valves V-3, V-4, V-5 and V-6 are in their normal positions. Hot water flows through V-3 and V-5 to the zone, then back to the main hot water circuit through V-4. Valve V-6 is closed and thermostat T-5 is inoperative.

Cooling

When in the "cooling" cycle V-4, is closed and V-3 opens to return water. The zone pump temporarily recirculates all the water in order to avoid the dumping of hot water into the chilled water circuit. When this recirculating water cools to 80 F, T-5 opens V-5 to chilled



FLOW DIAGRAM

Fig. 61: Typical Zoned System

water and opens V-6 to chilled water return, thus completing the switchover from heating to cooling.

Unit Controls

Thermostat T-6 operates valve V-7 in the water circuit to the unit coil. As stated earlier, T-6 may be a wall mounted thermostat or a thermostat mounted within the unit. V-7 may be a throttling valve or a three-way mixing valve.

If V-7 is a throttling valve, the volume of water circulated by the zone pump is variable. If this volume is reduced appreciably, an objectionable increase in pump discharge pressure will result unless (1) a pump with a flat pressure-volume characteristic is used or (2) a pressure relief valve or other pressure control is provided in a bypass connection around the pump. This bypass connection and relief valve are shown in the diagram.

If V-7 is a three-way mixing valve, the volume of water circulated by the zone pump is constant and no pressure relief control for the zone pump is required. A varying portion of the water flows through the unit coil while the rest bypasses the coil.

T-6 is direct acting during heating operation and reverse acting during cooling operation. Switchover is accomplished by changing the supply air pressure to T-6 by means of switch S-1 and three-way air valve VA-1.

High Pressure Double Duct Systems

In a high pressure double duct system, space temperature control is accomplished with relative ease by thermostatic operation of a valving device or damper at each room mixing unit. Since this control method does not depend on changes in the volume of air delivered to the space, it should function with virtually no disturbance to air distribution patterns and should introduce no new noise problems. To accomplish this, however, control of total fan volume or duct static pressures should be employed.

As an aid in maintaining a constant air flow pattern through each duct, it is desirable to vary the duct temperatures in accordance with the system load. However, the air in the hot and cold ducts must be at a temperature that will always satisfy the space having the most extreme requirements. Because dehumidification requirements greatly limit the temperature variation permitted in the cold duct, changing load conditions are normally satisfied by varying the air temperature in the hot air duct.

The higher static pressures of high velocity double duct systems present a simpler control problem than the lower static pressures used in low velocity installations. In a high velocity system the mixing unit is designed to operate under relatively high pressure drops. Small variations in the high static pressure present in the duct at the mixing device, therefore, have comparatively little effect on the flow of air through the unit, especially since the flow varies as the square root of the pressure drop.

A typical arrangement for controlling the duct temperature in a double duct high velocity system is shown in Fig. 62. The hot duct temperature is controlled by the submaster hot duct thermostat, which operates the parallel valves on the heating coil in sequence. The control point of this thermostat is reset by the outdoor master thermostat according to a predetermined schedule.

The air in the cold duct is maintained at the desirable dew point temperature by the cold duct thermostat, which operates a three-way mixing valve on the cooling coil. At a predetermined outdoor temperature, the system is switched to natural cooling by the two-position switchover thermostat. When outdoor air is used for cooling the cold duct thermostat controls the operation of the outdoor air dampers and, through use of the three-way air valve, the return air dampers and exhaust dampers. This thermostat also controls the operation of the cooling coil if and when mechanical cooling is required. The minimum outdoor air damper is open whenever the fan is running.

The simple control arrangement in Fig. 62 can be modified easily to suit particular applications and requirements.

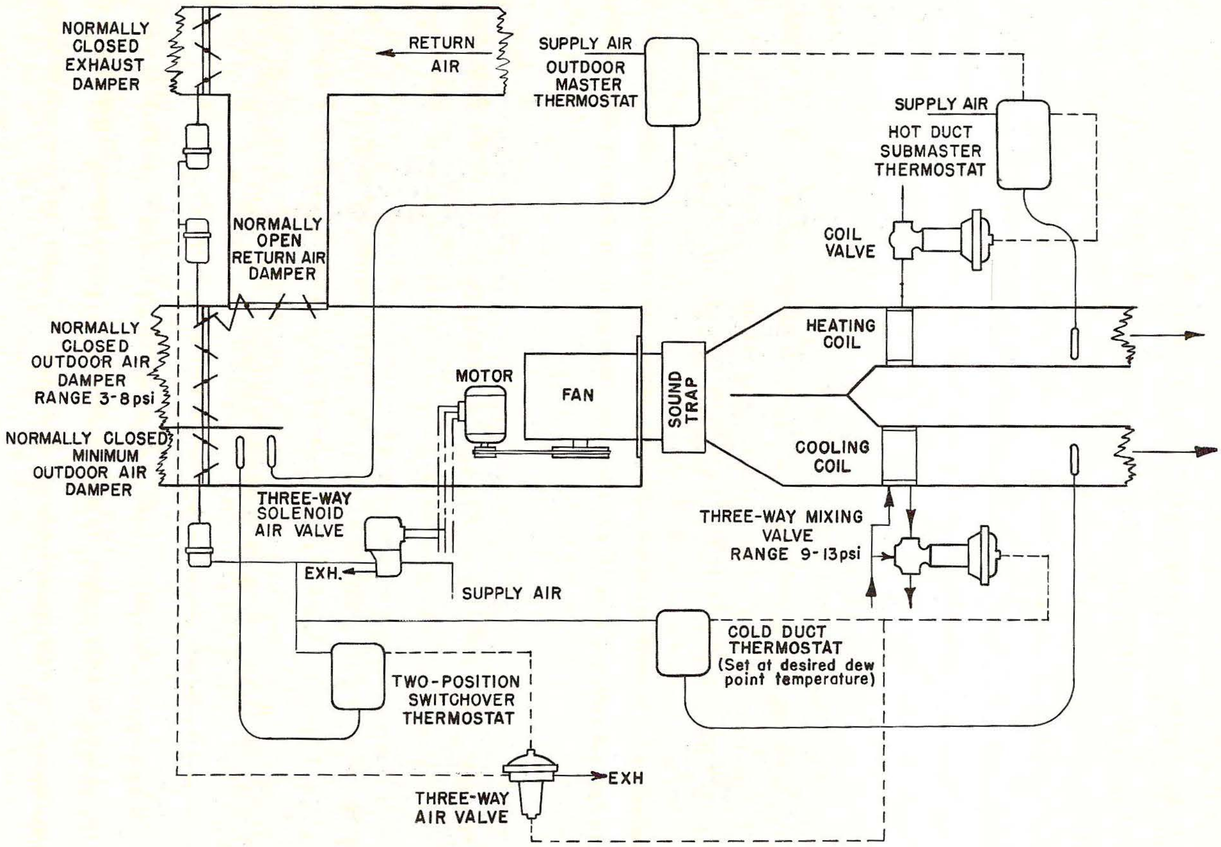


Fig. 62: Temperature Control for a Double Duct System

Unit Ventilators

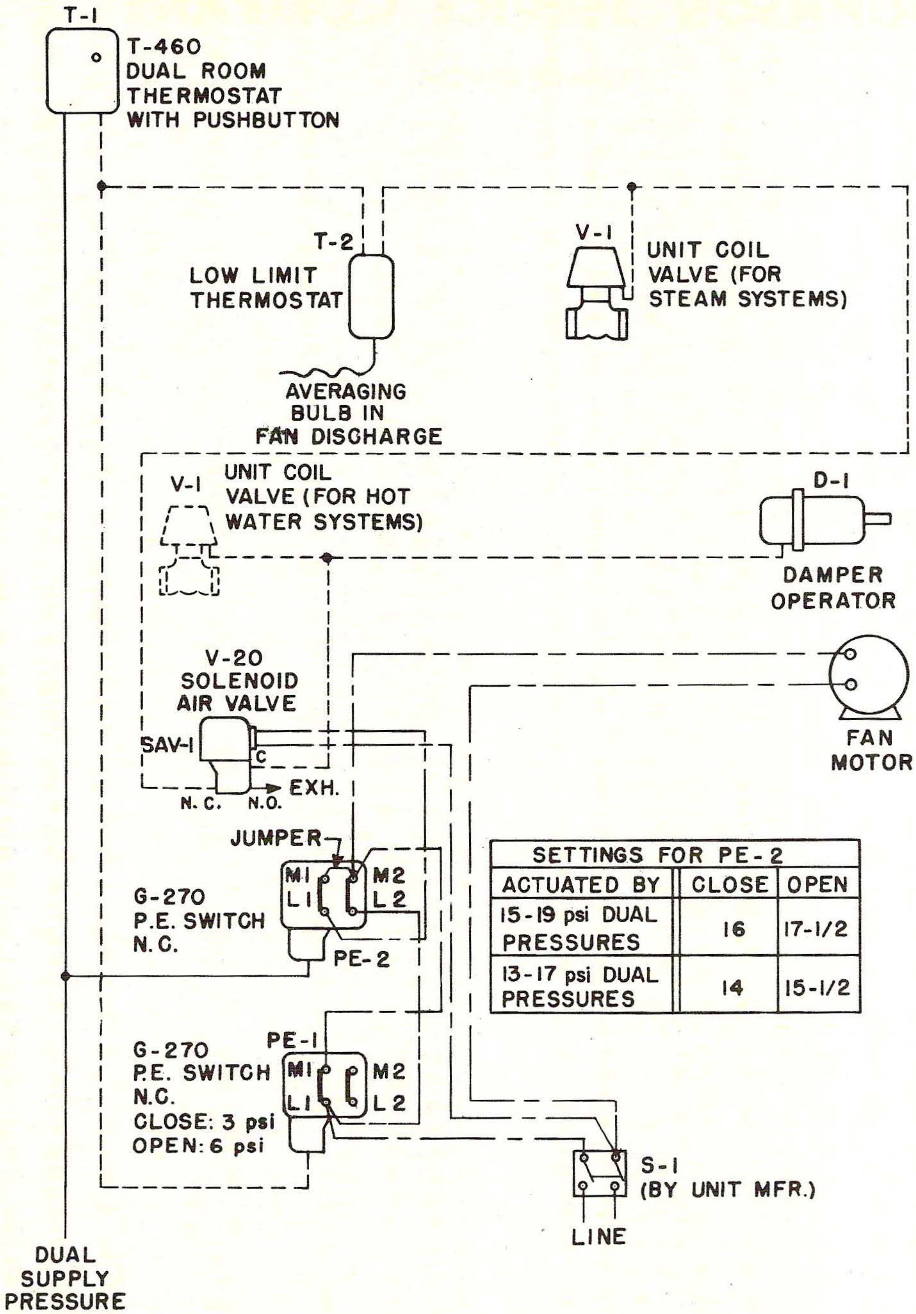
A unit ventilator is a forced air heating unit equipped with dampers for introducing outdoor and recirculated air in varying quantities, the fans running continuously during periods of normal occupancy. The unit ventilator is designed primarily for spaces having a relatively high occupancy load, with the requirement for positive ventilation, or where large internal heat gains due to occupants, sun, etc., make it necessary at times to dissipate excess heat.

It is the usual practice to shut off the unit ventilator fans at night or during periods of non-occupancy. If dual thermostats are used, the normal steam supply to the units is maintained at night, with the units operating as convectors. If the maximum convective heating capacity within the room is insufficient to maintain the night temperature, it is then necessary to operate the unit ventilator fans intermittently.

Figure 63, page 28, shows one method of accomplishing intermittent night operation of the unit fans. Switchover from continuous to intermittent operation is accomplished by a double-pole pressure-electric switch actuated by the dual pressure line.

When the dual supply pressure is at its low (day) value, PE-2 is closed, fans run continuously and solenoid air valve SAV-1 is energized to permit operation of the dampers. T-1 is at its day setting and controls the unit in the normal manner.

When the dual supply pressure is changed to its high (night) value, PE-2 opens to stop the fans. Solenoid air valve SAV-1 is de-energized and outdoor air damper is positively closed. T-1 is at its night setting, PE-1 is open and unit coil valve V-1 is closed. As the room temperature drops to the night setting, control pressure from T-1 decreases and gradually opens V-1, permitting the unit to operate as a convector. If the unit output as a convector is insufficient to maintain the night setting, T-1 then closes PE-1 to start the fans. As the temperature starts to rise, T-1 again stops the fans and, if necessary, closes unit coil valve V-1.



SETTINGS FOR PE-2		
ACTUATED BY	CLOSE	OPEN
15-19 psi DUAL PRESSURES	16	17-1/2
13-17 psi DUAL PRESSURES	14	15-1/2

Fig. 63: Unit Ventilator Control for Intermittent Night Operation. Switchover from Dual Pressure System Using Double-Pole Pressure-Electric Switch

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