As shown, the two elements are rigidly connected by means of a rod so that motion of one causes motion of the other. On the connecting rod is a power takeoff that operates single-pole double-throw contacts (as shown) or valves. A compression spring permits setting of the differential pressure at which the device operates. The sum of the forces developed by the low-pressure bellows and the scale spring equals the force developed by the high-pressure bellows at the control point.

In discussing this type of controller, two terms must be defined and thoroughly understood. *Instrumental differential* is the difference in pressure between the low and the high pressure elements for which the instrument is adjusted. In the case of a temperature element this difference is expressed in degrees. *Operating differential* is the difference in pressure or temperature required to open or close the switch contacts. It is actually the change in *instrument differential* from cut-in to cut-out for any setting. Operating differential can be varied by means of a second spring that acts in the same direction as the first, and takes effect only at the cut-in or cut-out point, without affecting the other spring. A second method could be to adjust the distance between collars Z-Z on the connecting rod. The greater the distance between them, the greater the operating differential.

Where a constant instrument differential is required on a temperature sensitive differential controller throughout a large temperature range, it is usually necessary to use a different fill in one element than in the other, if they are of the vapor charged type. The alternate is to use liquid filled power elements.

A second type of differential-temperature control employs two capsules and capillaries connected to one bellows and a liquid fill. This is known as a *constant-volume* type fill, since the operating point corresponds to a constant volume of the two capsules, capillaries, and bellows. It should be noted that if the two bulbs have equal volume, a rise in the temperature of one bulb requires an equivalent fall in the temperature of the other to maintain the operating point.

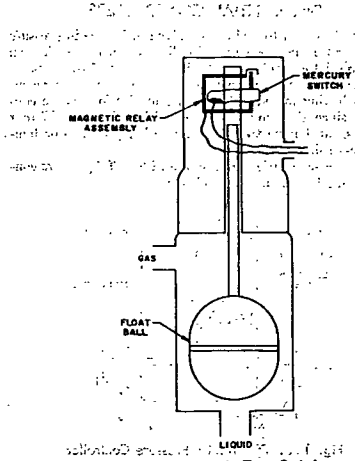


Fig. 2 .... Magnetic Float Switch

FLOAT SWITCHES

The float switch is a device in which a float, through variation in the level of a liquid, operates one or more sets of electrical contacts. It is connected by equalizing lines to the vessel in which the liquid level is to be maintained or indicated.

Operation and Selection

Some float switches (see Fig. 2) operate from the movement of a magnetic armature which is located in the field of a permanent magnet. Others (see Fig. 3) employ a variable electric signal generated in a pickup coil located on the float chamber to operate a power relay. Still others employ true solid state circuits in which a variable signal is generated by liquid contact with a probe which replaces the float. The latter methods are adapted to remote controlled applications and are preferred for ultra-low temperature applications. Switches having mercury-tube contacts are usually not recommended for installation in an ambient temperature lower than −25 F since mercury will freeze solid at temperatures of approximately −38 F.

Application

The float switch can be used to maintain or indicate the level of a liquid, operate an alarm, control the operation of a pump, or to perform many other functions.

A float switch, solenoid liquid valve, and hand expansion valve combination can be used to control the refrigerant level on the high or low pressure side of the refrigeration system in the same manner as high side or low side float valves are used. The hand expansion valve, located in the refrigerant liquid line immediately downstream of the solenoid valve, is initially adjusted to provide a refrigerant flow rate at maximum load, so as to keep the solenoid liquid valve in the open position 80 to 90 percent of the time; it need not be adjusted thereafter. From the outlet side of the hand expansion valve the refrigerant passes through a line and enters the evaporator or surge drum, depending on the unit design.

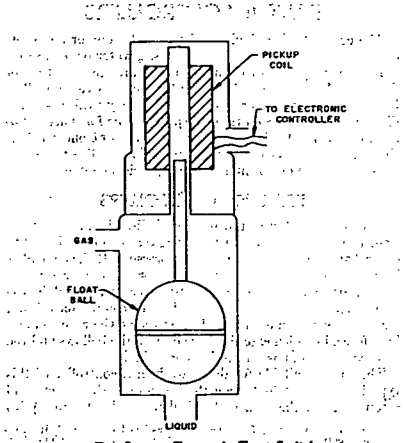


Fig. 3 .... Electronic Float Switch

When the float switch is applied for low side level control, proper precautions must be taken to provide a quiet liquid level that properly falls in response to an increase in evaporator load, and rises with a decrease in evaporator load. The same recommendations for insulation of the body and liquid leg of the low side float valve apply to the float switch when it is used for refrigerant level control on the low pressure side of the refrigeration system. To avoid floodback in this application, controls should be wired to prevent the opening of the solenoid liquid valve when the solenoid suction valve closes or when the compressor stops.

PART II: CONTROL VALVES

Valves are used to start, stop, direct, and modulate the flow of refrigerant to satisfy the system requirements in accordance with load requirements. To assure satisfactory performance, valves should be adequately protected from foreign material, excessive moisture, and corrosion in refrigeration systems, by the installation of properly sized strainers and driers.

Space does not permit illustration of all of the valve designs and constructions which are currently available. It should be noted that the diaphragm and bellows can be used interchangeably in various types of refrigerant flow control valves.

THERMOSTATIC EXPANSION VALVES

The thermostatic expansion valve controls the flow rate of liquid refrigerant entering the evaporator in response to the superheat of the refrigerant gas leaving the evaporator. Its basic function is to keep practically the entire evaporator active, without permitting unevaporated refrigerant liquid to be returned through the suction line to the compressor. The thermostatic expansion valve accomplishes this by controlling the mass flow rate of refrigerant entering the evaporator so that it equals the rate at which the refrigerant can be completely vaporized in the evaporator by the absorption of heat. Since the thermostatic expansion valve is operated by the superheated refrigerant gas leaving the evaporator and is responsive to changes in superheat of this gas, a portion of the evaporator must be devoted to superheating the refrigerant gas.

Unlike the constant pressure type, use of the thermostatic expansion valve is not limited to constant load applications. They are used successfully for controlling the refrigerant flow in air conditioning, commercial, low temperature, and ultra-low temperature refrigeration systems. They are also applied to control all types of direct expansion evaporators.

Operation

A schematic cross-section of the thermostatic expansion valve, with the principal components identified, is shown in Fig. 4. The three forces shown which govern thermostatic expansion valve operation are:

- P_1 = the vapor pressure of the thermostatic element (a function of the bulb temperature) which is applied to the top of the diaphragm and acts to open the valve.
- P_2 = the evaporator pressure, which is applied underneath the diaphragm through the equalizer passage, and acts in a closing direction.
- P_3 = the pressure equivalent of the superheat spring force, which is applied underneath the diaphragm, and is also a closing force.

At any constant operating condition, these forces are balanced and $P_1 = P_2 + P_3$.

Fig. 5 shows an evaporator using Refrigerant 12 and operating at a saturation temperature of 40 F (37 psig). Liquid refrigerant enters the expansion valve, is reduced in pressure and temperature at the valve port, and enters the evaporator at point A as a mixture of saturated liquid and vapor. As flow continues through the evaporator, more and more of the boiling refrigerant is evaporated. The refrigerant temperature will remain at 40 F until the liquid portion is completely evaporated by the absorption of heat at point B. From this point, additional heat absorption increases the temperature and superheats the refrigerant gas, while the pressure remains constant at 37 psig, until at point C (the outlet of the evaporator) the refrigerant gas temperature is 50 F. At this point the superheat is 10 F deg (50 − 40).

An increase in the heat load on the evaporator increases the temperature of the refrigerant gas leaving the evaporator. The bulb of the thermostatic expansion valve senses this increase; the thermostatic charge pressure (P_1) increases and causes

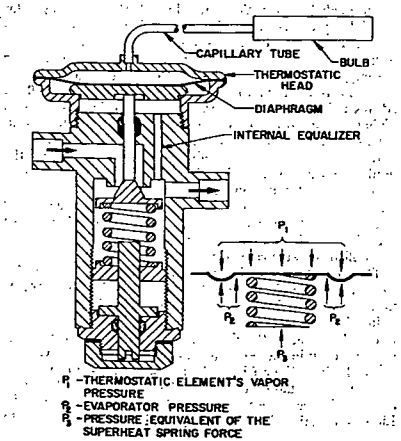


Fig. 4 .... Thermostatic Expansion Valve*

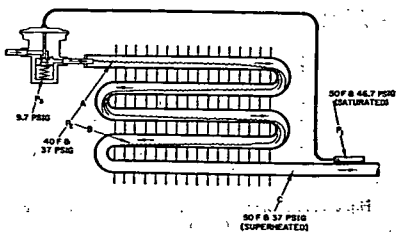


Fig. 5 .... Thermostatic Expansion Valve Controlling Flow of Liquid Refrigerant 12 Entering Evaporator