equipment. This arrangement eliminates any possibility of direct contact between the air and refrigerant.

REFRIGERATION CONTROL

Expansion Devices

In addition to means of controlling the compressor capacity and the necessary limit and safety controls as outlined under the section describing the compressors, reciprocating compressor refrigeration systems require a device for controlling the expansion of the refrigerant from the high liquid pressure to the low evaporator pressure.

Automatic Expansion Valves. An automatic or pressure controlled expansion valve operates to maintain a constant pressure in the evaporator. The liquid refrigerant passes through an orifice, the opening size of which is controlled by means of a needle valve connected to a flexible bellows. This bellows expands or contracts with variations in the evaporator pressure transmitted to the expansion chamber through the refrigerant outlet from the evaporator. The position of this needle valve is controlled by the degree of compression in an adjustable spring, balanced against the bellows, and these two forces operate to maintain a constant pressure in the evaporator by increasing or decreasing the flow of liquid refrigerant. Such an

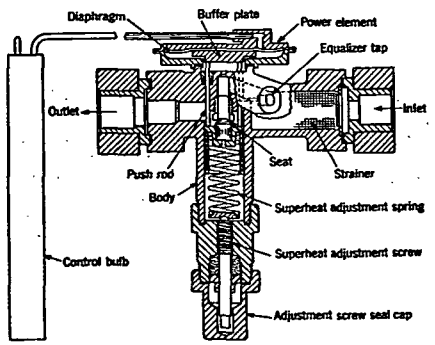


FIG. 14. TYPICAL THERMOSTATIC EXPANSION VALVE

expansion valve is usually applied to evaporators of the direct expansion type, but is not satisfactory for fluctuating loads such as are encountered in air conditioning installations.

Thermostatic Expansion Valves. A thermostatic expansion valve controls the flow of liquid refrigerant to the evaporator so as to maintain the entire coil filled with evaporating refrigerant, and to keep a constant superheat in the refrigerant gas leaving the coil. The construction of such a valve is shown in Fig. 14 and is similar to that for an automatic expansion valve but incorporates, in addition, a power element responsive to changes in the degree of superheat of the refrigerant gas leaving the coil. This power element consists of a bellows connected by means of a capillary tube to a feeler bulb fastened to the suction line from the evaporator. The bulb, bellows, and tube are usually charged with the same liquid refrigerant used in the evaporator itself. A starved condition in the evaporator results in a greater superheat in the gas leaving the evaporator, and this in turn operates through the power element to increase the flow of liquid refrigerant. A flooded evaporator reduces the discharge superheat, and thus tends to reduce the flow of liquid refrigerant. Such an expansion valve is satisfactory for operation with fluctuating loads since this type of control tends to keep the evaporator filled with refrigerant at all times.

Low-Side Float Valves. A liquid refrigerant control of the low-side float valve type consists of a ball float located in either a receiver or the evaporator itself on the low pressure side of the system. A needle valve, operated through a simple lever mechanism attached to the float, permits the passage of more or less refrigerant, as the level in the receiver or the evaporator fluctuates. Such a control must be used in conjunction with a flooded evaporator, and has been applied extensively to

household refrigerators and, to some extent, in commercial and industrial installations.

High-Side Float Valves. A high-side float valve differs from a low-side float valve in that the float is located in a receiver or container on the high pressure side of the system. Proper operation again depends upon metering of the refrigerant through a controlled opening, depending upon the level of the liquid refrigerant in the container. Such a control has the disadvantage that the evaporator must be placed directly adjacent to the float container, or some intermediate pressure device must be applied to prevent flashing of the refrigerant upon pressure drop.

Capillary Tubes. A capillary tube may be used as a liquid refrigerant expanding device. Such a device consists of an extremely small bore tube (in the order of 0.04 inch in diameter) of five to twenty feet in length. Although such a restricting device operates as a very simple means of expanding the liquid refrigerant, it has the disadvantage that no modifications are possible to adjust the rate of expansion under various operating conditions. The bore and length of the tube, as well as the proportions of the rest of the system, are critical. It is for these reasons that its application has been limited to factory assembled domestic and commercial units.

Refrigerant Flow Control

The capacity of the refrigeration system must be controlled in accordance with the load imposed on the system. Except for those cases where the compressor is started and stopped by a thermostat responding to load conditions, some form of control of the refrigerant flow is usually required. Controlling the flow of refrigerant in accordance with the load may be accomplished in a number of ways, some of which are:

1. *Solenoid valves* are frequently used for control of gas or liquid flow. A solenoid valve is placed in the liquid line ahead of the expansion valve. It is closed whenever the compressor is not in operation and thus leakage into the evaporator is prevented. In most cases it is controlled by a thermostat responding to the load. Solenoid liquid valves are widely used for control of refrigerant flow to individual evaporators in a multiple evaporator system operated by one compressor. The compressor capacity is controlled separately by a controller responding to suction pressure. Solenoid liquid and suction valves are sometimes used to isolate an evaporator completely for defrosting purposes.

When solenoid liquid valves are used for controlling refrigerant flow, a *pump-down cycle* of control is often employed. The termostat closes the solenoid liquid valve and the compressor then pumps down until stopped by the low suction pressure switch. The compressor cannot restart until the thermostat again opens the solenoid liquid valve.

2. *Expansion Valve Modulation.* This form of flow control utilizes the throttling characteristics of the expansion valve to starve the coil under reduced load conditions. This may be accomplished by a device attached to the expansion valve or a pilot control which varies the setting of the expansion valve by changing the pressure in the equalizer line. Either of these are actuated by a controller measuring load conditions and the compressor capacity control is from suction pressure. Since short-cycling of the compressor is apt to occur if the flow of refrigerant is reduced too much, some limit to prevent this is required.

3. *Evaporator Pressure Control* is accomplished by back pressure valves. These are placed in the suction line between the evaporator and the compressor, and maintain the evaporator pressure constant by regulating the amount of vapor drawn from the evaporator. The compressor capacity is controlled from suction pressure at the compressor. The use of back pressure valves permits a lower pressure at the compressor than would be permissible at the evaporator, thus minimizing short-cycling. On a multiple evaporator system served by one compressor, the evaporators may be maintained at different temperatures. Back pressure valves can be equipped with an air connection for automatically varying the evaporator pressure in accordance with the demands of a pneumatic controller. Means for mechanically readjusting the valves by use of a proportioning electric operator also are available.

Condenser Control

The majority of refrigeration systems, other than fractional horsepower, use water cooled rather than air cooled condensers. Condenser control is used for the purpose of conserving water or limiting the condenser pressure,