3. *Indirect brine coolers.* The indirect cooler, where brine is cooled by the refrigerant and the resulting cold brine is used to cool either air or water, introduces several other considerations. It is not the most economical from a power consumption standpoint, as it is necessary to cool the brine to a temperature sufficiently low so that there is an appreciable difference between the average brine temperature and that of the substance being cooled. This requires that the temperature of the refrigerant must be still lower, and consequently the amount of power required to produce a given amount of refrigeration increases due to the higher compression ratio. There are other considerations which make such a system desirable. In the first place, where a toxic refrigerant is undesirable or cannot be used because of fire or other risks, especially in densely populated areas, the brine can be cooled in an isolated room or building and can then be circulated through the air conditioning equipment. This arrangement eliminates any possibility of direct contact between the air and refrigerant.

REFRIGERATION CONTROL

In addition to the compressor, evaporator, and condenser, several auxiliaries are required for proper operation of a refrigeration system. Some device must be supplied for the controlled expansion of the refrigerant from the high condenser pressure to the low evaporator pressure; controls are required for the on-off operation of the compressor, the flow of the condensing medium, and for safety devices; proper piping is required for connecting the various portions of the systems. Where refrigerating apparatus is used for the cooling of rooms, additional controls are required.

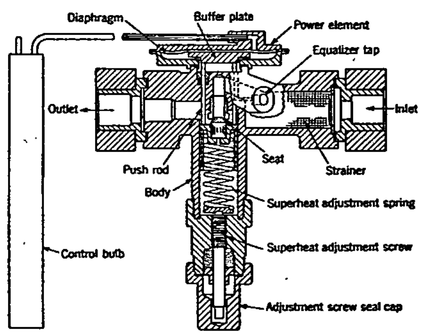

FIG. 11. TYPICAL THERMOSTATIC EXPANSION VALVE

Expansion Devices

Some form of expansion device must be provided to control the rate of flow of the liquid refrigerant between the high and low side pressures of the system. This device is usually an expansion valve and may be either manual or automatic; however, with few exceptions, manual valves are obsolete and no longer used.

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 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. 11 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.

Refrigeration Control Devices

In addition to automatic control of expansion of the liquid refrigerant, a completely automatic refrigeration system requires (1) some means for on-off operation of the compressor motor, (2) control of the flow of the condensing medium, and (3) safety devices for prevention of damage to the equipment. In addition, special controls designed for specific applications are frequently required. The various types of devices used to accomplish these purposes are so numerous that it would be impossible to describe all of their modifications. Only the general purposes and operating characteristics of the more typical mechanisms are here discussed.

Compressor Motor Controls. Two types of controls are used for intermittently starting and stopping compressors. The first of these is a pressure motor control responsive to the evaporator pressure, and the second a thermostatic motor control responsive to the temperature of the load surrounding the evaporators. In the first case the compressor operation is indirectly dependent upon the temperature of the load, and is controlled by the refrigerant pressure at the point of control location. The second type is dependent upon the temperature of the load being cooled.