With the pressure actuated device, the control is frequently located directly on the condensing unit, and the low pressure in the suction line or the crankcase of the compressor is used to control motor operation. Such a control usually consists of a low pressure bellows, connected through tubing directly to the low pressure control source, and an electrical switch operated through linkage by the movement of the bellows. The electrical circuit is closed on rising pressure, and opened on falling pressure. The thermostatic type of motor control is usually similar in construction to the pressure control, with the exception that a temperature bulb and capillary tube replace the pressure line, and the temperature bulb is located adjacent to the evaporator itself. In this case motor control is directly responsive to changes in the temperature of the load surrounding the evaporator. Frequently, a high pressure safety cutout switch is combined with the motor control, and operates to cut off the power from the motor in case the high side pressure exceeds a predetermined limit.

Solenoid Valves. Solenoid or magnetic stop valves are frequently used in refrigeration systems for control of gas and liquid flow. When applied as liquid stop valves, they are placed in the liquid line between the condenser or receiver and the evaporator, and the line is open to passage of the refrigerant only when the compressor is in operation. When the compressor is not in operation, leakage of liquid refrigerant in the evaporator is prevented. In some cases such a magnetic stop valve is operated directly by a thermostat located at the point of the load, and the compressor motor operation is controlled independently by a low pressure switch. Magnetic liquid stop valves are also widely used for the control of the refrigerant flow to individual evaporators in a multiple evaporator system operated by one compressor. In some installations magnetic liquid line and suction line valves are used to isolate completely an evaporator for defrosting purposes. A magnetic valve may be installed in a by-pass around one or more cylinders of a multiple cylinder compressor, and thereby be used to unload a compressor during starting to reduce load. Additional applications are found in control of the circulation of brine in a secondary refrigeration system.

Suction Pressure Valves. Suction pressure control valves, frequently called back pressure regulators or two-temperature valves, are sometimes placed in the suction line to prevent the evaporator pressure and temperature from dropping below a predetermined level. Typical applications of such controls occur in water cooling or milk cooling systems, where freezing and other damage would result if the evaporator pressure dropped too low, or in multiple systems where several evaporators are supplied by one condensing unit. Thus, different evaporators may be kept at different temperatures by maintaining a pressure drop between the evaporator and the suction line.

Condensing Water Control. The majority of the refrigeration systems, other than fractional horsepower, use water cooled rather than air cooled condensers, since the lower condensing temperatures result in more economical operation. Automatic control of the water flow to the condenser must be maintained if water wastage is to be eliminated. Such control may be provided through the use of either an electric solenoid water valve or by means of a pressure control valve. With a solenoid valve, the flow is two-position, either *off* or *on*, and its operation is simultaneous with starting and stopping of the compressor motor. With a pressure operated valve, the flow is modulated and is dependent entirely upon condenser pressure rather than condensing unit operation. Similar water valves controlled thermostatically by the temperature of the water discharged from the condenser are also available.

Safety Controls. Many controls are designed not to aid in proper operation of the system, but to prevent damage in case of improper operation. One such safety control is the high-pressure cut-off frequently combined with the low-pressure motor control as previously described. Another safety control often used is a low voltage cut-off which shuts down the system automatically in case the line voltage drops below a minimum value. High pressure relief valves are used for safety purposes to prevent damage in case excessive condensing pressures are encountered.

Refrigeration Control for Air Conditioning Equipment

When refrigerating equipment is used for space cooling, two major control problems exist: one is control of the temperature and the other, control of the humidity. In some applications the amount of latent heat

to be removed is small compared with the sensible heat. In such cases, sufficient dehumidification will usually occur without any special provisions. In other cases, such as theaters, where the latent load is relatively high, the air must be cooled below its dew-point temperature, and sometimes rewarmed to return it to the comfort range. Chapter 38, Automatic Control, discusses, among other topics, control systems for unit coolers, well water and ice cooling systems, central fan systems, and all-year air conditioning systems.

REFRIGERATION PIPING

The pressure drop which occurs during passage of the refrigerant through connecting piping is similar in effect to that which occurs through suction and discharge valves of the compressor. Thus, the effect of the pressure drop in the suction line between evaporator and compressor requires that a lower pressure be maintained inside the compressor during suction than

TABLE 5. FREON-12 LIQUID LINES, TONS CAPACITY PER 100 FT EQUIVALENT LENGTH

LINE SIZE, INCHES	PRESSURE DROP PER 100 FT EQUIVALENT LENGTH, PSI			
	3	5	10	20
3/8 OD	0.88	1.14	1.80	2.58
1/2 OD	2.89	3.64	5.56	8.50
1/2 IPS	4.86	6.81	10.2	15.8
5/8 OD	4.86	6.81	10.2	15.8
3/4 IPS	9.73	12.6	18.5	27.0
7/8 OD	10.5	14.1	21.8	33.0
1 IPS	21.4	28.2	41.3	60.8
1 1/8 OD	21.4	28.2	41.3	60.8
1 1/4 IPS	36.9	48.1	70.5	101.
1 3/8 OD	36.9	48.1	70.5	101.
1 1/2 IPS	62.0	80.2	114.	160.
1 5/8 OD	62.0	80.2	114.	160.
2 IPS	124.	161.	231.	328.
2 1/2 IPS	230.	297.	426.	607.
3 IPS	364.	469.	676.	972.
3 1/2 IPS	539.	704.	1005.	1430.
4 IPS	753.	972.	1385.	1945.

Note: Tonnage values above those underlined give velocities of 300 fpm or less.

is maintained in the evaporator. The pressure drop through the connecting piping between the compressor and the condenser requires that a higher pressure be maintained inside the compressor during discharge than in the condenser. These losses result in a greater compression ratio, and therefore greater power requirements, as well as a lower volumetric efficiency and higher displacement requirements. Pressure losses in the liquid line between condenser or receiver and the expansion valve may result in some flashing of the liquid refrigerant, unless the liquid is subcooled. In all cases, frictional losses should be kept to a minimum, and piping should be selected which will give the smallest loss consistent with overall economy in the system.

Refrigerant liquid lines from the receiver to the expansion valve should be preferably designed with a pressure drop of less than 5 psi, and with 10 psi as the maximum. A velocity of 100 to 250 fpm is recommended to prevent a pressure drop great enough to cause vaporization of the refriger-