with the cooling coils. Another common and efficient method of cooling spray water is to use a Baudelot type of heat absorber where the water flows over direct expansion coils at a rate sufficiently high to give efficient heat transfer from water to refrigerant.

Another type of spray water cooler is the shell and tube heat exchanger in which the refrigerant is expanded into a shell enclosing the tubes through which the water flows. The velocity of the water in the tubes affects the rate of heat transfer, and as the refrigerant is in the shell completely surrounding the tubes at all times, good contact and a high rate of heat transfer are insured. The disadvantage of such a system is that with the falling off of load on the compressor the suction temperature or the temperature in the evaporator drops and there is a possibility of freezing the water in the tubes, which, of course, might split the tubes and allow the refrigerant to escape into the water passage. This danger can be eliminated by automatic safety devices.

Another system of cooling spray water is to submerge coils in the spray collecting tank, or in a separate tank used for storage. The heat transmission through the walls of the coils, however, is low and a great deal more surface is required than for any other type of cooler. However, with large storage tanks this type of cooling can be utilized to advantage.

When direct cooling of air is employed, the refrigerant is inside the coil and the air passes over it. Cooling depends upon convection and conduction for removing the heat from the air. The type of coil used can be either smooth or finned, the finned coil being more economical in space requirement than the smooth coil. The fins, however, must be far enough apart so as not to retain the moisture which condenses out of the air.

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, but there are other considerations which make such a system desirable. In the first place, where a toxic refrigerant is undesirable or cannot be used, due to fire or other risks especially in densely populated areas, the brine can be cooled in an isolated room or building and then be circulated through the air conditioning equipment in perfect safety because it is used to cool the water or air, without any possibility of direct contact between the air and refrigerant.

REFRIGERANT PIPE SIZES

The selection of proper pipe sizes and frictional pressure losses varies with the installation and the capacity of the system. Generally the suction piping should be selected so that the pressure loss is between 2 and 3 lb per square inch. The pressure drop in liquid lines should be maintained so as to permit no vaporization in the pipes with limiting pressure drops not to exceed 5 lb per square inch. Hot or discharge gas

lines should be limited to approximately 4 lb per square inch pressure drop. All pressure drops mentioned are total system losses and not only include the piping losses, but also the pressure losses in the valves, fittings and coils.

For installations involving piping connections between compressors and evaporative or other remote condensers, pressure drops for discharge or hot gas lines may be referred to in Table 1. Pressure losses in liquid refrigerant lines of various sizes and capacities are given in Table 2. Pressure drops of suction refrigerant pipe lines at varying capacities and refrigerant temperatures may be referred to in Table 3. All tables are for 100 ft of pipe, including an average number of fittings, and for other lengths the losses are proportionate. Allowances should be considered for drops through control and regulating valves which must be added to the other pipe losses to determine the total drop. All copper pipe referred to in these tables are of type *L* wall thickness and are designated by outside diameter.

OPERATING METHODS

There are various methods of designing and operating air conditioning systems to obtain economical results. Peak outside conditions seldom exist for periods of greater than 3 hr. On many installations there is a peak internal load which may or may not coincide with the peak outside conditions. Thus, each application must be carefully analyzed by the engineer, and the proper equipment installed to satisfy the requirements. Adequate automatic controls should be installed for any system selected.

Where there are a number of small rooms to be conditioned, as for example, a group of hotel bedrooms where the load varies with occupancy and exposure, it may be best to employ individual room units, each with its own control. These individual units may be of the self-contained type (condensing unit, evaporator, fan and controls all in one cabinet) or of the remote type with the condensing units located outside of the room. In some cases it is good practice to use one large condensing unit to serve a group of room evaporator units. Where this is done, the condensing unit must have some type of control which will prevent freezing evaporator temperatures when only a portion of the evaporators are in use. This can be accomplished by means of a back pressure regulating valve which maintains the evaporator pressure at a safe limit, but allows the crank case pressure to fall. Other methods of accomplishing the same result are the use of a variable speed compressor or the use of a partial by-pass from the high side to the low side of the compressor. Any of these three methods of lowering the condensing unit capacity drop the operating cost at the reduced loads, but the operating cost per ton is higher.

Central Distribution Systems

On air conditioning systems using duct distribution, the same general types of control are employed to meet the varying load conditions, i.e. (1) the system may consist of several condensing units and evaporators which are cut in or out, depending upon the demand, or (2) condensing