but the resulting loss in efficiency with the higher pressure gases limits th centrifugal compressor to the two refrigerants named. At the prese time the centrifugal compressors are limited to air conditioning systems about 75 hp and more. Centrifugal compressors are usually built in t or more stages where the compression ratio is high, and their desig follows closely that of any other centrifugal equipment, such as gene service pumps and fans.

Steam jet compressors which have recently entered the field are simpl and compact and, having no moving parts, they produce practically vibration but are not economical for water temperatures much belo 40 F or where the cost of generating steam is higher than the cost operation with other prime movers.

Rotary compressors are generally used for methyl chloride and dichloro difluoromethane because of their relatively low pressure and compressi ratios. These compressors find widest use for fractional tonnage duty

The source of condensing water to some extent governs the type refrigerant used. If condensing water is available at temperatures of more than 70 to 75 F any of the refrigerants mentioned can be us economically, but if the available condensing water temperature is abo 80 F, carbon dioxide becomes uneconomical as its critical temperature approximately 88 F. A condensing water temperature over 80 F mak the power required for compression high. All refrigerants have criti temperatures and pressures sufficiently high so that their efficiency is n materially affected by the condensing water temperatures, except in far as this temperature affects the compression ratio. Steam jet cooli systems can use water up to 85 F, or even slightly warmer.

The applicability of the various refrigerants is interesting. Carb dioxide is limited by the condensing water temperature; the power con sumption is slightly higher than that of other refrigerants; and the pre sures are three to four times that of ammonia.

The condenser pressures of methyl chloride and dichlorodifluorometha are approximately one-half that of ammonia.

Ammonia, probably the best known refrigerant, has the disadvanta of being toxic, and under certain circumstances explosive, corrosive, a irritating, even in small quantities in the atmosphere. Ammonia is us exclusively in the larger indirect or brine cooling air conditioning syste

Sulphur dioxide is corrosive and irritating even in small quantities the atmosphere and it is toxic under certain circumstances.

Dichloromethane operates at pressures below that of the atmosphe and it is to some extent toxic.

Dichlorodifluromethane under normal circumstances is non-toxic, no irritating, and non-explosive, but under high temperatures it brea down into several obnoxious, poisonous components.

Methyl chloride, under certain conditions, is explosive and sligh toxic.

The steam ejector water vapor system has none of the disadvantages toxicity, explosiveness and corrosiveness encountered in the other re gerants, but the system operates at less than atmospheric pressure. Th however, is not an important factor as there are no moving parts in compressor and the possibility of inleakage of air is remote as all of

equipment can be welded air and water tight. The supply of water is inexhaustible, and as a refrigerant, the make-up cost is negligible. The same boiler equipment can be used for heating in winter and for cooling in summer.

Electric Motors

The motors used for driving compressors can be roughly classified in three groups: synchronous, multispeed, or variable speed. Further information on motors may be found in Chapter 17.

Coolers

The types of coolers used in connection with air conditioning work fall into three general groups. The *first* is the direct cooling of water; the *second*, direct cooling of air; and the *third*, cooling of brine for circulation in a closed system, which can cool either water or air. One method of the direct cooling of water is to install direct expansion coils in the spray chamber so that the water sprayed into the air comes in direct contact 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