operation upon a difference in pressure between the inside of the cylinder and the suction or discharge line. Although mechanically-operated valves might have some advantage, they have proved unsatisfactory because each change in the evaporator or condenser-operating pressures requires a change of valve setting. The pressure differentials required for operation of the valves depend upon the valve design and the compressor speed. The suction and discharge valves may be arranged with both located in the compressor head, or with the suction valve on the top of the piston and the discharge valve in the compressor head (uniflow arrangement). The valves themselves are usually classified as either poppet, ring-plate or flexing.

Lubrication and Cooling. Lubrication of modern compressors is accomplished by either splash lubrication or forced lubrication. The latter is used on large compressors, while simple splash lubrication is used in the smaller units.

Large compressors are usually water cooled with the water jacket either cooling the cylinder walls, or both the cylinder walls and the compressor head. Small compressors are either water cooled or air cooled with extended finned surfaces cast on

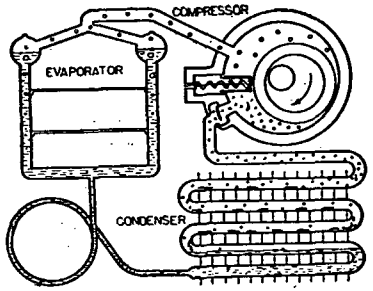

FIG. 10. DIAGRAMMATIC VIEW OF ROTARY COMPRESSOR WITH FLOODED EVAPORATOR AND CAPILLARY TUBE

the exterior of the cylinder. In a few cases small compressors may be found in which there is no attempt to add any purposive cooling other than through non-finned surfaces to the lower temperature air.

Water cooling is more effective than air cooling, but even under the best conditions cylinder cooling removes only a portion of the superheat in the refrigerant gas. This removal of heat from the cylinder results in some decrease in the work of compression, as well as reduction in condenser load.

Rotary Compressors

In recent years rotary compressors, usually hermetically sealed, have become quite popular for fractional tonnage applications and are being designed in increasingly larger sizes. Of the various designs attempted, the single blade rotary compressor, shown diagrammatically in Fig. 10, is the most popular. An eccentric driven rotor revolves within a housing in which the suction and discharge passages are separated by means of a sealing blade. When the rotating eccentric first passes this blade and the suction opening, the compressor suction space is very small. As the eccentric rotates, this crescent-shaped space becomes increasingly larger, thereby drawing in a charge of suction gas. When the eccentric again passes the blade, the gas charge is cut off from the suction inlet, compressed, and discharged from the compressor. Such rotary compressors are quiet in operation and reasonably free from vibration. In common with other types of hermetically sealed units, they have the advantages of comparatively low loss of refrigerant and sealed-in lubrication.

Centrifugal Compressors

Centrifugal compressors are used with very low pressure refrigerants; usually both evaporator and condenser work below atmospheric pressure. Water and monofluorotrichloromethane (CCl_3F) are the refrigerants commonly used in centrifugal machines.

Compression of the refrigerant is accomplished by means of centrifugal force; therefore, this type of compressor is inherently suitable for large volumes of refrigerant at low pressure differentials. Two or more stages are usually required and high speeds are necessary to obtain good efficiency.

The evaporator is usually constructed as an integral part of the centrifugal type condensing unit, to chill water which is then circulated to the

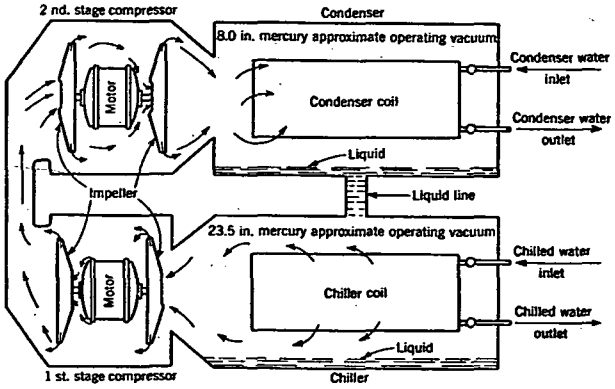

FIG. 11. ENCLOSED TYPE CENTRIFUGAL CONDENSING UNIT

air conditioning system. This is done because it would not be economical to pipe these large volumes of refrigerant any distance.

Centrifugal compressors, like reciprocating compressors, can be divided into two general types, open and enclosed. In general, the open type compressor is geared to the driving mechanism, and operates at higher speed than the driving motor or turbine. A modern, completely enclosed, direct-driven centrifugal compressor is illustrated in Fig. 11.

Centrifugal refrigeration compressors are particularly well suited to direct steam turbine drive because of their high operating speed. Water cooling equipment of one design is operated between 3500 and 4000 rpm for units developing 1000 to 2000 tons capacity, and from 7000 to 8000 rpm for units developing 100 to 200 tons capacity. However, a great many applications, particularly in the smaller sizes, are electric motor-driven and equipped with standard gear-type speed increasers. Centrifugal systems are particularly well adapted to large capacities (up to 3000 tons) although it is also possible to secure units as low as 50 tons in rating. Because centrifugal units operate best with refrigerants possessing a high specific volume, and because of the simplification of lubrication difficulties, they are frequently used for extremely low temperature applications. They are adaptable to a wide range of temperatures from -130 F to 50 F. One important advantage is their flexibility under varying loads, since units may be