temperature. Practical operation, therefore, dictates that the heat pump be used in conjunction with either an air or water heating system with actual distribution of the heat to the rooms through either air ducts, convection radiators, or panels.

In general, it is believed that the future of this device is very promising, and it is recognized that there are a number of practical and economical systems in operation at the present time. However, design data for the majority of types of systems are inadequate, and it is therefore recommended that the enthusiasm and the interest which have greeted the emergence of the heat pump from the category of a scientific toy to one of practical application, should be tempered with caution, since it will probably be several years before proper development and design information will enable the widespread satisfactory application of the heat pump. It is for this reason that no design information is presented at this time in THE GUIDE. A wealth of literature concerning individual installations is available, and reference to the many articles which have appeared in current technical magazines should form sufficient information for those interested in the development of this type of heating.

BASIC REFRIGERATION EQUIPMENT

Compression Refrigeration Machines

Compression of the refrigerant gas drawn from the evaporator may be accomplished by one of several means. Positive displacement may be used as in the reciprocating, rotary or gear types of compressors; centrifugal force may be applied as in the centrifugal compressor; an ejector may be used as in the steam jet refrigeration cycle; or absorption of a low pressure refrigerant gas in a secondary fluid, followed by the absorbent's release upon application of heat, may be utilized. A detailed discussion of the equipment required for each of these types of systems is beyond the scope of this chapter. For a more comprehensive treatment, reference may be made to the bibliography. The present discussion is limited to positive displacement reciprocating compressors, rotary compressors and centrifugal compressors.

Reciprocating Compressors

Reciprocating compressors may be classified according to (a) cylinder design, (b) compressor drive, (c) valves, and (d) lubrication and cooling.

Cylinder Design. Cylinder design may vary as to number, arrangement, and action (*i.e.*, single-acting or double-acting). Single-acting compressors usually have their cylinders arranged vertically, radially, or in a V or W shaped arrangement. Double-acting compressors, with refrigerant gas drawn in, and compressed on both the head and crank ends of the cylinder, are usually arranged horizontally. Reciprocating units are available with from one to sixteen cylinders with the V, W, or radial arrangements best adapted to the greatest numbers. The present trend is toward higher operating speeds with a low displacement per cylinder, together with an increase in the number of cylinders. Whereas the original reciprocating compressors were slow speed (50 to 55 rpm) steam driven devices, modern electric motor-driven compressors range up to 3500 rpm. Cylinder heads are usually bolted tight to the cylinders, but in some large compressors where there is danger of wet compression or of foreign materials entering the compressor space, a secondary head known as a safety head, may be seated at the end of the cylinder and held in position with heavy springs. Normally, this head remains stationary, but excessive pressures in the clearance space are relieved by movement of the safety head, and thus prevent damage to the cylinder.

Compressor Drives. Reciprocating compressors may be subdivided on the basis of source of motive power, and whether they are open or hermetic. Practically all

modern compressors are electric motor-driven, although a few large, steam-driven compressors are still being installed where steam forms the most economical source of energy. In a few cases, as with truck transportation, the compressor may be driven by an internal-combustion engine.

The division of compressors into open or closed types is dependent upon whether the motive power is received from an external source, or whether the motor is direct drive and sealed within the housing. In the open type, power is received from an external source with one end of the compressor crankshaft extending through the crankcase, and usually V-belt driven. The point of emergence of the shaft from the crankcase forms a weak point of refrigerant leakage, and is most frequently sealed with a bellows type crankshaft seal. Horizontal double-acting compressors operate with a sliding piston rod, moving back and forth through a stuffing box. If the motor is direct-drive and enclosed within the compressor housing, the compressor is classified as closed or hermetic. This eliminates the necessity of any shaft seal, and not only prevents refrigerant leakage at this point, but reduces operating noise. One disadvantage is the inaccessibility of moving parts for repairs, but lubrication is greatly simplified since both the motor and compressor operate in a sealed space with the lubricating oil.

Compressor Valves. All refrigeration compressor valves are dependent for their operation upon a difference in pressure between the inside of the cylinder and the

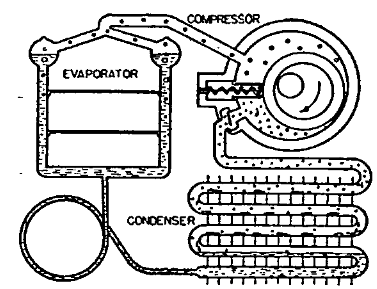

FIG. 8. DIAGRAMMATIC VIEW OF ROTARY COMPRESSOR WITH FLOODED EVAPORATOR AND CAPILLARY TUBE

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 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.