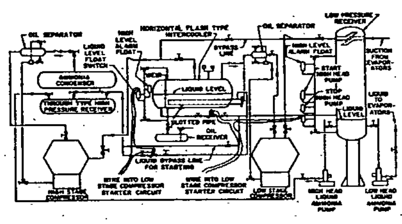

1. For low-pressure receiver and low head liquid ammonia pump details see Fig. 28.
2. For high head pump details see Fig. 25.
3. For condenser-receiver details see Fig. 11.
4. For compressor cooling see Fig. 7, 8, or 9.

Fig. 31 .... Arrangement for Compound System with Flash Type Intercooler

Fig. 31 illustrates a two-stage system with a low-pressure receiver and a low-head liquid ammonia pump for circulating to the evaporators and with a horizontal flash type intercooler. A high-head liquid ammonia pump can also take a suction from the low-pressure receiver and pump any excess ammonia back to the high-pressure receiver during unusual operation of the evaporators.

An oil separator is used on both the low- and high-stage compressors. It returns oil to the crankcase.

A check valve is used on the line from the top of the intercooler to the top of the discharge piping from the low-stage compressor to prevent liquid from flowing back through the discharge line when the low-stage compressor is shut down for any reason. This check valve is required because the discharge and suction sides of the compressor are equalized when it stops.

When starting a system with only the high-stage compressor in operation, the liquid feed should bypass the intercooler. This is required since the intercooler would be at a lower pressure than the low-pressure receiver. Under this condition liquid from the intercooler would not be able to flow to the higher-pressure vessel.

CASCADE SYSTEMS

Cascade systems employ two different refrigerant circuits to produce a desired temperature.

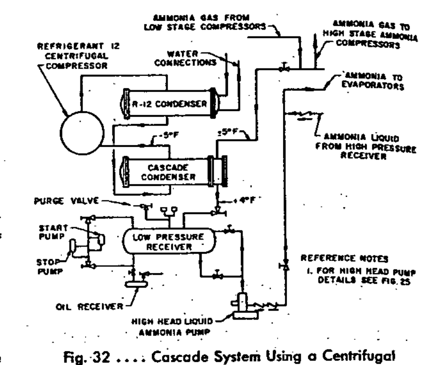

Fig. 32 .... Cascade System Using a Centrifugal Refrigerant 12 Compressor for Condensing Ammonia

A series cascade system could be illustrated by an ammonia system operating from −40 F evaporator temperature to a condensing temperature of plus 5 F with a Refrigerant 12 system providing an evaporator temperature of −5 F for condensing the ammonia.

A parallel cascade system would be one with an ammonia system operating at an evaporator temperature of plus 5 F and with the evaporated gas being recondensed at a slightly lower pressure in a cascade condenser by a Refrigerant 12 system at an evaporator temperature of −5 F.

As an added parallel type cascade system, an illustration would be with only part of the ammonia at the plus 5 F temperature being re-condensed by the Refrigerant 12 system, and with the remaining part being taken into an ammonia compression system and discharged into the condensers.

Fig. 32 is a cascade system using a centrifugal Refrigerant 12 compressor to condense ammonia at plus 5 F.

Purging of non-condensables from the low-pressure receiver is usually accomplished by a small purge compressor that takes its suction from the top of the low-pressure receiver and discharges into a water-cooled ammonia condenser and receiver from which the air can be purged as shown in Fig. 11.

CHAPTER 72

REFRIGERANT PIPING SYSTEMS FOR MULTI-STAGE APPLICATIONS

Compound Systems; Cascade Systems; Reasons for Multi-Stage Systems; Refrigerants; Equipment Considerations, Compressors, Condenser, Evaporator; Accessory Equipment, Subcoolers, Gas Intercooler, Heat Exchangers, Oil Return Equipment, Expansion Tanks, Refrigerant Liquid Pumps, Liquid Level Indicators and Sight Glasses, Knock-Out Drums; Pipe Sizing, Arrangement and Size of Piping for Oil Return; Liquid Feed Control, Controlling Load During Pull Down, Operation at Varying Loads and Temperatures; Moisture; Insulation and Vapor Barriers

THIS chapter discusses multi-stage systems using positive displacement compressors. Piping systems for ammonia (Refrigerant 717) are discussed in Chapter 71 and therefore only mentioned in this chapter.

A refrigeration system which consists of more than one stage of compression is defined as a multi-stage system. In general, there are two types of multi-stage systems, compound and cascade.

COMPOUND SYSTEMS

A compound system is a multi-stage application where compressors are interconnected in series in the same refrigerant system. Fig. 1 shows a simple outline of a two-stage compound system. In addition to the major components shown, compound systems are likely to contain additional components such as desuperheaters and liquid coolers, as shown in Fig. 2. Knock-out drums, oil recovery devices and other accessories are used when necessary or desirable. In some cases two or more stages of compression may be contained in a single compressor (internally compounded). In these cases one or more of the cylinders will be isolated from the others so that they may act as an independent stage of compression.

CASCADE SYSTEMS

A cascade system is a multi-stage application in which two separate refrigerant systems are interconnected in such a manner that one provides the means of heat rejection (condenser) for the other. The lower system may, therefore, operate at a much lower temperature. Cascade systems have the additional feature, over compound systems, of permitting the use of different refrigerants in each cycle of the cascade. Fig. 3 shows a simple outline of a cascade system. As in the compound systems, additional equipment beyond the major components such as knock-out drums, oil recovery devices, etc., may be used.

The cascade system is most often used where the range of pressures (using a single refrigerant) from evaporating to final condensing temperatures is greater than can be handled with commercial compressors or shells, or where the conditions of service are such as to make a cascade system more economical by possibly reducing the displacement of the lower stage, line sizes, etc. The cascade system makes possible the elimination of problems of balancing the oil in the crankcases between separate stage compressors. Although it does require an additional temperature difference between the condenser of the first cascade and the evaporator of the second cascade, no desuperheater or subcooler is required.

Each refrigerant circuit in the cascade system may in itself be either a single-stage or a compound system. An example might be the use of Refrigerant 13 in a single-stage compressor with its condenser rejecting heat to an evaporator which forms a part of a two-stage Refrigerant 22 system.

In the discussion which follows the term multi-stage refers to both compound and cascade systems.

REASONS FOR MULTI-STAGE SYSTEMS

There are several factors which limit the use of single-stage systems.

The evaporating and condensing temperatures necessary and available may be such as to require a compression ratio high enough to result in very poor volumetric efficiency of the compressor, with the result that the total displacement for two or more stages may be less than the displacement required for single-stage operation. Thus a multi-stage system can result in lower compressor costs and almost certainly lower operating costs, than single-stage systems for the same conditions of service.

The difference between the high pressure and low pressure may be more than can be handled by the available compressor.

When a refrigerant is selected that has an acceptable evap-

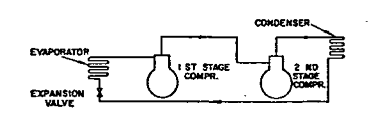

Fig. 1 .... Basic Elements of a Two-Stage Compound System