CENTRIFUGAL REFRIGERATION CYCLE

2.5. Elementary Vapor-Compression Refrigeration Cycle with Centrifugal Compressor. The vapor-compression refrigeration cycle may also be adapted to equipment designed for *centrifugal compression* of the refrigerant vapor. With such a system compression is accomplished

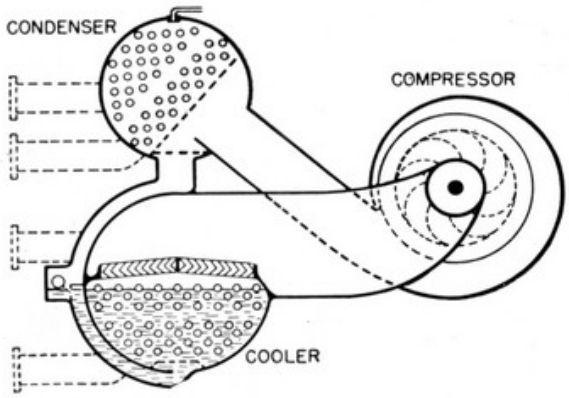


Fig. 2.15.

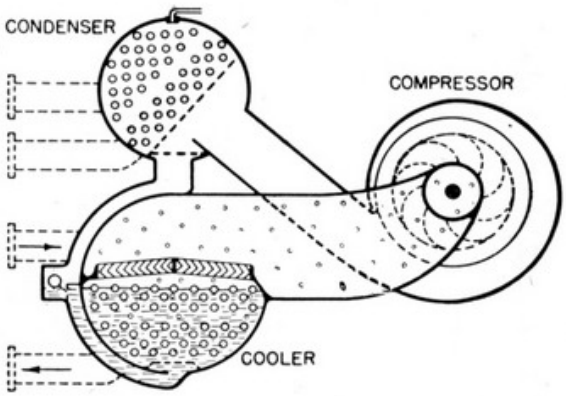


Fig. 2.16.

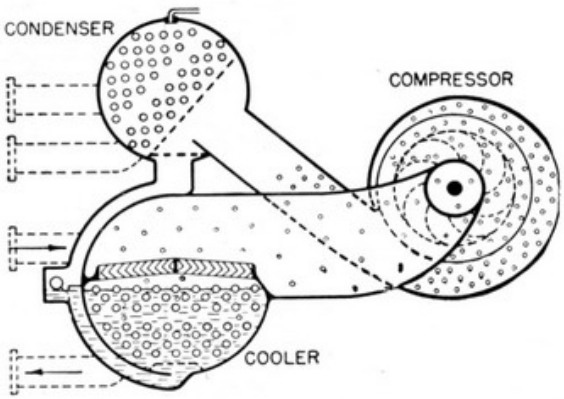


Fig. 2.17.

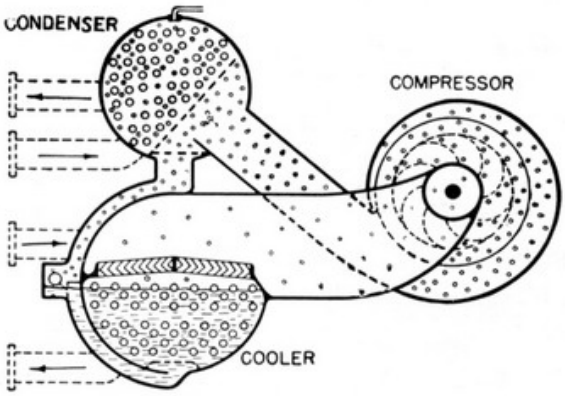


Fig. 2.18.

through centrifugal force in a manner similar to that utilized in the movement of air by a centrifugal blower. Since compression is not positive, the pressure differential developed is low compared with that for reciprocating compressors. Therefore, refrigerants operating satisfactorily with low compression ratios must be used.

Centrifugal compression systems are usually designed with a *condenser*, *evaporator*, and *compressor*, all mounted on a single base. A *secondary refrigerant* such as a *brine* or *water* is used to convey heat from the point of the load to the evaporator. Progressive stages in the operation of a typical centrifugal refrigeration system are shown in Figs. 2.15 through 2.19.

"Refrigeration & Air Conditioning," Jordan & Priester, USA, 1956

In Fig. 2.15 the system is inoperative, with the liquid refrigerant stored in the cooler or evaporator. The liquid refrigerant surrounds the cooler tubes, through which brine is circulated when the system is under load.

In Fig. 2.16 the cooler is loaded through the circulation of brine from the point of the load to the cooler tubes. Heat is absorbed, and boiling of the liquid refrigerant occurs. The centrifugal compressor is started, thus removing refrigerant vapor from the cooler and at the same time evacuating the cooler to an evaporator pressure corresponding to the desired evaporator temperature. Refrigerant vapor is shown entering at the hub of the centrifugal compressor.

In Fig. 2.17 refrigerant vapor has passed through the compressor and is shown entering the passageway leading to the condenser. Compression of the refrigerant has occurred by virtue of the centrifugal force imparted to the vapor by passage through the compressor impeller and by the additional velocity head imparted to the mass as it is carried in rotation by the whirling impeller.

In Fig. 2.18 the gaseous refrigerant has entered the condenser and surrounds the condenser tubes, through which cold water has started to circulate.

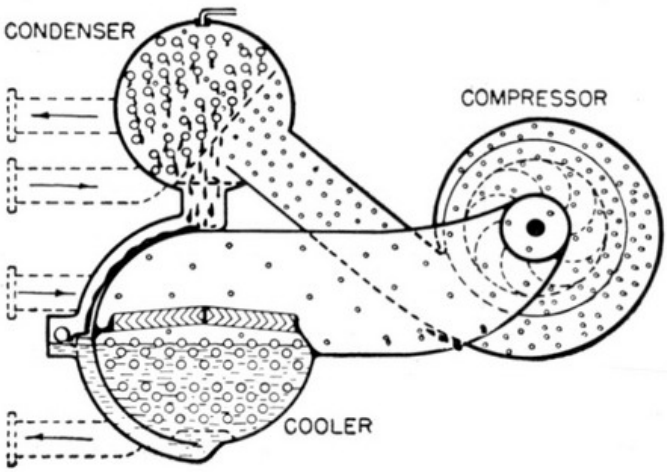


Fig. 2.19.

In Fig. 2.19 condensation of the refrigerant is occurring in the condenser, and the liquid flows by gravity to the cooler. A constant level of the refrigerant in the cooler is maintained by means of a float-operated valve. The system is now in complete and continuous operation.

7.12. Centrifugal Refrigeration. A *centrifugal* refrigeration system operates upon the vapor-compression refrigeration cycle. Unlike the reciprocating and rotary machines, it is dependent upon centrifugal force and not positive displacement for compression of the gas. The theory of its operation was discussed in §6.5. Centrifugal units are particularly well adapted to large-capacity systems (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, they are frequently used for extremely low-temperature applications.

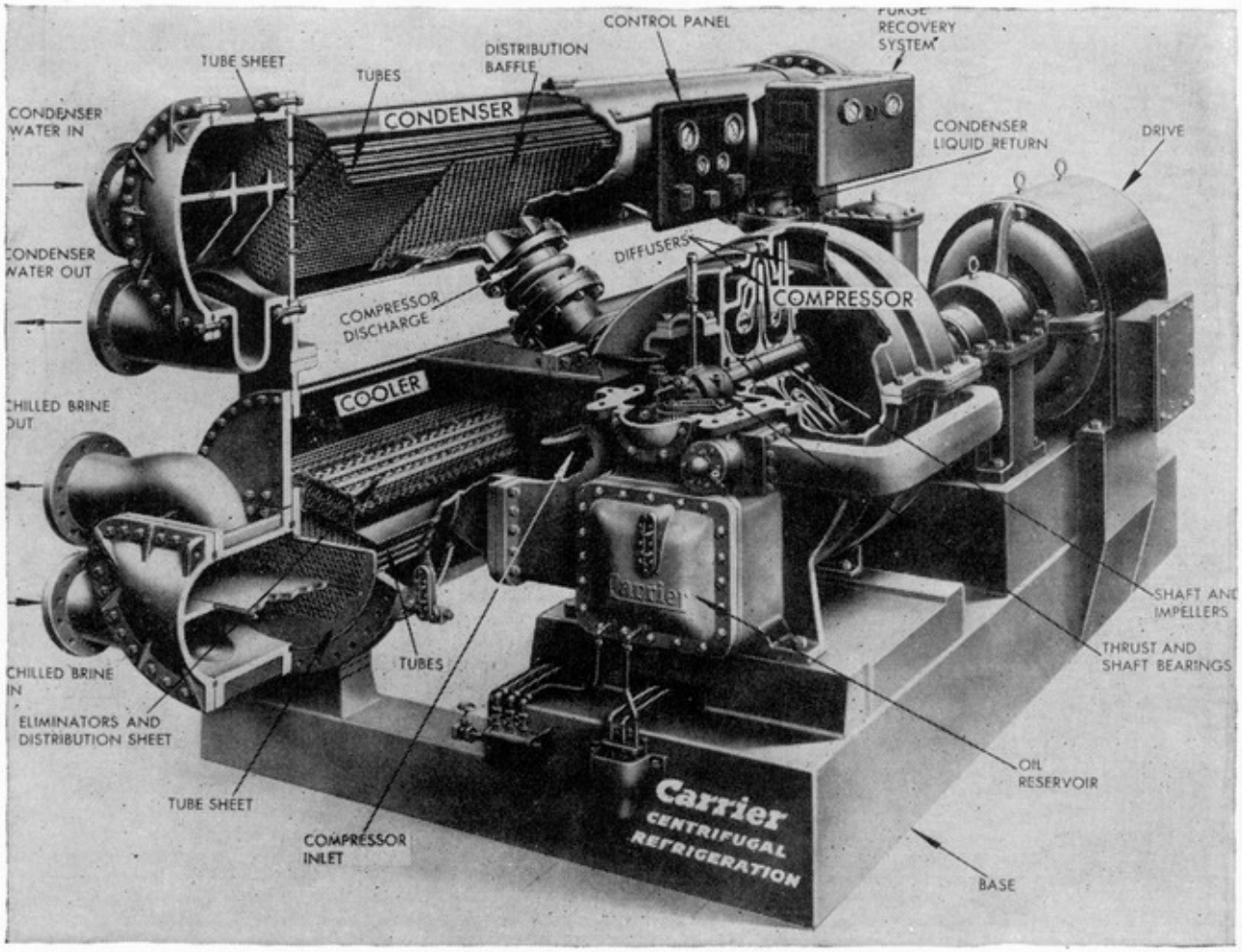


Fig. 7.22. Three-stage centrifugal refrigeration unit. Courtesy Carrier Corp.

They are adaptable to a wide range of temperatures from −130 F to 50 F. One important advantage of centrifugal machines is their flexibility under varying loads. Units may be designed to operate at capacities as low as 20 per cent of normal load with reasonable efficiency.

7.13. Centrifugal-Refrigeration Equipment. Cutaway views of three typical *centrifugal* refrigeration units are shown in Figs. 7.22, 7.23, and 7.24. The unit shown in Fig. 7.22 is available in capacities ranging from 100 to 1200 tons. The *condenser*, *evaporator*, *compressor*, *speed increaser*,

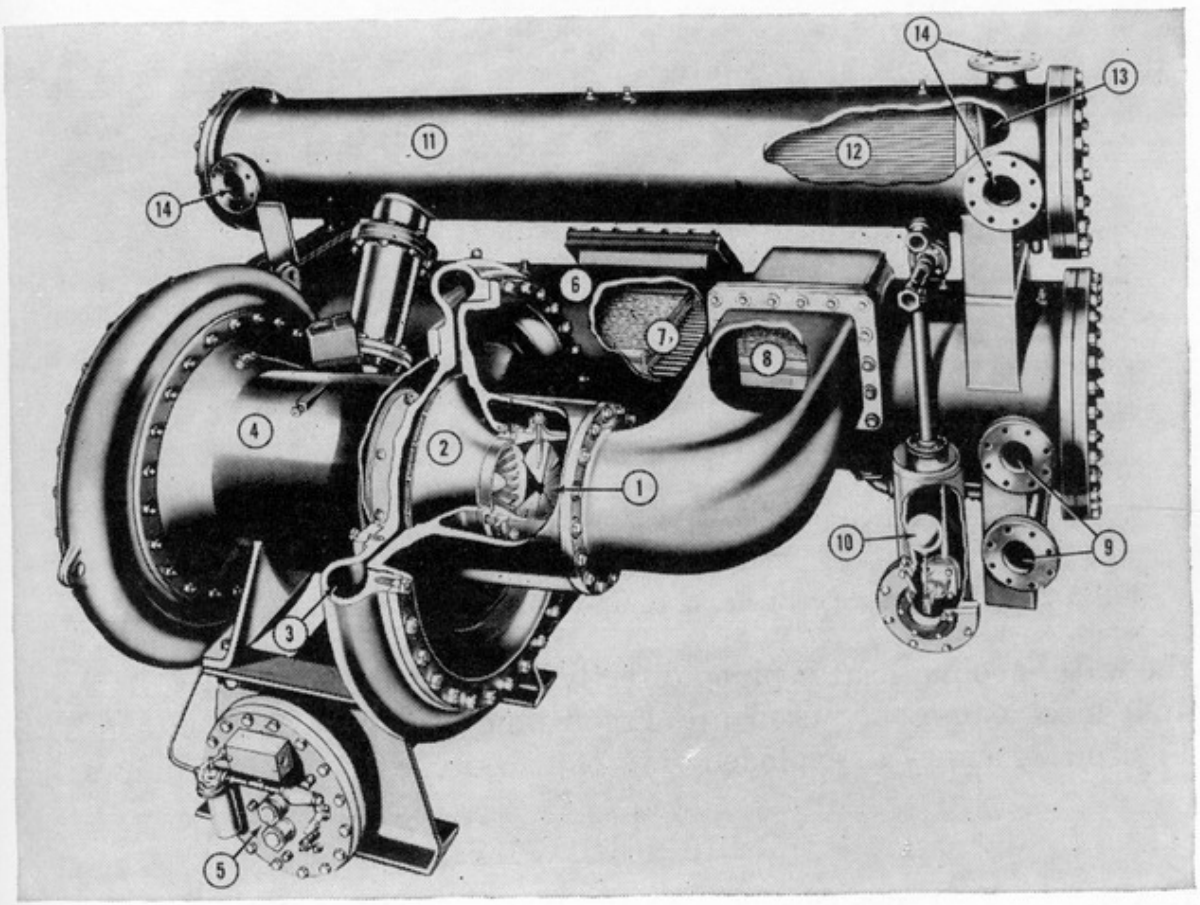


Fig. 7.23. Centrifugal refrigeration unit for water cooling. Courtesy Trane Co.

and *motor* are mounted on a single base. Freon-11 is used as the refrigerant, and the compressor is designed with *three stages*. The condenser is equipped with a *fully automatic purge* to eliminate air and other noncondensable gases, and the unit is equipped with an *economizer* to permit liquid intercooling and thereby increase the cycle efficiency.

Figure 7.23 shows a hermetically sealed centrifugal system designed primarily for process water-cooling and air-conditioning purposes. It is constructed in sizes ranging from 50 to more than 300 tons capacity. In the figure, liquid refrigerant from the condenser (11, 12) flows to the evaporator (6, 7) through the float valve mechanism (10) which controls the liquid level in the evaporator. Evaporated refrigerant passes

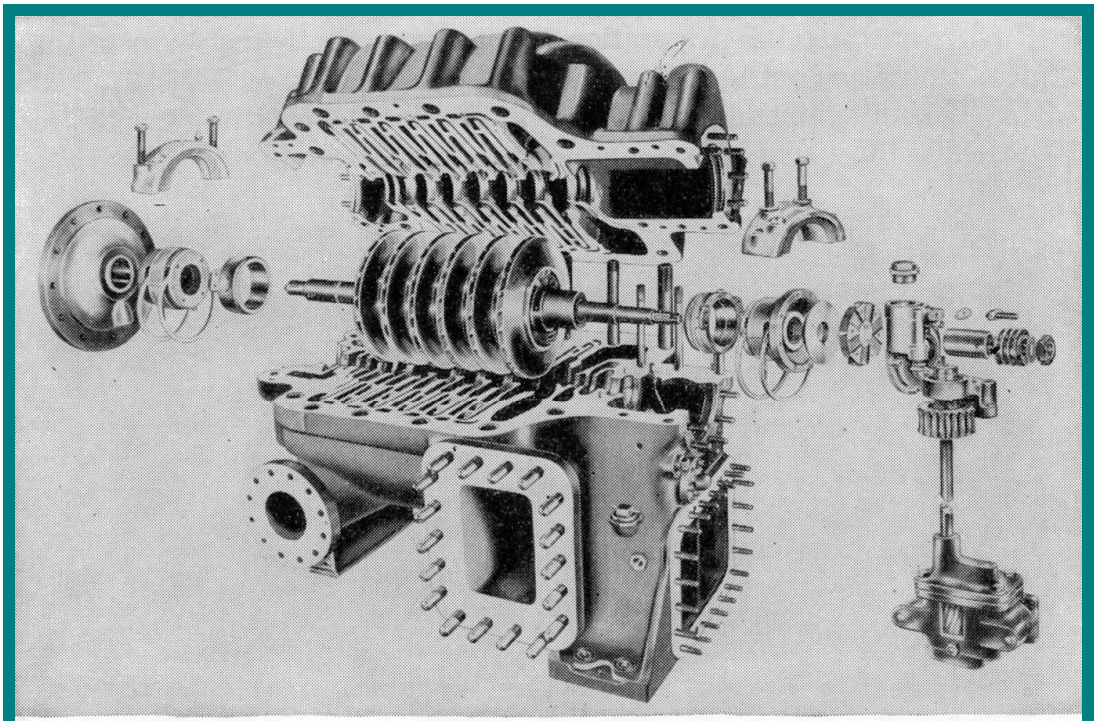


Fig. 7.24. Multistage centrifugal compressor. Courtesy Carrier Corporation.

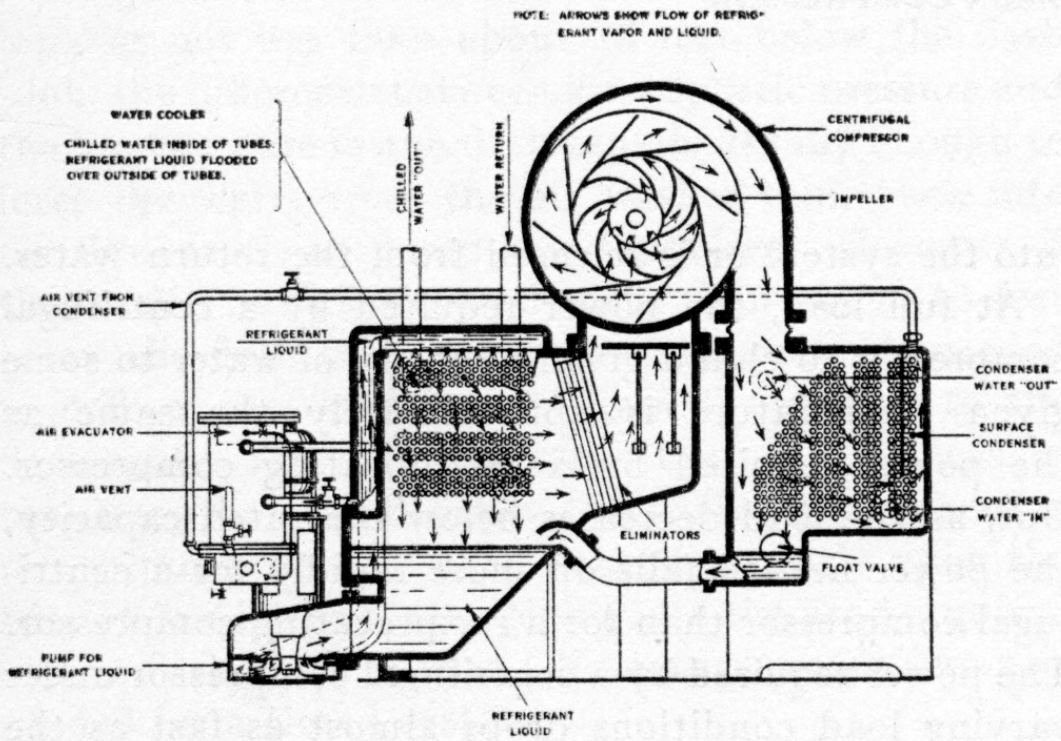
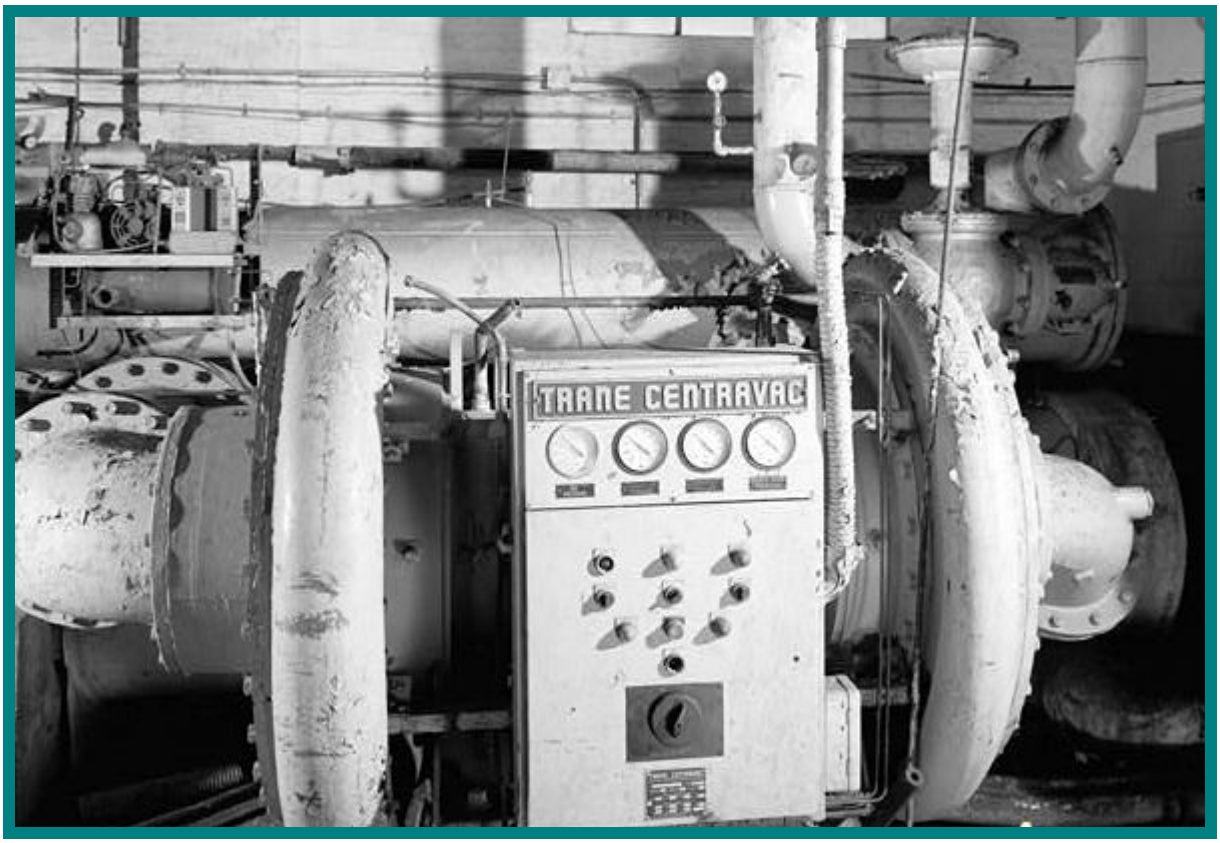
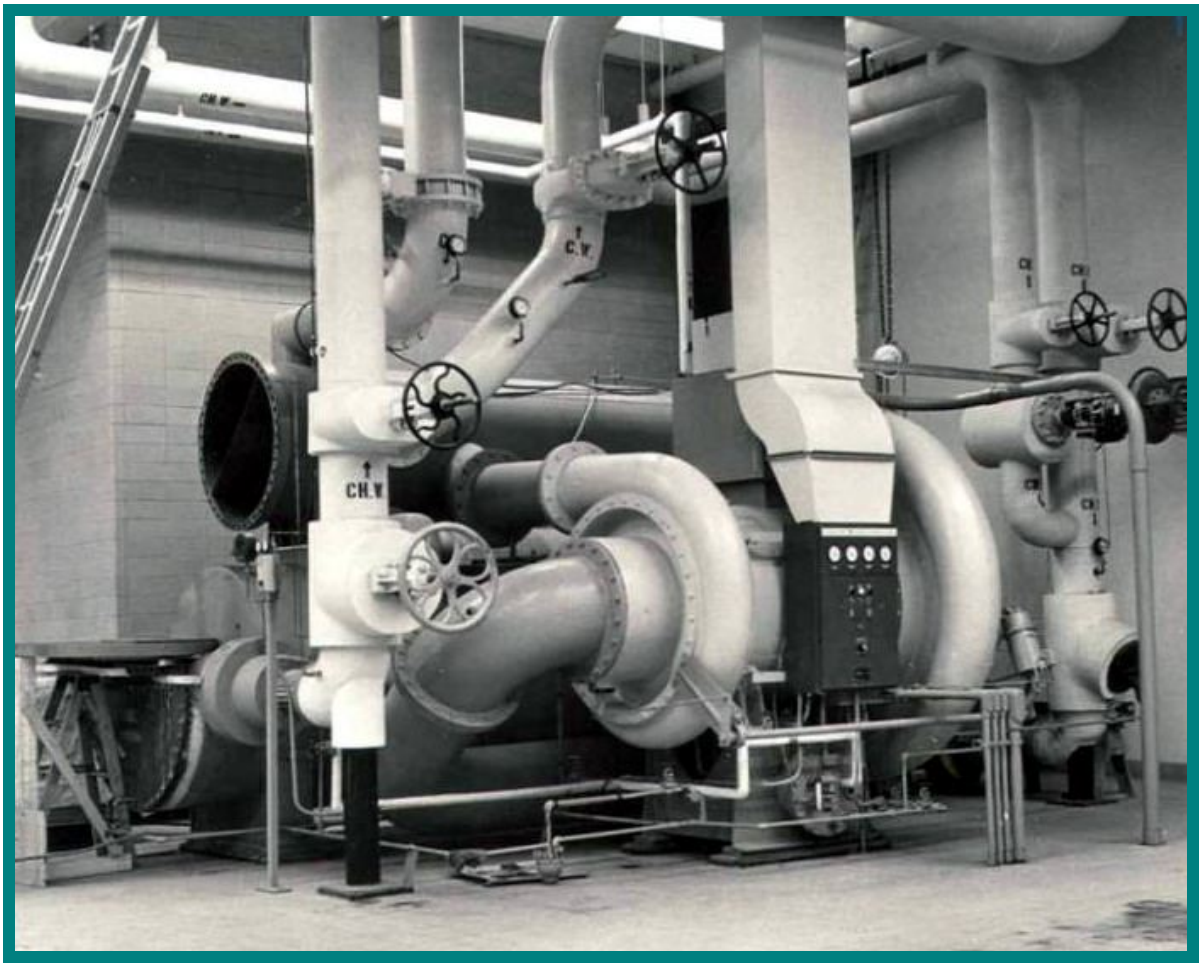


FIGURE 7-R

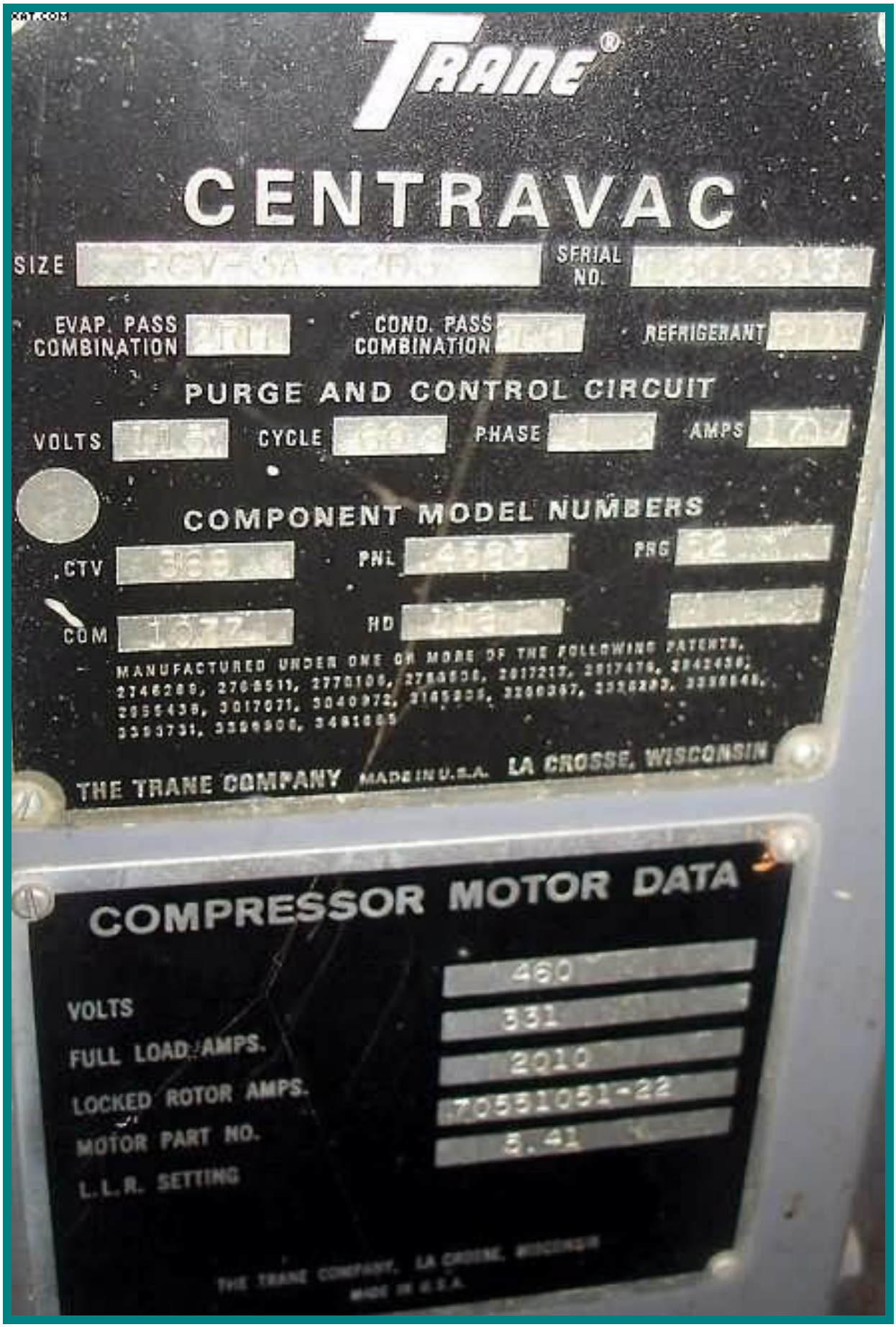
CENTRIFUGAL F-11 COMPRESSOR

Carrier Corporation centrifugal

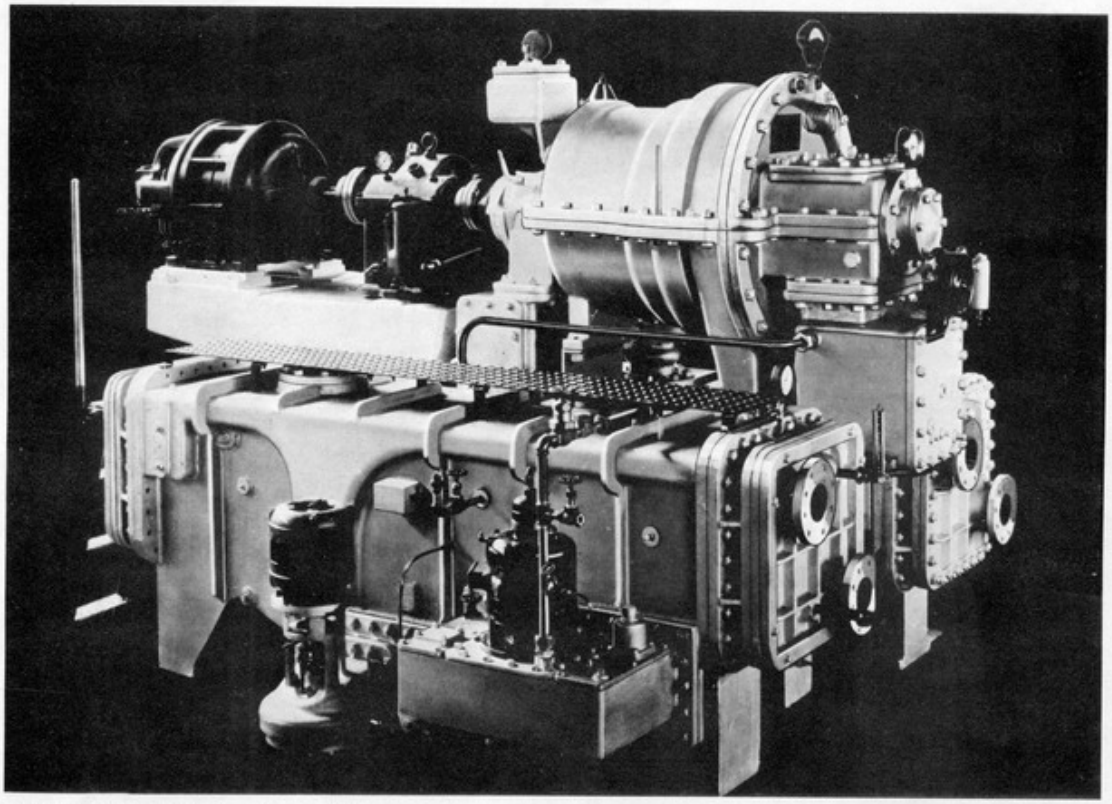




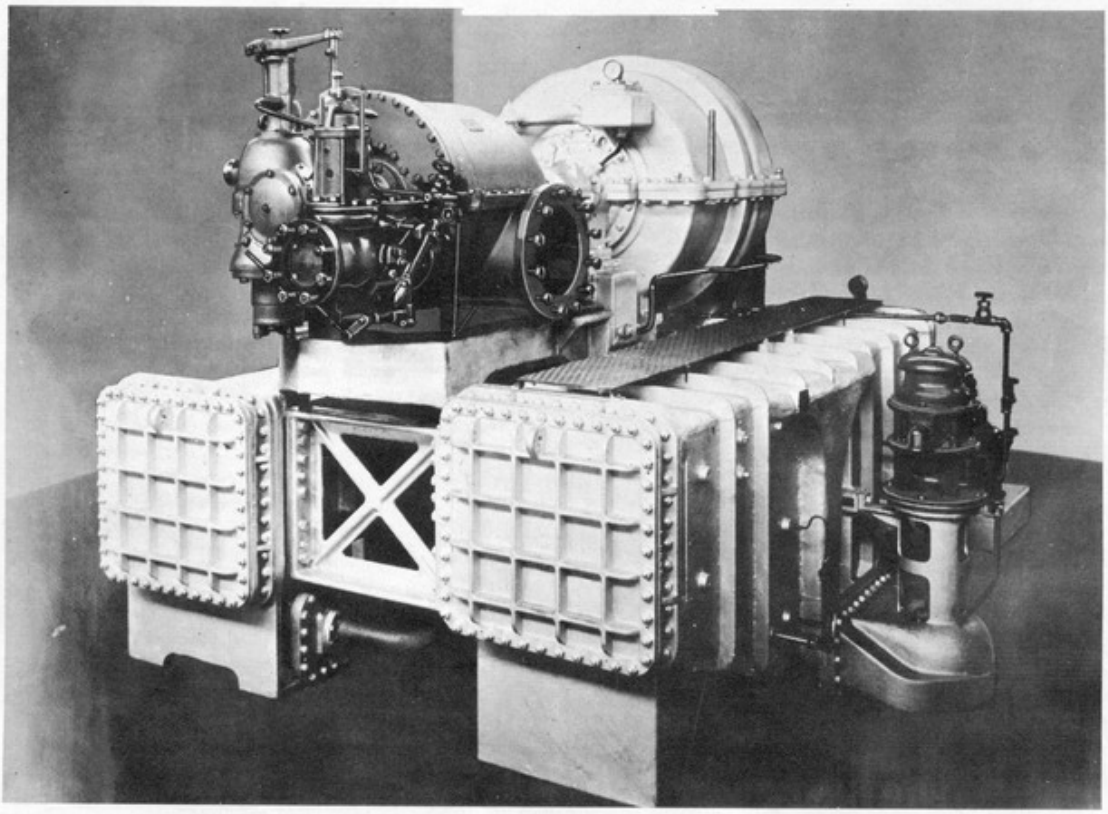
Trane “Centravac” centrifugal chillers



“Centravac” panel



A 1930 centrifugal refrigeration machine



Early model of a centrifugal refrigeration machine. Note the cast iron rectangular evaporator and condenser vessels

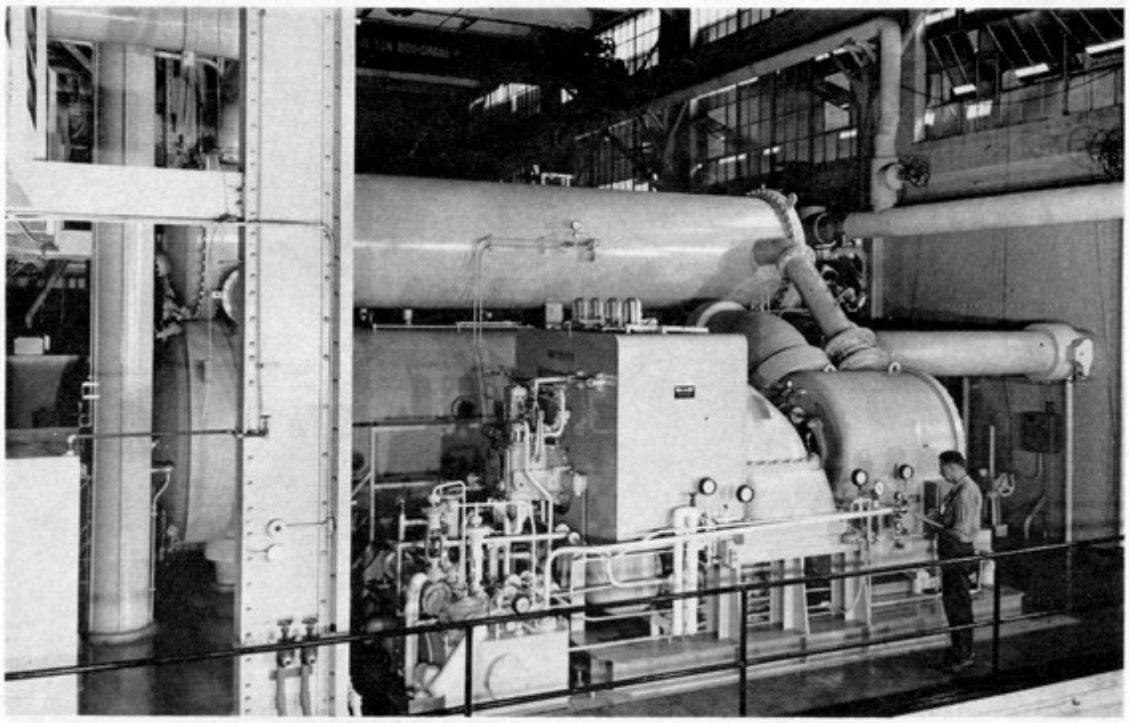


Fig. 7. First of 4 large capacity units installed recently for a 40F system. They use R-12, and produce 2900 tons each.

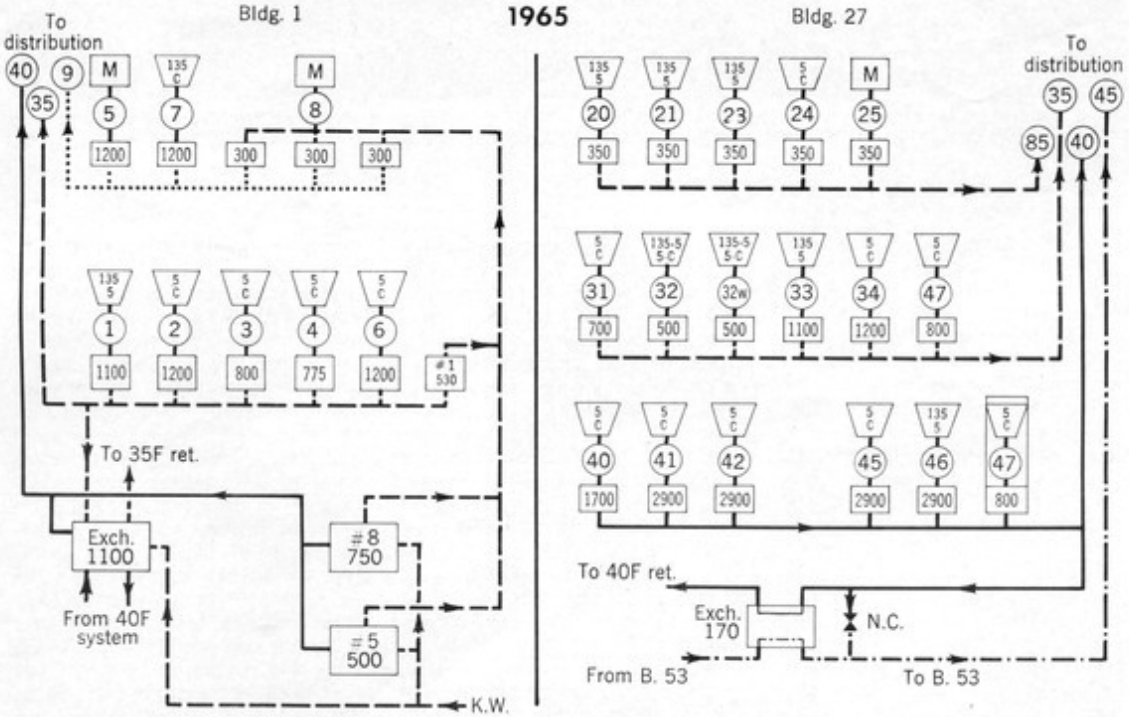


Fig. 8. Current installed capacity, 28,285 tons, is composed of 23 centrifugals using R-11 or R-12 and one reciprocating ammonia unit.

Refrigeration at Kodak, USA

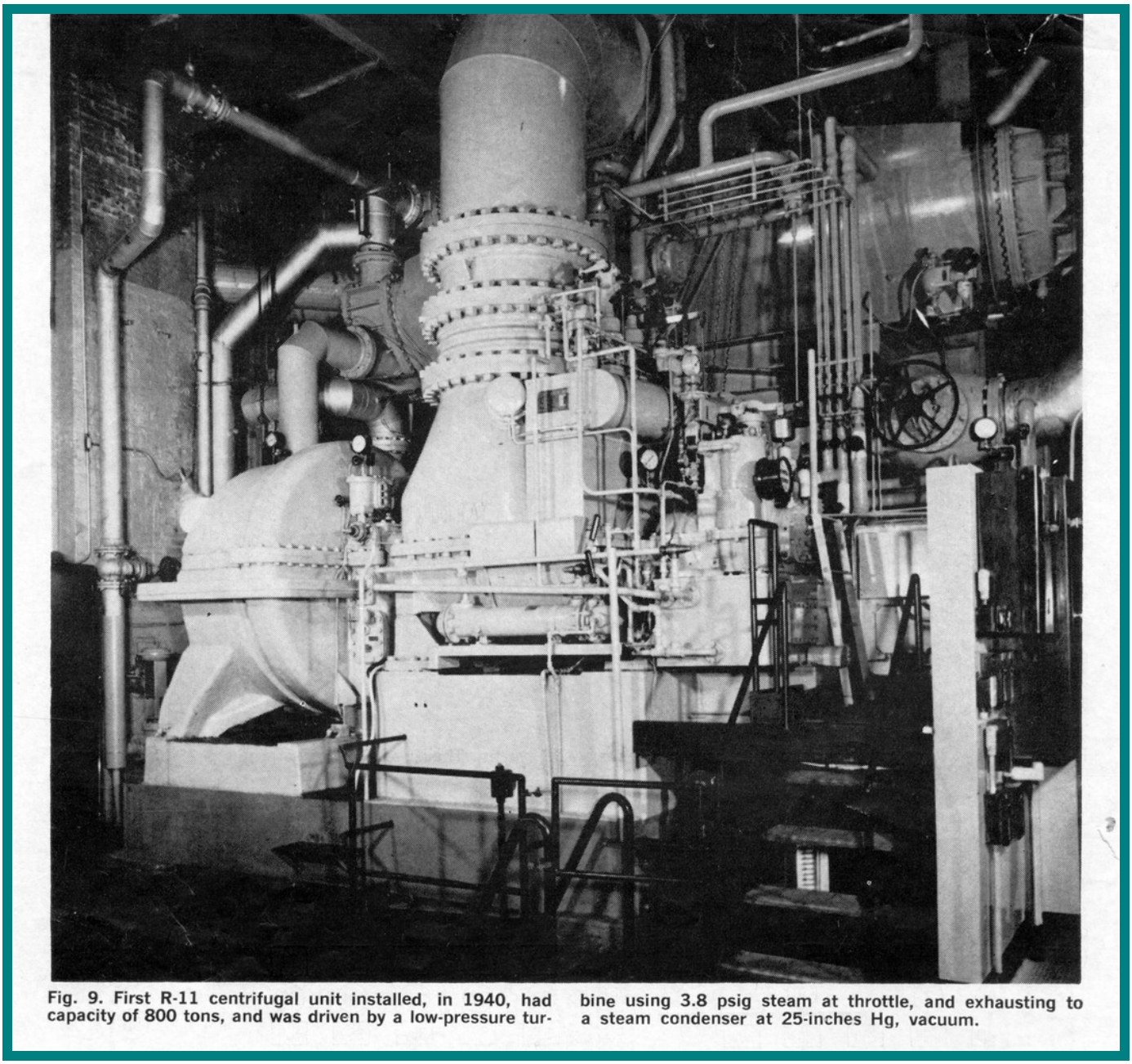
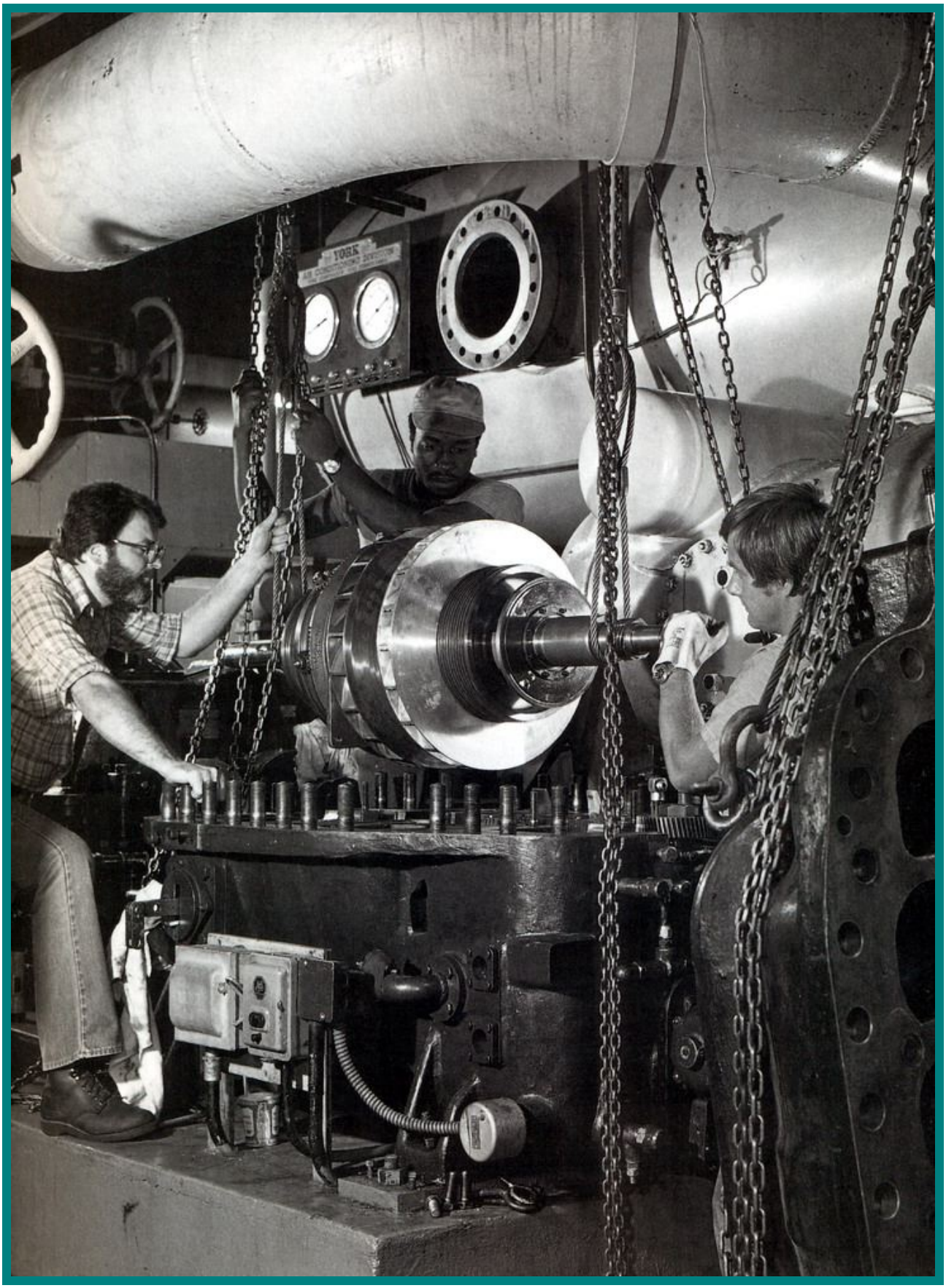
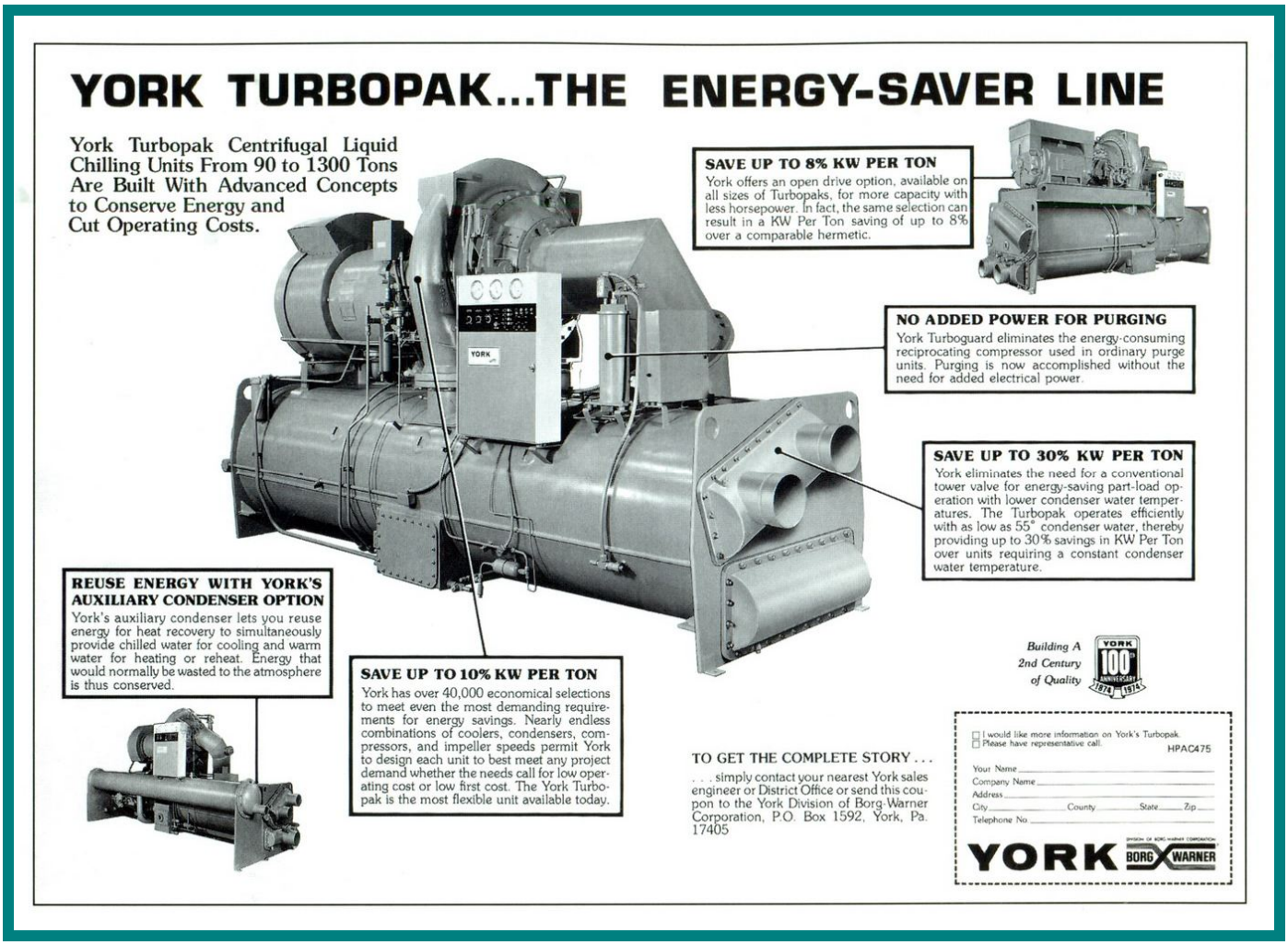


Fig. 9. First R-11 centrifugal unit installed, in 1940, had capacity of 800 tons, and was driven by a low-pressure turbine using 3.8 psig steam at throttle, and exhausting to a steam condenser at 25-inches Hg, vacuum.

Kodak



Maintenance on a York "Turbocompressor" in the Empire State Building, New York in the 1970's
"The Legend of York International," Jeffrey L Rodengen, 1997



1974 York advertisement (Rodengen)

Centrifugal Compression as Applied to Refrigeration

W. H. CARRIER
Newark, N. J.

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Willis Carrier's classic paper of 1926