A second method of providing for economy of operation, is to have storage capacity which can be utilized during the peak period. A further reference to the Weather Bureau records, indicates that maximum conditions occur during the day for not more than three hours duration, and consequently, the refrigerating system can be run for a longer period at maximum efficiency, with tanks to store cold water or brine for supplementing the actual output of the refrigerating equipment when the load is more than the machine will carry. This situation brings complications. Storage tanks require space and extra apparatus, which increases the cost of the entire system, and further, it is difficult to determine what the size of the compressor should be, because of the other variables which enter the problem. Depending upon the availability of storage space, the compressor could be designed for any capacity above 50 per cent of the maximum load, so the smaller the compressor, the larger the storage space, and vice versa.

A third method, is to provide in the compressor itself, some means of reducing the capacity. This can be done by varying the speed (and consequently the displacement of the compressor), or by varying the displacement, either by a partial by-pass of the cylinder, or a clearance pocket in the head of the cylinder when reciprocating compressors are used. It might be assumed that the efficiency would remain practically constant. This is not correct, inasmuch as the machine friction remains constant with the by-pass or clearance pocket method, which raises the power required per ton of refrigeration developed. Also, the volumetric efficiency of the machine falls off rather rapidly when the clearance pocket or partial by-pass is used. By varying the speed of the compressor, the efficiency of the motor falls off as the speed is changed, the power output of the motor varies below maximum, and again, the compressor friction remains constant. Of the two methods, the clearance pocket, or partial by-pass of the cylinder is probably the more efficient, for general use.

Another method of operation is automatic starting and stopping of the refrigerating machine, with the automatic control designed to function as the load varies. This, however, is not considered good practice as mechanical troubles develop and the life of the system is impaired. While the equipment is kept in good condition, however, the machine will operate at maximum efficiency so long as it runs. The constant starting and stopping of large compressors is liable to cause the power factor to decrease if adequate allowance is not made.

All of the methods described are used from time to time.

The methods of varying the output of a refrigeration system which have been outlined, apply to the reciprocating type of compressor, although variations in the speed of the compressor to change the refrigerating output is common to all types of mechanical refrigeration.

There is a further method of controlling the compressor output which is particularly adaptable to the centrifugal type of machine. This is accomplished by varying the amount of condensing water used, with the fluctuation in demand load. Because of the characteristics of the centrifugal type of apparatus, as the condensing water quantity is reduced and the condensing temperature consequently raised, the discharge pressure of the centrifugal machine rises correspondingly and the horse power input to the machine falls off. While this reduces the total power input to the

machine, it does not necessarily reduce the power input per ton of refrigeration developed, as the power input does not drop with a rising discharge pressure as fast as the refrigerating effect produced. It is a method, however, which shows marked economies over the method generally used by the operating engineer, which is to lower the suction pressure in order to reduce the refrigerating output of the system.

Steam Jet System

So far the discussion has been confined to reciprocating, centrifugal, and rotary compressors. There is another type of compressor which, under certain circumstances, is desirable for use with air conditioning. Reference is made to the steam jet compressor. Fig. 3 shows a complete flow diagram of the system. The power used for compressing the refrigerant

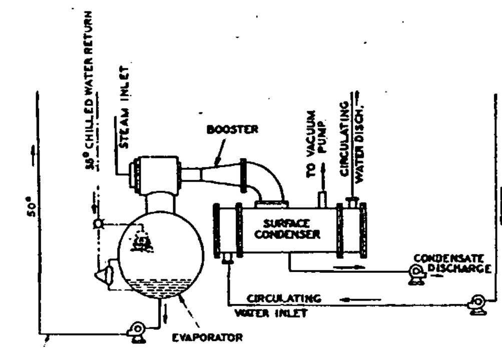

Fig. 3. Diagram of Steam Jet Refrigeration Unit

is steam, taken directly from the boiler, thus eliminating the mechanical losses of manufacturing electric current. As the compression ratio between the evaporator and condenser under normal circumstances is large the mechanical efficiencies of the equipment are somewhat lower than those of the positive mechanical type of compressor; also the condensing water requirements are considerably greater, as both the refrigerant and the impelling steam must be condensed.

The steam jet system functions on the principle that water under high vacuum will vaporize at low temperatures, and steam ejectors of the type commonly used in power plants for various processes, will produce the necessary low absolute pressure to cause evaporation of the water.

Fig. 2 shows a typical water cooling application. The water to be cooled enters the evaporator and is cooled to a temperature corresponding to the vacuum maintained. Because of the high vacuum, a small amount of the water introduced in the evaporator is flashed into steam, and as this requires heat and the only source of heat is the rest of the water in the evaporator tank, this other water is almost instantly cooled to a temperature corresponding to the boiling point, determined by the vacuum maintained. The amount of water flashed into steam is an extremely small percentage of the total water circulated through the