tors, the humidity in the food-storage compartment is low due to the presence in the cabinet of the cold evaporator, and therefore rapid drying of uncovered foods occurs. The sealed chamber maintains a high humidity because the cooling surface is the whole surface of the chamber, operating at practically the same temperature as the air inside. Food desiccation is thus held to a minimum. Temperatures just above freezing provide the additional advantage of inhibiting bacterial action. This combination of high humidity and near-freezing temperature is optimum for extended storage of unwrapped or uncovered perishable foods.

Automatic ice-making is also available in some two-temperature refrigerators. As ice is removed from a storage container in the freezer, the icemaker automatically refills the ice-making cavities with water from the house piping and ejects cubes until the storage container is again full.

Automatic Defrosting

Another important feature in household refrigerators is the rapid automatic defrosting of the evaporator. Early attempts to solve the problem of removing the frost from the evaporator were confined to providing a manual means for modifying the operation of the standard temperature control. This modification permitted the evaporator to operate above 32 F for a period of time. More recently defrost clock mechanisms became available as accessories. These devices interrupt the power supply to the refrigerator for a sufficient length of time once a day, to permit the day's accumulation of frost to melt from the evaporator during the early morning hours. However, these schemes present the problem of maintaining temperatures adequate for the proper storage of frozen food such as ice cream.

Another method is to have a separation between the subfreezing and main food-storage compartments. The evaporator used in the main food-storage compartment operates above freezing during all or a portion of the cycle, thus permitting the accumulated frost to melt. The sub-freezing compartment has to be defrosted by the usual methods although less frequently than in the conventional arrangement.

Practically all the manufacturers now offer one or more models, including some of the two-compartment type, which obtain rapid automatic defrosting.

Various means are employed to apply heat to the refrigerating system to obtain rapid melting of the accumulated frost. This heat may be supplied by direct application of electrical heat or by suitable means for introducing hot gas to the evaporator. Defrosting periods range from 5 to 30 minutes duration. This short defrosting cycle permits no substantial rise in the frozen-food temperature or in the food-compartment temperatures. These refrigerators permit the safe storage of frozen foods over considerable periods of time while maintaining the evaporator relatively free of frost. The defrost water may be collected in a removable container inside the refrigerator or conveyed to a receptacle outside to the cabinet, from which it can evaporate.

Another solution is to separate the evaporator from either (or both) the subfreezing compartment and the main food-storage compartment. By suitable air ducting arrangements the compartment is cooled by forced convection. This has the advantage of simplifying the problem of evaporator defrosting. In the subfreezing compartment, it has the further advantage of preventing or reducing frost buildup on the frozen foods.

CABINET DESIGN

The fundamental factors in the design of a cabinet are its usable food-storage *capacity* in cubic feet and its external *dimensions*, both of which are influenced by competitive considerations. The method of computing usable cubical contents and shelf area is contained in the American Standard B38.1-1955.

Structure

The external shell of the cabinet is generally a single fabricated steel structure which supports the inner food compartment, the door, and the refrigerating mechanism. In general, the door and breaker strip construction is similar to that shown in Fig. 1. The door covers the whole front of the cabinet. A single plastic sheet serves as the inner surface for the door and the door breaker strips. The door is formed to the contour of the cabinet opening and to accommodate the shelves and compartments attached to it. The air gap between the breaker strips and the door panel contributes substantially to the total heat leakage of the cabinet. Therefore, this gap should be kept as small as possible, and the width of the breaker strip kept as wide as practicable. Mechanically, the overall structure of the cabinet should be strong enough to stand shipping. A cabinet that will withstand shipping is almost certain to be strong enough to withstand daily usage. The inner food liner should be so designed that it does not chip or craze at the points of support. Shelves must be designed with adequate strength so that they will not sag under the heaviest anticipated load. Cabinet hardware should be satisfactory for a total of approximately 350,000 door openings.

Insulation

In a domestic refrigerator insulation usually varies from 2 to 3½ in. in thickness. Insulating materials in common use are rock wool and glass wool. Other types are (1) expanded-in-place foam insulations which have good moisture sealing properties and structural rigidity and (2) insulations impregnated with a gas having a thermal conductivity less than that of air. This may allow the cabinet wall thickness to be reduced.

Although it is desirable to obtain an exterior cabinet shell as nearly vapor-tight as possible, consideration should be

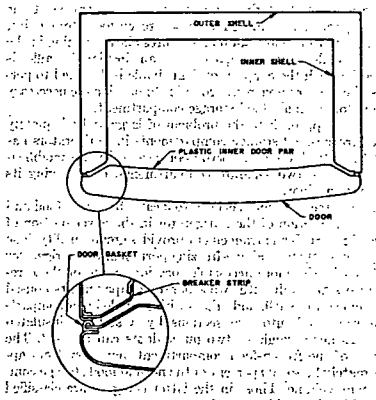


Fig. 1 Door and Breaker Strip Construction

given to the fact that, when water vapor is migrating from the ambient air into the insulation, it is also passing from the insulation into the area around the cold evaporator. Consequently, the design of door gaskets, breaker strips, and other parts should provide maximum barriers for vapor flow from the room air to the insulation, but, at the same time, provide as free a passage as is practicable between the insulation and the inside of the cabinet.

The effect of insulation thickness on heat leakage is not the only important consideration. Another very important one is the maintenance of the exterior of the surface of the cabinet at a temperature sufficiently high to prevent moisture condensation on the surface. Areas where condensation will usually occur are around the hardware or along the edge of the door opening. Good practice suggests that, with a 40 F refrigerator interior temperature in an 80 F room, no external surface temperature on the cabinet should be more than 5 F below the room temperature. In some instances, particularly in two door designs, it may be necessary to include a very low wattage heater immediately behind certain localized areas, to raise their temperature sufficiently to prevent moisture condensation at these locations during periods of relatively high ambient humidities. These heaters are generally made of a fine resistance wire or ribbon-wound on a flexible core and encased in a plastic or rubber sheath.

Finishes

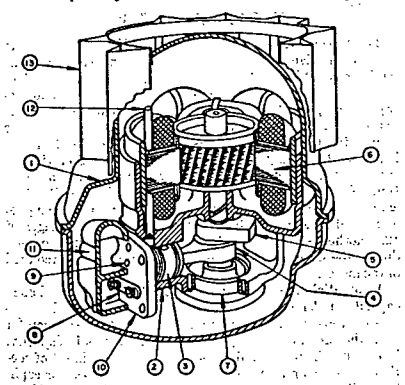
Modern synthetic baked enamel finishes are common for refrigerators. Customarily, they are applied over a chemically treated surface to obtain good paint adhesion and prevent spreading of the rust if scratches extend through the finish.

In addition to the synthetic enamel finishes, there are improved vitreous enamel finishes that usually consist of one ground coat and two or three finish coats, each of which is fused on separately. The finish used almost universally on the food compartment liner is an acid-resistant vitreous enamel. However, suitable synthetic organic finishes are now available for this application. Some refrigerators have this type of finish on the food compartment liners. There has been a marked increase in the use of color in refrigerators. On some models it is used on the interior components such as breaker strips, shell fronts, compartment fronts, and the escutcheons and panels on the cabinet exterior. Most manufacturers now offer a wide selection of other models completely color-styled including the food compartment liner and the cabinet exterior. Plastics are used to a considerable extent in present day refrigerators, primarily because of their ease of fabrication, low heat conductivity, pleasing appearance, cleanability, and resistance to moisture.

Low odor level is of utmost importance in the selection of a plastic for use in a refrigerator. Impact resistance, wearing qualities, electrical insulating ability, low water absorption, are other important characteristics that must be considered in selecting the plastic most suited for the particular application. Polystyrene is widely used for door panels, door shelves, evaporator doors, baffles, breaker strips, drawer, pans, and many small items.

The phenolics are generally used for laminated door panels in molded parts such as terminal boxes, and as a binder for the glass fiber insulation.

The good bearing qualities of nylon are used to advantage in such applications as hinges, latches, and rollers for sliding shelves. Gaskets, both for the refrigerator and the evaporator doors, are generally made of vinyl or rubber.



1. Hermetic housing
2. Cylinder
3. Piston
4. Connecting rod
5. Counter-balance
6. Motor
7. Outer bearing
8. Discharge valve assembly
9. Suction valve port
10. Valve plate
11. Cylinder head
12. Suction gas intake pipe
13. Cooling fins

Fig. 2 Hermetic Motor Condenser Unit with Reciprocating Pump

COMPRESSOR UNITS

Brief descriptions will be given of hermetic, reciprocating, and rotary compressors. For more complete descriptions see Chapter 38, Compressors.

Hermetic Units

Household refrigerators employing a mechanical compressor utilize hermetic unit design. The motor compressor unit is an integral assembly, and is sealed into a gas-tight housing eliminating shaft seals, belts, pulleys, and open motor bearings. The unit may be mounted on springs within the shell, or pressed tightly into it (Fig. 2). This assembly is externally supported by rubber or spring mountings. The chlorofluoromethane and ethane group of refrigerants are almost universally employed in the present hermetic units. Refrigerant 12 is the most widely used in both reciprocating and rotary compressors. However, Refrigerant 22 is used in some reciprocating compressors.

Reciprocating

Reciprocating compressors are either of the automotive type with the wrist pin in the piston, or a scotch-yoke type (Fig. 2 and Fig. 3). The advantage of the latter is the flexibility between the axis of the piston and the motor axis. With the automotive type, it is necessary that the wrist pin be exactly at right angles to the piston axis, otherwise noise will be introduced due to the misalignment of parts. When parts are not built with sufficient rigidity, misalignment under load may occur even though no-load accuracy exists. This condition does not exist in the scotch-yoke design, because it has flexibility in two directions.

Rotary

Rotary compressors are generally one of two types. In one type the integral rotor and shaft assembly is concentric with the circumference of the rotor and eccentric to the circum-