many manufacturers are offering a wide range of air-cooled condensing units and remote type air-cooled condensers. Sizes are currently available, in one combination or another, to handle plants from the smallest to the largest.

New air-cooled condensing units and remote air-cooled condensers are weatherproof and may be installed outdoors where good air circulation is available.

The air-cooled condensers are provided with single or multiple circuit coils so that they may serve one or several condensing units. Air-cooled condensers may be used to advantage in many places to take over the condensing service now handled by water-cooled condensers. Proper selection of such remote air-cooled condensers is important and special consideration must be given to capacities of refrigeration required in relation to maximum and minimum condensing air temperatures for each area. In many cases, the use of air-cooled condensing units or air-cooled condensers will reduce both operating and maintenance expense. Manufacturers' tables for such application should be consulted.

Cooling Units

The cooling units or evaporators for a frozen food locker plant must provide the proper temperatures for three general types of refrigeration services.

The first is that of the chill, aging, and curing rooms. Temperatures here are non-freezing, and average about 35 F. Some variations may be required to meet special conditions such as in a meat curing room where best results are obtained with a temperature of 38 to 40 F. These rooms may be handled with either forced air or gravity circulation type evaporators, installed in such numbers and locations that each room has good air distribution. The temperature difference from air to evaporator should average 10 to 15 F deg between the refrigerant and the design temperature of the room for forced air units. If gravity types are used, they should be selected at an average of 20 to 25 F deg difference. With either type, modern refrigeration practice requires automatic defrosting. Forced air units are now the most popular with engineers and plant operators for the above purpose. Many plants, however, especially smaller ones, are operated successfully with the gravity type.

The second type of refrigeration to consider is for freezing. The *sharp freeze* method consists of a low temperature room, equipped with non-defrosting overhead cooling units (plates or pipe coils), where heat transfer from the food to be frozen is dependent upon gravity air circulation. In such freezers, the design room temperature is usually − 15 to − 20 F with refrigerant temperature 5 or 10 deg lower. This type of freezer is used in some of the older plants, but is not usually selected for the modern plant because of the larger space required, the increased investment, and because freezing is often slower than with other methods.

The *contact freezer* is generally of the cabinet or room type. Low temperature plates are ideal for this type freezer. The packaged food is placed directly on them for freezing. The freezer should be as small and compact as possible, yet ample to handle the peak volume of products to be frozen. The freezer should not be used for storage purposes. Refrigerant temperatures of − 10 to − 20 F in the plates will provide satisfactory freezing results. If a walk-in freezer room is specified, it is good practice to install a bank of overhead plates to take care of the heat leak and service load. This is not necessary with a cabinet-type freezer which is usually installed in the locker room.

The air temperature in the freezer cabinet or room using contact freezing is of secondary importance. It will vary in relation to the loading. When the freezing cycle of a heavy load is completed, the air temperature will usually drop to within a few degrees of the plate temperature. If loadings are continuous, the air temperature of the freezer will show little variation. The simplicity of a plate-type freezer makes it popular.

Blast freezers were employed in a few locker plants at the beginning of the industry, but were not popular due to the defrosting problems. During the last few years, however, many improvements have been made in these freezers, especially in respect to defrosting. With these improvements, there has been an increase in popularity and, likewise, in the number of installations. Some types of blast freezers are used for freezing only. Other types are available for both freezing and locker room refrigeration. The freezing is accomplished by a rapid circulation of air over the low temperature coils and the food is usually placed in wire baskets or upon wire racks. The refrigerant temperature in a blast freezer is usually selected at − 5 to − 10 F. If properly operated within capacity limits, a good product results.

The freezing of food in a locker plant freezer should be fast enough to allow two or three turnovers or freezings per 24 hr.

The third type is the refrigeration of the locker storage room which may be accomplished with gravity or forced air cooling units. Regardless of the type used, the design temperature of the storage space should be 0 F or below, with an allowable variation of ± 2 to 3 deg. In order to produce this result, it is necessary that the capacity of the refrigeration equipment be sufficient to handle the heat leak load during periods of peak ambients. *The locker room should not be used to freeze products, but used for storage only.*

If gravity-type units are used for the locker room, they should be distributed over aisles so that complete coverage is effected for the whole room. Banks of several plates each are usually used, although in some plants closely spaced pipe coils are used. By installing gravity-type units over the aisle, periodic removal of frost is made much easier. Such locker room units are usually selected to operate at a temperature difference of 15 to 20 deg.

If forced air units are used to refrigerate the locker room, they should provide air distribution to all parts of the room. Ducts are sometimes necessary in large locker storage rooms. If ducts are not used, the velocity of cold air as it leaves the grille or distribution hood must be high enough to reach the farthest part of the room. The space between top of the lockers and ceilings should be open and unobstructed.

Forced air units for locker rooms should be selected for a smaller temperature difference than that used for gravity applications, usually 5 to 10 F.

Positive means of defrosting forced air units must be provided. Outdoor air, hot gas, water, or electric defrosting have been successfully used. Defrosting may be controlled manually or automatically, and if manual, must be scheduled by the operator on a regular daily basis. Consideration must be given to disposal of defrost water.

Temperature Control Devices

An important requirement of the modern frozen food locker plant is that it be entirely automatic in respect to regulation of temperature. The condensing unit controls may be of the low pressure or thermostatic type. Temperature regulation in such systems is usually accomplished by controlling the running time of the condensing unit, and applying the proper controls to one or more evaporators.

When a single condensing unit is used for each zone of re-

frigeration, the low pressure type of control may be used. It will function satisfactorily for either low or normal temperature areas. Low pressure control is necessary where automatic defrosting of normal temperature evaporators is desired.

If more than one temperature zone of refrigeration is connected to a condensing unit, it will be necessary to observe the usual rules for multiple control. Evaporators in different temperature zones in a system of this kind usually operate at different suction pressures, and, therefore, evaporator regulator valves or themostatically controlled solenoid valves will be required on all except the lowest temperature refrigerant circuit.

If the temperature variation between zones is only a few degrees, such as between a chill room at 35 F and a cure room at 40 F, it will usually be satisfactory to use an evaporator regulator valve or snap action valve in the suction line to the cure room evaporator. Some engineers install special controls in the freezer cabinet or room in order to prevent the cycling of the condensing unit during the handling of a heavy freezing load. This may be accomplished by a manually operated switch connected across the terminals of low pressure control, so that the operator has the option of closing the switch and causing the condensing unit to operate continuously until the freezing has been completed.

This function may also be handled on a semi-automatic basis by having a special thermostatic control in the circuit instead of the manually operated switch just described. This special control is provided with a flexible capillary tube between the switch mechanism and the bulb or operating element. The operating element may be inserted in a package of food which is being frozen and the control so adjusted that the condensing unit will operate continuously without cycling until the food has reached a predetermined low temperature (usually about 0 F).

If the refrigeration system is planned so that one condensing unit will handle both the freezer and the locker room evaporators, there are certain precautions which should be taken to prevent wide fluctuations in the temperature of the locker room. Such installations may be provided with a suction line solenoid valve with thermostatic control on the locker room evaporator. The thermostat should be adjusted to close the solenoid valve if the temperature of the locker room drops below a certain predetermined point, usually − 3.5 to − 4 F. This condition may be obtained during periods of heavy loading of the freezer which may require continuous operation of the condensing unit for several hours. Without the thermostatically controlled suction solenoid valve in the circuit, the locker room evaporators may continue to function and produce wide temperature variations.

For liquid refrigerant control, most engineers prefer thermostatic expansion valves for frozen food locker plant refrigeration systems. A few prefer expansion valves of the automatic type. Thermostatic control of the condensing unit is required, with automatic expansion valves. Most ammonia refrigeration systems used in frozen food locker plants are equipped with a low side float control which regulates the flow of liquid refrigerant to the evaporators which are usually of the flooded type. Additional control and safety devices usually required are water regulating valves, high pressure cutouts and modulating damper controls with forced air systems.

CALCULATIONS AND EXAMPLES

The service load factor (lights, air infiltration through door openings, occupants, etc.) to be considered in the refrigeration load may be handled either by making rather elaborate and extensive calculations (See Chapter 27, 1961 GUIDE AND DATA BOOK), or by adding an arbitrary heat transmission factor when calculating the heat gain through insulation. This arbitrary factor is included in some manufacturers' tables under the classification of light, normal, heavy, or super service. For small limited service plants, light service is probably satisfactory for the locker room and normal service for the chill room and other above freezing areas. For large multiservice plants, higher factors, such as normal, heavy, or super, are suggested for the locker room with correspondingly high factors for the chill room and other non-freezing areas. Most refrigeration locker plant engineers have found that the results of the simple second method are just as satisfactory and accurate as the more elaborate method. When reviewing the examples A, B, B Alternate and C at the end of the chapter, it is necessary to consider these service load factors, if they are to be used as a pattern for plant design.

However, before reviewing any of these examples it is important to examine first the provisions for curing facilities which are specifically covered in Plan B, B Alternate, and C. Since these plans do not provide for large curing rooms it is necessary to consider additional facilities where curing and storage age of meats, especially pork, will be a major factor. These facilities may require more bins and floor space in the curing room and more chilling and processing equipment. Some operators have found that they need as much as 86 percent of their storage space equipped with meat curing and storage facilities.

Where climatic conditions are favorable, considerable aging of cured meats, especially hams, is accomplished in dry, tight rooms at room temperature. This process may take from two to four months and requires special treatment but no additional refrigeration facilities.

Patrons usually take cured meats home as soon as curing is completed. Except in the case of *heavy cured* meats, some spoilage will occur in hot weather, if the meat is not used within a reasonable time. This problem can be solved by the rental of bins or bin space on a month-to-month basis in the cured meat storage room.

Many attempts have been made to standardize frozen food locker plants so that the plans and specifications for a given size would be available for several projects. This has been done to a certain degree as far as equipment is concerned, and, in some cases, many of the details of building construction have been similar. It is not likely that such a procedure will be carried out with any great number of plants, however, because each one differs in some respects from all others. The following examples A, B, B Alternate, and C are, therefore, included here for reference purposes only.

PLAN A—120 LOCKERS

Plan A, Fig. 2 provides for a small frozen food locker plant to be operated in connection with a grocery or meat market. This plant is typical of many that have been installed as an additional source of revenue to the store owner, as well as a convenience to the families in the community.

The general layout of a plant of this type and size should be be made so as to best use the space available for both operator and store customers, most of whom may be expected to become locker patrons. It is usually best to locate the plant in the rear of the store, so that patrons may enter the front and pass through the store to get to their lockers. This helps the sale of other merchandise, especially to those who were not formerly regular store customers.

If the store is a small one, there will be times when it will be