CONSTRUCTION OF FARM REFRIGERATORS & FREEZERS

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Is It Practical to Build Your Own Refrigerator or Freezer?

The answer to this question depends on several considerations

Complete refrigerators, freezers, and combinations of both are being manufactured commercially in various sizes. But many farmers may wish to build their own equipment because:

1. They have a particular space available which would not accommodate a standard size unit, but which could be adapted to a home-built one.

2. They have storage problems that require special space arrangements.

3. They have building materials readily available, can do most of the work themselves, and thus save money.

These factors are especially true of walk-in units.

A complete, mechanically cooled refrigerator or freezer has two main parts:

1. The box, or room, for the storage space.

2. The refrigerating unit for cooling it.

Sometimes it is practical and economical for a farmer to build his own box or room, but it is not practical for him to build the refrigerating unit. This is a complicated mechanism, factory-made with special tools. It must be bought complete except, in some cases, for the cooling coil.

The information in this circular is intended to help you decide whether you want to build a refrigerator or freezer for your home, and if so, what type you should choose. No working plans are furnished because of the wide variety of possibilities. Plans for standard sizes are available (see page 19), but if your space cannot accommodate a set plan, you will need to have one made, or draw it up yourself. Possible designs are suggested, together with a discussion of materials, essential construction methods, equipment, and costs.

This publication is the nineteenth in a series reporting results of investigations conducted by the California Agricultural Experiment Station in coöperation with the California Committee on the Relation of Electricity to Agriculture.

CONSTRUCTION OF FARM REFRIGERATORS AND FREEZERS

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IN BUILDING a cold-storage unit for your home, you have a choice of three main types. The one you choose will depend on the size you want, amount and kind of food to be stored, and available space.

In this circular, the cold-storage units which maintain temperatures above freezing (32° F) are called "refrigerators," those with temperatures below freezing are called "freezers."

1. REFRIGERATORS

There are two types of refrigerator, the reach-in and the walk-in.

Reach-in. These range in size from a few to about 100 cubic feet. The storage space is usually not more than 30 inches deep and 6 feet high, but the width is limited only by the space you have. A separate door is usually provided for each 3 feet of width.

Walk-in. This type ranges from about 100 cubic feet to any size desired, limited only by available space. It should, however, be at least 7 feet high inside.

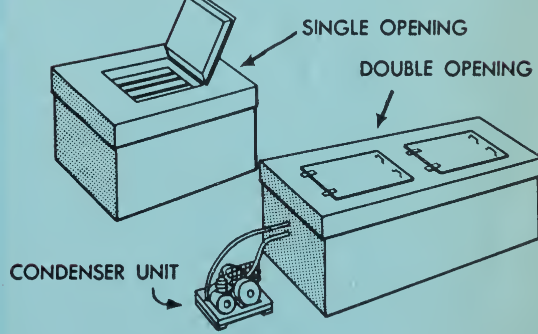
2. FREEZERS

For a home-built freezer, a single-compartment box is recommended. (There are some commercially made freezers with two compartments maintained at different temperatures—one for freezing, the other for storage after freezing. These are more expensive and difficult to build, and are not recommended for home construction.)

The size of freezer for farm use will depend upon your own requirements, and the space available. The general recommendation is at least 5 cubic feet for each person in the family. One cubic foot provides storage space for about 35 pounds of meat, or 25 rectangular quart contain-

TYPES OF REFRIGERATORS AND FREEZERS

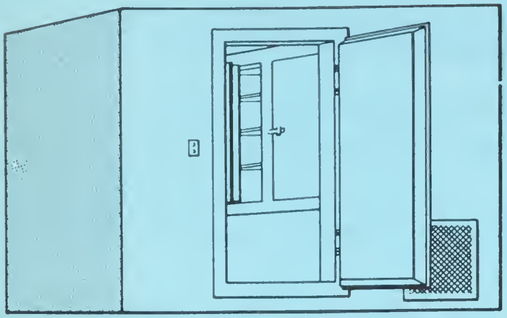
REACH-IN CABINET



REACH-IN CHEST

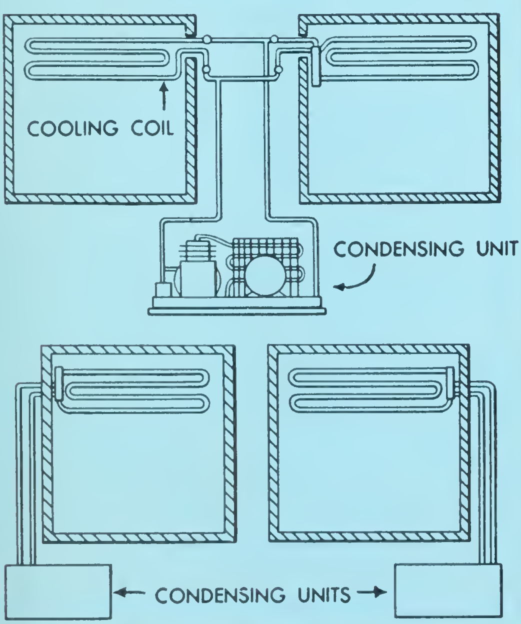
WALK-IN

COMBINATIONS



WALK-IN REFRIGERATOR WITH REACH-IN FREEZER

For a combination, a single condensing unit may serve both the refrigerator and freezer, or each may have a separate unit (see below).



ers, or 20 cylindrical quart containers, or about twice as many pints.

Like refrigerators, freezers are divided into two main types, reach-in and walk-in. For farm homes, the reach-in is more practical because the space required for frozen storage on most farms (usually less than 50 cubic feet) is not large enough for a walk-in.

There are two kinds of reach-in freezer:

Cabinet (side opening). This type is recommended when the freezer is located inside a refrigerator room because it requires less floor space than the chest type. The storage space should not be more than 30 inches deep (preferably less) nor more than 6 feet high. It may be as wide as the available space, provided there are enough doors for easy access to all parts of the interior.

Chest (top opening). When the freezer is built as an individual unit, the chest type is recommended because it is easier and less expensive to construct than the cabinet. It also has less trouble with air leakage and doors freezing to the jambs, and does not require defrosting so often. The storage space should not be more than 30 inches (preferably less) in depth or width because of the inconvenience in reaching the different parts. The chest itself may be any length, but it should have enough lids so that all parts may be easily reached.

3. COMBINATIONS

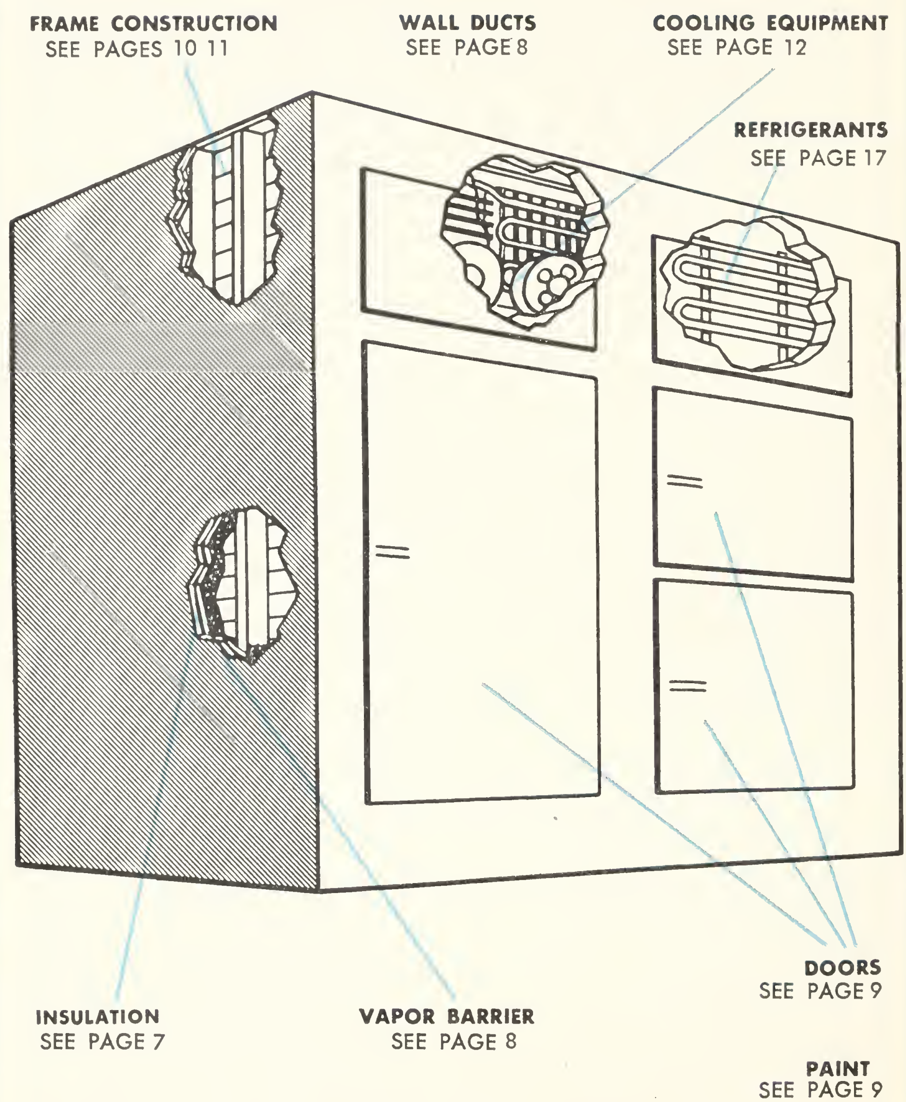
A combination walk-in refrigerator and reach-in freezer may be built with the two storage spaces as separate units or with the freezer inside the refrigerator. Two separate units are more convenient because the freezer may be used without having to open two doors and stand in a cold room. There is little difference in initial or operating costs in the two combinations. The saving on the freezer is offset by the added cost of the refrigerator due to the extra space.

The two storage spaces, in any combi-

Table 1: APPROXIMATE STORAGE SPACE NECESSARY FOR VARIOUS SIZES AND TYPES OF FARM PRODUCE AND CONTAINERS

Article	Length	Width	Height
	inches	inches	inches
Apple box	20	12	13
Berry crates—12-pint	20	15	5
15-pint	23	15	5
24-pint shallow	24	18	7
24-quart	24	12	13
32-quart	24	16	13
Cantaloupe crates—Standard	24	13	13
Pony	24	12	12
Jumbo	24	14	14
Standard flat	24	15	6
Pony flat	24	13	5
Jumbo flat	24	16	6
Cauliflower crate	25	19	10
Celery crate	25	22	23
Cherry boxes—Eastern	20	10	4
Lambert	20	11	5
Orange box	26	13	13
Lemon box	27	12	15
Grape box	18	15	6
Lettuce crate	25	19	14
Los Angeles lug	18	14	8
Egg crate—30 dozen	27	13	14
Milk cans—10-gallon	15	15	24
5-gallon	12	12	20
Bottle crates—12-quart	20	15	11
20-pint	20	15	9
Beef carcass—600 pounds	48	30	120
Rear quarter of beef—150 pounds	20	15	60
Front quarter of beef—150 pounds	48	15	60
Hog carcass—150 pounds	18	15	60
Lamb carcass—50 pounds	12	12	48
Veal carcass—100 pounds	18	12	60
Turkey—12 pounds	12	10	20
Chicken—4 pounds	8	6	12

WHERE TO LOOK FOR CONSTRUCTION DETAILS



nation, may be cooled by separate refrigerating units or by a single unit. Separate units are simpler and are preferable because one unit can still operate in case of trouble with the other. Although two small units are somewhat more expensive than one large unit, the difference is not great when you consider the cost of the extra controls, such as the two-temperature valve, shutoff valves, and check valve, all necessary with a single unit.

MATERIALS

Wood is the most common material used for home-built refrigerators and freezers because it is easy to work. Any kind of lumber may be used for framing, but it should be of a reasonably good grade, well dried, straight, and milled to a uniform width. Plywood and tongue-and-groove lumber are common materials used for the finish sheathings, but other materials, such as shiplap, fiberboard, and plaster may be used.

It is also possible to use concrete, brick, hollow tile, or other types of masonry. These have an advantage over wood because of their resistance to moisture and fire. However, they are more difficult to work with and are usually more expensive. Special lightweight types of masonry have more insulating value than the heavier types, but not enough to furnish all the insulation necessary. Regular insulating materials must also be used, as with any other masonry.

INSULATION

Insulation helps keep outside heat from getting into the storage space. Factors to consider when selecting materials are:

Heat conductivity
Odor
Moisture resistance
Availability
Ease of installing
Possibility of settling
Resistance to vermin
Cost

Table 2: CONDUCTIVITY OF SOME INSULATING AND STRUCTURAL MATERIALS

Material	Conductivity*	Thickness to equal 1 in. of corkboard
Balsam wool	.27	.90
Balsa wood	.35	1.17
Brick	5.00	16.67
Corkboard	.30	1.00
Cork (granulated)	.31	1.03
Celotex	.33	1.10
Concrete	8.00	26.67
Cotton	.27	.90
Firtex	.33	1.10
Foamglass	.42	1.40
Fiberglass	.27	.90
Insulite	.33	1.10
Mineral wool	.27	.90
Rock wool	.27	.90
Rock cork	.34	1.13
Redwood bark fiber	.26	.87
Sawdust	.41	1.37
Shavings	.41	1.37
Vermiculite (expanded)	.28	.93
Wood	.75	2.50

* B.T.U. per square foot per hour per inch of thickness per °F temperature difference.

There are a number of materials available in board, batt, and shredded or granulated forms which make a satisfactory insulator when properly installed and protected from moisture. Some of these materials and their heat-transfer factors are listed in table 2.

Corkboard is generally used as a standard for comparing the insulating value of various materials. The thickness of insulation is usually expressed as the equivalent thickness of corkboard. Each increase in the thickness of insulation decreases the heat conducted through it and reduces the operating cost. But there is an economic limit beyond which the added cost of the insulation is more than the saving in operating cost. There is also a practical limit because of the space occupied by the walls. The following thicknesses of corkboard or its equivalent are considered satisfactory:

Reach-in refrigerator	**3 to 4 inches**
Walk-in refrigerator	**4 to 6 inches**
Reach-in freezer	**6 to 8 inches**
Walk-in freezer	**8 to 10 inches**

Follow the manufacturer's instructions as to proper methods of installing a particular type of insulation. It is very important, with loose or granulated material, that the proper density be used so that it will not settle and leave air spaces.

VAPOR BARRIER

The protection of the insulation from moisture by a suitable vapor barrier is one of the most important features in the construction of a refrigerator or freezer. Air contains a certain amount of moisture in the form of vapor. The amount of vapor which air will hold depends on its temperature—the higher the temperature, the larger the holding capacity, and vice versa. When the air becomes saturated (filled with all the moisture it can hold), the vapor condenses into liquid and forms dew or fog. If the vapor is allowed to penetrate into the walls, it cools and condenses in the insulation. This reduces insulating value, and may also cause rotting.

There are two ways that vapor may enter the walls. First, it exerts a pressure in all directions and moves by diffusion from areas of high vapor pressure to those of lower pressure. Because the air in a refrigerator or freezer is cold, and the moisture is condensed or frozen on the cooling coil, the vapor pressure is lower than outside and the vapor tends to penetrate the walls, floor, and ceiling. It will easily pass through ordinary building materials and even some paints.

The second way in which vapor may enter the insulation is by "breathing" of the walls. Since the temperature surrounding the refrigerator or freezer changes between day and night and between seasons, there is a corresponding change inside the walls. When the temperature rises, the air expands and some air is forced out. When the temperature falls, the air contracts and some air is drawn in. If outside air is drawn in, it carries vapor with it. The air cools as it moves inside, and the vapor condenses.

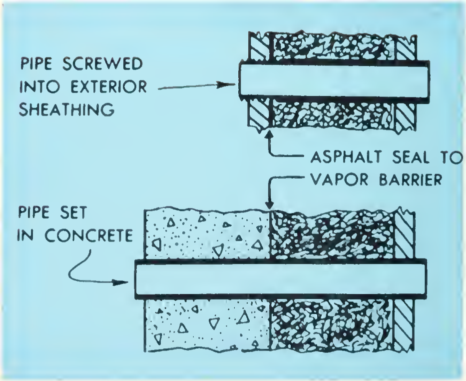
Some board and batt types of insulation are available which are already sealed against moisture or which may be sealed by coating with asphalt. But common practice is to construct a vapor barrier around the entire storage space outside the insulation. The barrier should be made of vapor-proof, odorless building paper lapped at least 4 inches and sealed with odorless asphalt at the joints. Use at least one layer for refrigerators and two for freezers. The paper's weight should be at least 35 pounds per 500-square-foot roll. Tarred and asphalted felts are not satisfactory.

It is very important that the asphalt be of a type suitable for refrigerator construction, otherwise odors may result which cannot be eliminated. Be careful not to have any holes or cracks in the barrier.

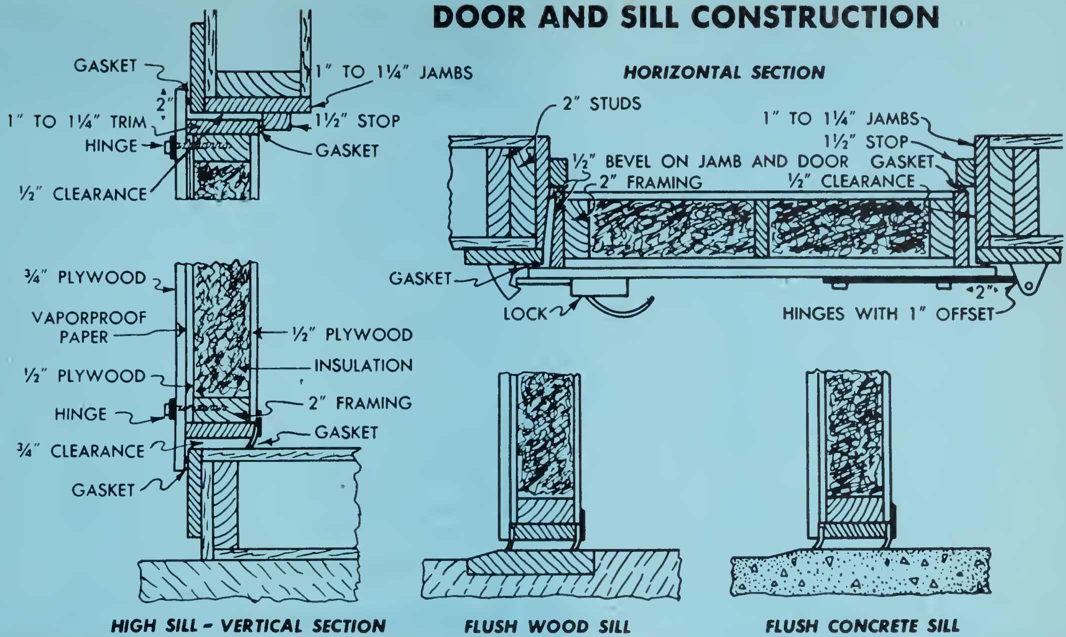
Do not place a vapor barrier inside the insulation so that moisture in the insulation may pass into the storage space. (This tends to dry the insulation.)

WALL DUCTS

The tubing connecting the condensing unit to the cooling coil, and the electric wiring (if a light is desired) must pass



DOOR AND SILL CONSTRUCTION



through the walls of the storage space. Drilling holes through the walls is not satisfactory because the vapor barrier is broken and moisture may get into the insulation. A satisfactory duct may be made of ordinary pipe which is sealed to the vapor barrier. The ducts should be placed near the top of the walls and close to the location of the cooling coil or the light. The following sizes of pipe for ducts are recommended for the tubing connections:

CONDENSING UNIT	SIZE OF PIPE
Up to ½ H.P.	**1 inch**
¾ to 1½ H.P.	**1 to 1¼ inch**
2 to 3 H.P.	**1½ inch**

A ½-inch duct is sufficient for the wiring.

DOORS

Walk-in type doors are heavy and have hard usage. If not well made of good materials, they will warp, sag, or come apart. This makes them difficult to open and close and allows air leakage. It is usually better to buy commercially made walk-in doors than to build them. Jambs and sills are included with ready-made doors. Do not make the rough wall opening until you have measured the jamb and sill of the door you buy. Stock walk-in doors 2 to 5 feet wide and 6 to 7 feet high are available. For ordinary use, a 2½-by-6 foot door is recommended.

The high sill is used where the floor of the refrigerator and outside floors are on different levels. The flush sill is used when the refrigerator and outside floors are on the same level. Flush concrete sills are recommended for wet locations.

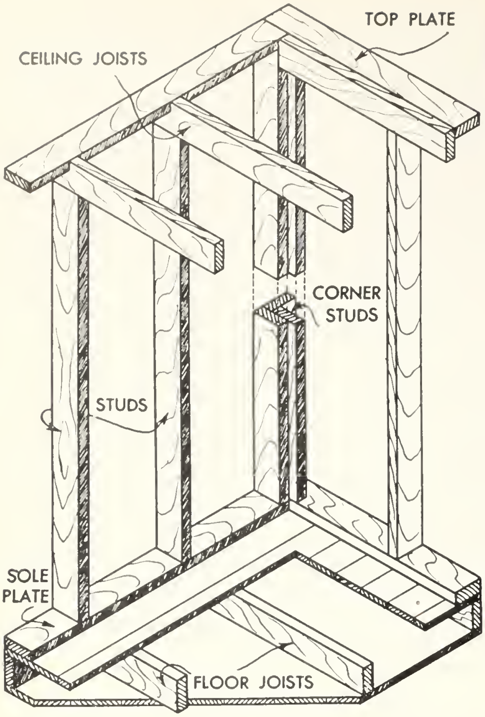
For a home-constructed door, all lumber should be clean, dry, well seasoned, and of the best grade available. The hardware should be heavy duty, galvanized, refrigerator type. The plywood should be held in place with rust-resistant screws.

For safety and convenience, locks on walk-ins should open from both sides.

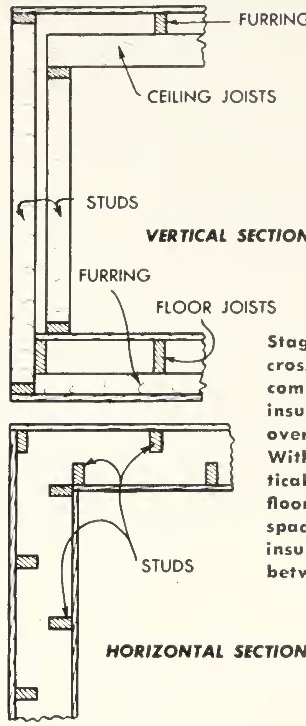
PAINT

Paint for the outside may be of any type or color desired. For the inside, however, only special odorless refrigerator paint should be used. Shellac or a good spar varnish are also satisfactory.

TYPES OF CO

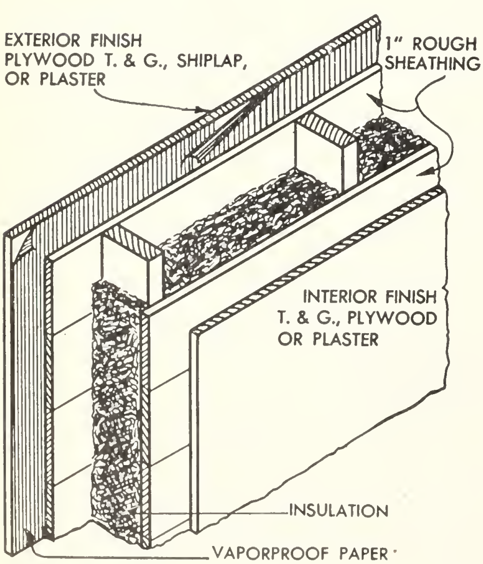


Above: solid stud and joist framing. This is the simplest and commonest type framing for insulation up to 6 inches thick.



Staggered stud and crossed joist framing, commonly used for insulation that is over 6 inches thick. With this type, practically all the wall, floor, and ceiling spaces have some insulating material between their sides.

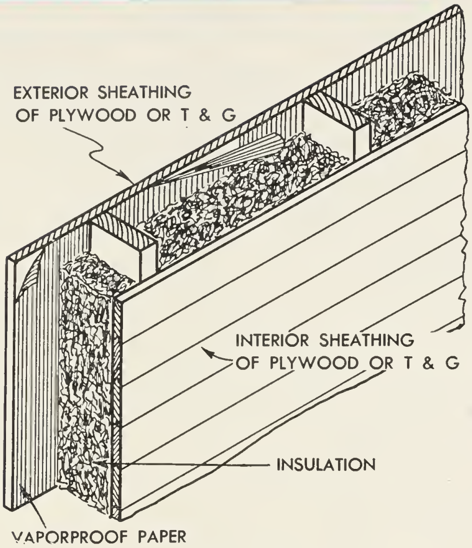
Below: wall construction with double sheathing on both exterior and interior.



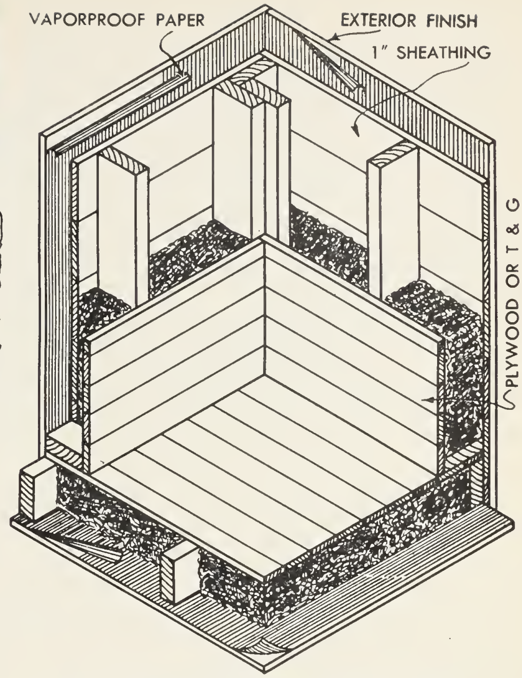
The spacing of the studs and joists in the framing will vary according to the type of insulating material used. For loose-fill insulation, a spacing of 24 inches or less is satisfactory. For the batt and board insulations, the spacing should be such that the insulating material will fit between the studs with a minimum of cutting and fitting.

Single sheathing is less expensive, but with this construction it is more difficult to erect the vapor barrier because there is no backing to press against in sealing the joints. When loose-fill insulation is used, the side from which it is installed (usually the interior) must be tongued-and-grooved lumber so that the sheathing may be put on as the insulation is put in place. With board and batt insulating materials which will stay in place, plywood may be used on both sides. With single

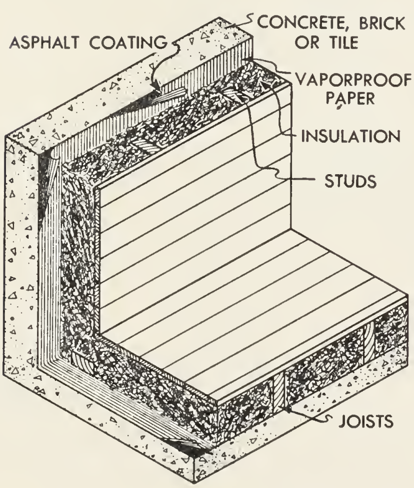
STRUCTION

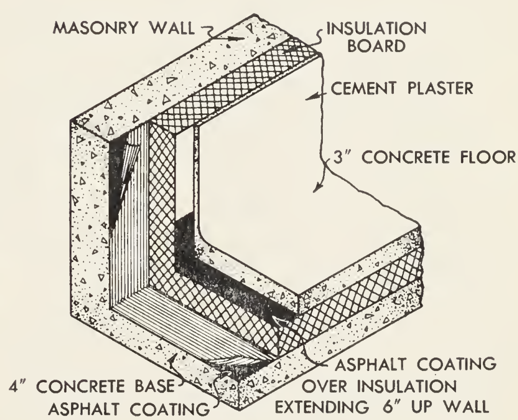


Wall construction with solid studs and single sheathing on both sides.



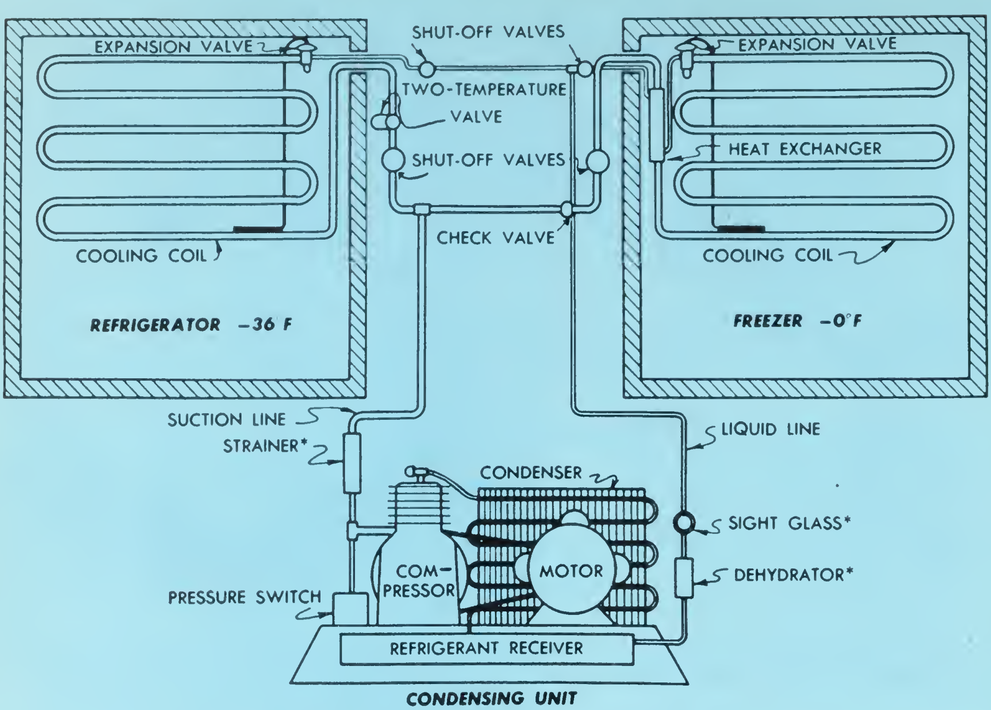
Wall and floor construction using solid studs with double exterior sheathing and single interior sheathing.



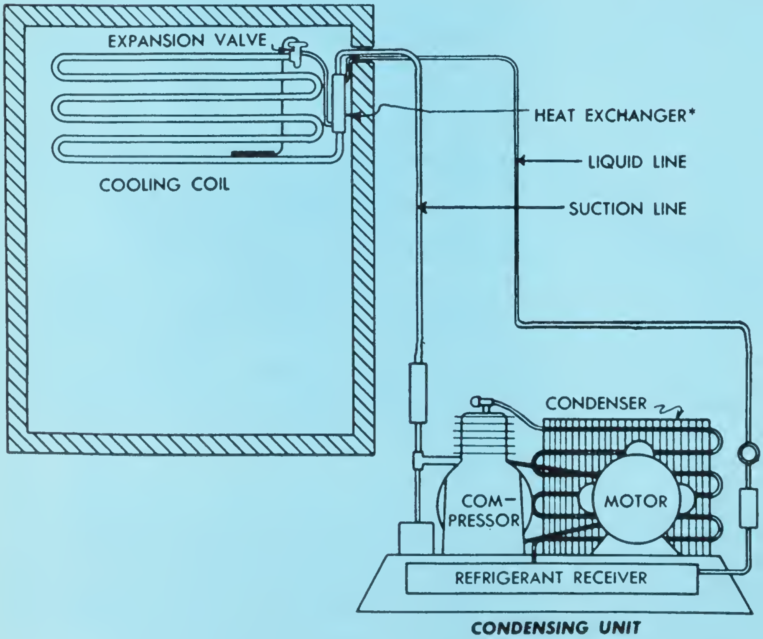


Left: wall and floor construction using concrete exterior and wood interior. Right: wall and floor construction using concrete and board type insulation. With both types of construction, the inside surface of the concrete should be sealed with asphalt before the vapor barrier is installed.

sheathing, 1-inch tongue-and-groove or at least 3/8-inch (preferably 1/2-inch) plywood should be used. Double sheathing is more expensive but the vapor barrier is easier to install, and the finish may be of almost any desired material since the rough sheathing furnishes all the necessary structural strength. The rough sheathing should be 1-inch material but may be of any grade available.



Above: refrigerating equipment for cooling two storage spaces held at different temperatures with a single condensing unit. Below: refrigerating equipment for cooling single storage space. Parts marked (*) are not a necessity.



The equipment to cool a refrigerator or freezer consists of two main parts, the condensing unit and the cooling coil (sometimes called an evaporator). These two units are connected by tubing or pipes to form a closed system containing a substance known as the refrigerant. During operation, the refrigerant enters the condensing unit as a gas. It is compressed under high pressure, cooled, and condensed to a liquid. The liquid refrigerant is released into the cooling coil through an expansion valve. There it absorbs heat, which converts it to a gas and it is then drawn back to the compressor. Auxiliary equipment, such as special valves, pressure switches, thermostats, etc., is needed for operation of the main equipment.

The condensing unit consists of the following parts:

1. **A motor, which drives the compressor.**
2. **A compressor, which draws the gas out of the evaporator and compresses it to high pressure.**
3. **A condenser where the gas is cooled and liquified.**
4. **A receiver where the liquid refrigerant is stored.**

Table 3: APPROXIMATE CAPACITIES OF CONDENSING UNITS AND SIZES OF COOLING COILS[1]

Horsepower of condensing unit	Type of condensing unit	B.T.U. per hour capacity of condensing unit		Square feet of surface area for plate or plain tube coils[2]	
		Freezer 0° F	Refrigerator 36° F	Freezer 0° F	Refrigerator 36° F
1/5	air	700	1500	23	40
1/4	air	950	2000	32	53
1/3	air	1400	2900	47	77
	water	1600	3400	53	91
1/2	air	2000	4400	67	117
	water	2400	5300	80	141
3/4	air	3000	6500	100	173
	water	3700	8000	123	213
1	air	4100	8500	137	226
	water	5000	10,500	167	280
1 1/2	air	6200	12,800	207	344
	water	7400	16,300	247	435
2	air	8200	17,000	273	453
	water	10,000	22,000	333	586
3	air	10,500	22,000	350	586
	water	13,000	29,000	433	772

[1] Based on 90° F air and 70° F water temperatures, and 15° F temperature differential between cooling coil and storage temperature.
[2] Finned-tube coils should have a rated capacity equal to the condensing unit.

The condenser is cooled by either air or water. The air-cooled type is less expensive and easier to install, but has less capacity per horsepower. The water-cooled type requires a continuous flow of water when operating, as well as some means of disposing of waste water. The sizes of condensing units are commonly designated by the horsepower of the motor used. Their refrigerating capacities are rated by the amount of heat (B.T.U.)[1] they will extract per hour. The capacity is greatly affected by the temperature of the refrigerant in the cooling coil because the temperature determines the pressure. The lower the pressure, the less the amount of gas taken into the compressor on each stroke. The temperature of the cooling medium also affects the capacity because the higher the temperature, the greater the pressure required for condensing the refrigerant. The approximate capacities for various sizes of condensing units are given in table 4. These capacities should be used for estimating only. The actual capacity of the units varies with different manufacturers and models. The size of condensing unit for a given job should be determined on a basis of a maximum of 12 hours' operation per day, to cool the storage space only, during the warmest part of the year. This will allow sufficient capacity for cooling or freezing the products and for losses in door openings with average farm use. Table 3 gives the heat leak factors for various insulation thicknesses. These may be used to determine the condensing unit capacity necessary.

[1] British Thermal Unit. Amount of heat required to increase the temperature of one pound of water one degree Fahrenheit.

Table 4: HEAT LEAKAGE FACTORS FOR DETERMINING CAPACITIES OF CONDENSING UNITS AND COILS*

Thickness of insulation equivalent to cork, inches	Heat leakage factor per square foot of exterior surface, B.T.U. per hour	
	Freezer 0° F	Refrigerator 36° F
1	60	38.4
2	30	19.2
3	20	12.8
4	15	9.6
5	12	7.7
6	10	6.4
8	7.5	4.8
10	6	3.8

* Based on 100° F air temperature around storage box and operating time of 12 hours per day for the refrigerating unit.

Here is how to find the necessary condensing unit capacity for your refrigerator.

First, find out the total number of square feet in the outside surface:

For example, a refrigerator 6 feet high, 8 feet deep, and 10 feet wide would have an outside surface of 376 square feet.

Multiply:

Width by height—6′ × 10′ = 60 sq. ft.		
Depth by height—6′ × 8′ = 48 sq. ft.		
Width by depth—10′ × 8′ = 80 sq. ft.		
		188
	Multiply by 2	**×2**
	Total	**376 sq. ft.**

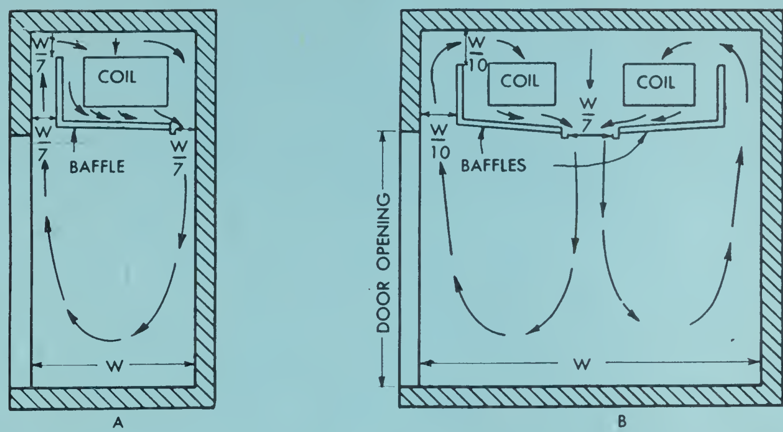
This refrigerator has the equivalent of 6 inches of cork insulation. Turn to table 4, where you will find that a refrigerator with 6-inch insulation has a heat leakage factor of 6.4 (B.T.U.) per square foot per hour.

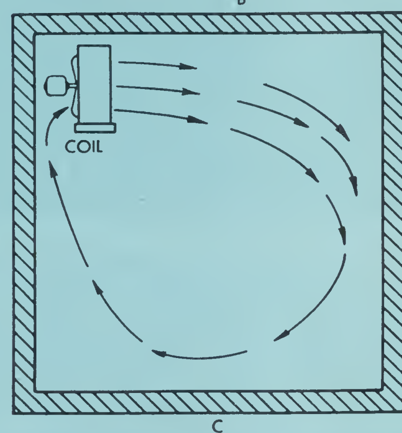
Multiply 376 by 6.4 = 2406 B.T.U. per hour. This is the capacity necessary for the condensing unit and cooling coil.

Now turn to table 4, column 4. Check back to column 1, where you will find that a one-third H.P. air-cooled unit would be the smallest size with this capacity.

The cooling coil (sometimes called an evaporator) is the part of the refrigerating unit located inside the storage space. It acts as a container for the refrigerant which absorbs the heat from the storage space and transfers it to the condensing

PLACEMENT OF COILS





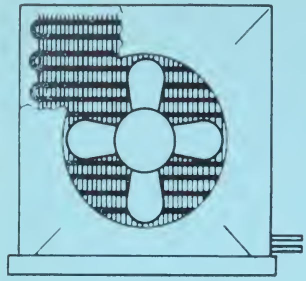
Location of the cooling coil: *A*, overhead, single, gravity type coil with L type baffle; *B*, overhead, double, gravity coils with V baffle; *C*, forced-draft coil with no baffling. Arrows show direction of air currents.

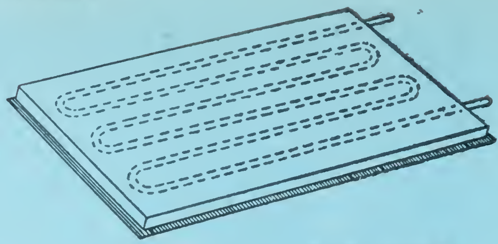
unit. Commercially made coils are available in various types, sizes, and shapes, and the choice among them depends on the conditions under which they are to be used.

A gravity type finned-tube coil depends upon natural convection currents to circulate the air over it. It consists of tubing through which the refrigerant flows, and sheet metal fins to increase the surface area. A forced draft finned-tube coil is equipped with a fan driven by an electric motor to circulate the air over it. This type is the most common for walk-in and large reach-in refrigerators because it has greater capacity for a given size and usually requires no baffling for proper air circulation in the storage space.

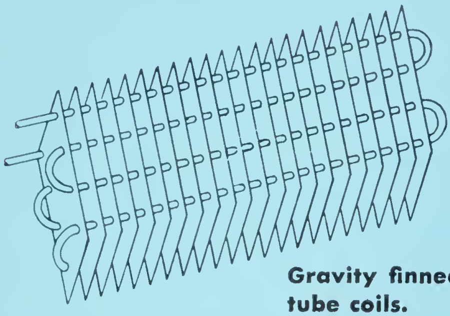
The finned-tube coils are designed for maintaining temperatures above 35° F where they can be operated on a defrosting cycle. (The frost melts each time the condensing unit stops.) This is desirable because their capacities are greatly affected if the frost decreases the space between the fins and cuts down the air circulation. Finned-tube coils can be used in freezers if an easy, convenient method of defrosting is provided. Usually, they must be defrosted at least once a week, and sometimes oftener. A common method of defrosting is to run water over

TYPES OF COOLING COILS

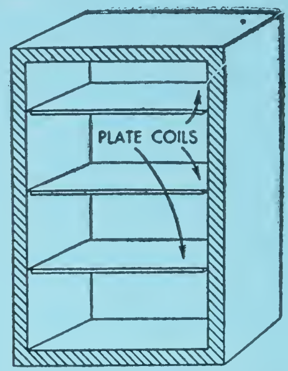




Finned tube, forced-draft coil.



Gravity finned tube coils.



Cabinet type freezer with plate coils as shelves.

the coils. Or you may have a special arrangement of the refrigerating equipment so that hot gaseous refrigerant from the compressor can be run through the coils.

Plate type coils may be used for maintaining temperatures both above and below freezing since their capacity is not greatly affected by frost. They are particularly adaptable for freezers as they can be used as shelves or partitions and can be easily defrosted by scraping. Some contain a solution in the jacket which freezes and furnishes a certain amount of holdover refrigeration in case the refrigerating unit is off for a limited length of time.

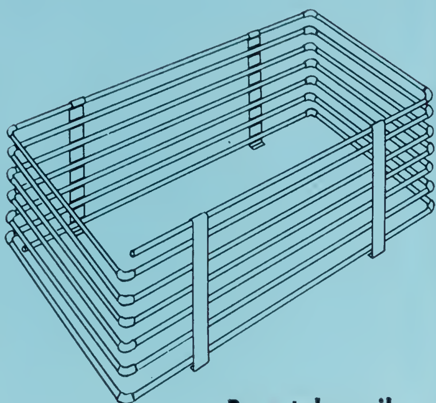
If you are planning on homemade coils, the bare tube type is the most practical. This type may also be used for maintaining temperatures both above and below freezing. These coils are more difficult to defrost than are the plate type, but are less expensive. Copper tubing is the most common material used, but steel, brass, or aluminum tubing or pipe are also suitable.

The heat absorbing capacity of a coil depends on its surface area, the rate of air movement over it, and the difference in temperature between it and the air. It is essential, for proper operation, that the correct size be installed. The capacities of finned-tube coils are rated by the manufacturers in B.T.U. per hour, and when the operating conditions are known,

Table 5: LENGTHS OF VARIOUS SIZES OF TUBING AND PIPE FOR ONE SQUARE FOOT OF SURFACE AREA

Tubing		Standard pipe	
Size, O.D.	Length for 1 sq. ft. of surface	Size	Length for 1 sq. ft. of surface
inches	feet	inches	feet
1/2	7.6	1/2	4.5
5/8	6.1	3/4	3.6
3/4	5.1	1	2.9
1	3.8	1 1/4	2.3
1 1/4	3.1	1 1/2	2.0

Left: flat plate type cooling coil consisting of tubing enclosed in sheet-metal casing.



Bare tube coil.

the proper size may be selected. The capacities of plate and plain tube coils are in direct proportion to their surface area and they are chosen on that basis. When you have determined the size of your condensing unit (see page 14), turn to table 4 to find the correct coil capacity.

REFRIGERANTS

The purpose of the refrigerant is to transfer heat. It absorbs the heat in the cooling coil and gives up the heat in the condensing unit. A number of different chemical compounds have been used for refrigerants, but the most common are ammonia, freon 12, methyl chloride, and sulfur dioxide.

Ammonia (NH_3) is a colorless substance with a strong, offensive odor. When mixed with water, it attacks copper and copper alloys but has no effect on iron or steel. Leaks are easy to find by the odor, or by burning sulfur, which forms a white smoke in the presence of ammonia. It is used mainly in large units (2 horsepower and larger).

Freon 12 ($C\ Cl_2F_2$), a relatively new substance, is the most common refrigerant in small units, but is also used in units up to 25 horsepower. It is colorless, odorless, noninflammable, nontoxic, and does not attack copper, copper alloys, iron, or steel. Leaks are relatively difficult to detect because of the lack of odor, but can be located by an alcohol flame which turns green if freon is present.

Methyl chloride (CH_3Cl) is colorless and has a sweet odor resembling chloroform. It does not attack copper, copper alloys, iron, or steel but is inflammable at certain concentrations. Leaks may be detected by a special type of alcohol torch.

Sulfur dioxide (SO_2), which is produced by burning sulfur, has a strong, suffocating odor. When mixed with water, it forms sulfurous acid which attacks iron, copper, and zinc. Leaks are easy to detect by the odor and by ammonia vapor which forms a white smoke in its presence. At one time, it was quite popular as a refrigerant in small units, but it has been largely replaced by freon.

Although one refrigerant may have advantages over others for certain jobs because of the pressures in the system and consequent danger of leaks, any one will operate satisfactorily if the equipment is properly designed and engineered for it. If the equipment is designed for a certain refrigerant, do not use another kind. While some of the refrigerants may be interchanged, it is usually necessary to make adjustments in the control valves, speed of the compressor, or other changes for proper operation.

AUXILIARY EQUIPMENT

A pressure switch or a thermostat, or a combination of both, is necessary for automatic operation of the refrigerating equipment. A pressure switch is operated by the pressure in the cooling coil which in turn is dependent on the temperature of the coil. A thermostat is operated by the temperature of the air in the storage space.

An expansion valve is necessary on each cooling coil to control the amount of liquid refrigerant going into the coil.

A dehydrator is desirable to remove any moisture which may be in the refrigerant.

A strainer or scale trap is sometimes desirable, particularly when steel pipe is used, to remove particles, such as scale or rust, in the system, which may cause trouble.

A heat exchanger is not necessary, but when used, it increases the efficiency and capacity of the condensing unit. Its purpose is to cool the liquid refrigerant going into the cooling coil by transferring heat to the gaseous refrigerant coming out of the coil.

Two temperature valves are necessary when you have two or more storage spaces, at different temperatures, but cooled by a single condensing unit. These valves control the operation of the cooling coils in the warmer storage space.

Shutoff valves are desirable and sometimes necessary for convenience in repair work. They close the liquid and suction lines to the cooling coil.

A sight glass, which is placed in the liquid line, is not necessary, but is a convenience for determining when the system needs more refrigerant.

Check valves are necessary when two or more storage spaces are maintained at different temperatures by a single condensing unit. These valves prevent refrigerant from one cooling coil flowing back into the other coils.

COSTS

The initial costs for constructing refrigerators and freezers vary with size, type, materials, and methods of construction, so that it is not possible to give definite figures. However, under present prices, the materials (labor excluded) for constructing the storage space will usually cost from 50 cents to $1.00 per square foot of exterior surface. The cost of the refrigerating equipment, including the cooling coil, will vary from about the same cost as the storage space for large walk-in rooms to three to four times the cost of the storage space for small reach-in boxes. The exact cost of the refrigerating equipment may be obtained from dealers who sell it. The operating costs also vary according to size, location, temperatures, thickness of insulation, use, and electric rates. Observations of well constructed, reach-in refrigerators and freezers, and walk-in refrigerators up to 300 cubic feet, indicate that the operating cost usually averages less than $5.00 per month, and most often is between $1.00 and $3.00 per month. The electrical energy used by these units varies from 50 to 200 kilowatt hours per month.

UNIVERSITY PLANS FOR REFRIGERATORS AND FREEZERS

The Agricultural Engineering Division of the College of Agriculture has designed four different sizes of refrigerators and three sizes of freezers. Detailed plans and specifications for these units may be obtained for a small cost from the Agricultural Extension Service, University of California, Berkeley. The following is a list of these plans.

Plan No.	*Type*	*Cubic feet of storage space*	*Exterior dimensions*	*Cost of plan*
C-152	Reach-in refrigerator*	35	2′10″ × 4′9″ × 7′5″	51¢
C-153	Reach-in refrigerator	40	2′10″ × 4′9″ × 7′5″	51¢
C-154	Semiwalk-in refrigerator	80	3′10″ × 5′6″ × 8′9″	51¢
C-155	Walk-in refrigerator	125	4′10″ × 5′9″ × 9′3″	51¢
C-103	Chest type freezer	12	4′ × 4′ × 2′9″	26¢
C-104	Chest type freezer	21	4′ × 6′ × 2′9″	26¢
C-105	Chest type freezer	30	4′ × 8′ × 2′9″	26¢

* Same as C-153 except has ice-making coil.

In order that the information in our publications may be more intelligible, it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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