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Letter
Circular
LC-472

DOMESTIC ELECTRIC AND GAS REFRIGERATORS

June 11, 1936.
(Replaces LC-412)

This letter circular has been prepared to serve as a reply to numerous requests for information on domestic refrigerators. Many of the letters received ask for information on the details of construction or the characteristics of the various makes of refrigerators on the market. Others ask for recommendations or for opinions on the comparative value of the various makes or for a list giving their 'ratings'. It is not however, a function of the National Bureau of Standards or of other government agencies to collect or distribute information on the relative merits of commercial products, nor to give opinions or make recommendations concerning them. The Bureau has not made the extensive tests that would be required to answer such questions, and does not expect to make such tests in the future.

The purpose of this letter circular is to summarize the information available at the Bureau, and to answer some of the more usual questions.

General Types of Refrigerators

There are two general types of refrigerating systems, the compression and the absorption type. The compression type consists essentially of three parts, a cooling unit, which is inside the refrigerator, a motor driven compressor and a condenser, which are outside the refrigerated compartment. If the machine has been running and is then shut down, ordinarily there will be some liquid refrigerant in the condenser under high pressure, and some in the cooling unit at lower pressure. As the refrigerator and cooling unit become warmer, an automatic switch starts the motor. The compressor then removes vapor from the cooling unit, so that the liquid therein can evaporate at low pressure and temperature, and thus effect cooling. The compressor, taking the vapor from the cooling unit at low pressure, must compress it to a pressure sufficiently high to cause liquefaction in the condenser, from which heat is removed by the air. The liquid from the condenser then passes through an expansion valve or equivalent device, to the cooling unit, so that the operation is continuous as long as the motor runs. When the cooling unit and refrigerator have cooled sufficiently, the automatic switch stops the motor.

In the absorption type the vapor from the cooling unit is absorbed in a suitable substance, such as water, or other liquid, or by a solid which is capable of absorbing large quantities of vapor. Subsequently, the substance containing the absorbed vapor is heated, either electrically or by a flame, and the vapor is driven off, then cooled and condensed to a liquid, which is returned to the cooling unit. Machines of this type have few or no moving parts, and practically all of them are almost noiseless in operation. Some of the machines using a liquid absorber are continuous in operation, the heat being applied always to one part, while the liquid is caused to circulate. Others are of the intermittent type, the heat being supplied for a time to one part, then to another part, or to one part at intervals.

Nearly all of the machines now on the market are designed to provide for freezing ice cubes, and since this feature is so very generally included, no further consideration of it is required here.

A very large number of makes of refrigerating machines of the compression type have been put on the market. These have included such variations as direct drive, belt drive, and gear drive; reciprocating single or multiple cylinder compressors, various types of rotary compressors; various refrigerants such as sulfur dioxide, methyl chloride, ethyl chloride, ammonia, volatile hydrocarbons, and more recently, materials known by trade names such as freon, carrene, etc.; refrigeration by direct expansion or by the use of brine tanks, etc. Completely sealed machines of the compression type are also available and are offered by several manufacturers. It is impracticable to discuss here the various merits and demerits of the features which are often emphasized out of all proportion to their importance, in advertising and by salesmen. The user of a machine is not so much concerned with the kind of drive, refrigerant or absorbent used, type of compressor or system of refrigeration as he is in the kind of service the machine will give and what the service may cost over a period of years. For example, a machine with a rotary compressor may be either better or worse than one with a reciprocating compressor, since the success or failure of either will depend upon the quality of the whole machine and not upon such a single feature of design.

Selection of a Refrigerator

Knowledge of details of design is of value to the expert in judging whether the machine is designed and made so that it can be expected to have a reasonably long life and give satisfactory service during its life. The fact that

a machine has one or several features of design which seem superior does not necessarily indicate that it will prove to be superior to other machines having other features of design. For example, the refrigerant used is a factor of minor importance as regards efficiency, since machines can be designed to use any of the ordinary refrigerants effectively. Similarly, either compression or absorption machines can give very satisfactory service.

Short-time tests of refrigerating machines unfortunately can not furnish complete information as to their relative merits. Such tests may disclose obvious defects and will readily show the power or gas consumption and the efficiency of the unit at the time of test. By operating the machine under extreme conditions, for example, at high room temperatures, it is possible to make an estimate of the margin of reserve in power, cooling capacity and strength of parts above ordinary requirements, but none of these tests gives information on the most important points, namely, the durability and reliability in service of the average machine under ordinary conditions.

Fortunately, the problem of selecting the "best" machine does not now have the importance it may have had at one time. There are a large number of machines on the market any one of which may be expected to give satisfactory service. Undoubtedly, some are better than others, and some are better investments than others, but so far as is known to the Bureau, tests sufficiently comprehensive to bring out such differences could not be completed before the machines under test were superseded by later models so that even if such tests were attempted they would be useless by the time they were completed. It is true that when thousands of machines are manufactured and sold, some proportion of even the most carefully made ones may prove defective, and perhaps none will be perfect. However, unless one happens to make an unfortunate choice, he may expect to obtain about as satisfactory a machine as his neighbor who chooses a different make.

Dependable information on the electric energy or gas consumption of the various makes and models of refrigerators under standard test conditions would be of value to the prospective purchaser, and in some cases manufacturers supply such information concerning their own product.

Hazards of Refrigerants

The refrigerant, which is a necessary part of the machine, may be considered safe as long as it remains in its proper place within the system. If the refrigerant escapes

from the system, either by a slow leak, or rapidly, the hazards will depend upon the amount of refrigerant escaping, the speed with which it escapes, and its characteristics. In case of a leak, the possible hazards include: (1) fire or explosion, if the refrigerant is one that will burn, (2) personal injury, if suddenly released, or if breathed in sufficient quantity for a sufficiently long time, (3) incidental damage to foods, fabrics or furnishings.

Only those refrigerants which will burn or propagate a flame in air present a fire or explosion hazard. Refrigerants which will not burn include sulfur dioxide, "carrene", "freon 12" and "freon 114". Refrigerants which will burn very readily include butane and isobutane, which are similar to gasoline or fuel gas, while ethyl and methyl chloride burn less readily and ammonia burns with difficulty. If a refrigerant which will burn escapes in sufficient quantity into a confining space and is ignited, a fire or even an explosion may result.

The danger of personal injury from breathing the vapor of the refrigerant mixed with air is limited by the fact that the amount of refrigerant in a domestic unit is comparatively small, usually not over three pounds. Even if the entire amount were released into a poorly ventilated room containing only 1000 cubic feet, there would be little or no danger from breathing the resultant mixture of refrigerant and air, except in the case of ammonia or sulfur dioxide, which would be so irritating that no one would remain in the room if able to escape.

Most persons are familiar with the odor of ammonia in the ordinary household ammonia, and with that of sulfur dioxide which is produced by sulfur matches and the sulfur candles used in fumigation, and will recognize that a small amount of either causes only temporary discomfort. The amount in a refrigerating system is large enough, however, to cause serious injury if released into a confined space and breathed for any considerable length of time, as might be the case if occupants were unable to escape.

Some refrigerants which produce little or no effect if breathed in the amounts which could result from leakage from a domestic unit are decomposed by heat, for example, by passing through the flame of a gas burner, and the products of decomposition are distinctly irritating and poisonous. Refrigerants which are decomposed in this way include "freon 12" and "freon 114", "carrene", methyl chloride and ethyl chloride. It is not probable, in a domestic installation, that dangerous conditions would be produced in this way.

As concerns spoilage of food by the refrigerant in case of a leak, it may be said that if spoilage is not indicated either by appearance, odor or taste, the food is probably fit for use, but if there is any doubt, it is better to throw it away rather than worry about it. The damage to fabrics and furnishings in case of a leak of refrigerant is usually minor.

Although the hazards resulting from leakage of refrigerant are not great, there is a very distinct trend, among manufacturers, toward the use of those refrigerants which will not burn and which can be breathed in moderate amounts without producing irritation or distress. The safety rules in some of the larger cities tend to encourage this trend.

Important Factors in Choice of a Refrigerator

1. Record of the manufacturer and the machine. A newly developed design may represent a distinct advance, but there is a greater risk that it may prove unsatisfactory than in the case of one which has stood the test of service.

2. Noise. Unless a machine runs quietly when new and continues to do so, it will be unsatisfactory to most of its users.

3. Useful life. The aggregate cost of refrigeration depends to a considerable extent upon the length of life of the machine, and upon the cost of service and repairs. Very little information on this point is available, and the purchaser must depend upon the reputation of the product and such information as he can find in regard to durability.

4. Efficiency of the machine. There are some differences in the operating efficiencies of different machines, and figures on operating costs can sometimes be obtained. If a machine is not well made or is allowed to deteriorate, efficiency may be greatly reduced after a short period of use.

5. Insulation of the refrigerator. The refrigerator should be well insulated, preferably with not less than a two-inch thickness of some good insulating material or its equivalent. Refrigerators depending largely upon ordinary air spaces for insulation or those with thin walls and doors are likely to require considerable power or fuel to keep them cold.

6. Convenience and ease of cleaning. Such items as shelf arrangement, etc., are of importance to the user. In some locations a machine with door hinges at the right may

be much more convenient than one with hinges at the left or vice versa. In many cases this feature is not noticed until the refrigerator is installed.

7. Attention required from user. If attention such as oiling or adjustments are required from time to time, the points requiring attention should be few in number, and should be readily accessible where the machine is to be installed, lest it suffer from neglect.

8. Servicing the machine. Any machine is likely to require service or repairs at some time or other, and it is important to know whether satisfactory local service facilities are available.

Other Sources of Information

1. "Household Refrigeration", 4th Edition, by H. B. Hull, published by Nickerson and Collins Co., Chicago, 1933, 700 pages, $4.00.

2. A booklet entitled "Home Economics Bibliography 5 - Household Refrigeration". This booklet, containing a list of references to articles, mostly non-technical, of interest to the householder, may be obtained free from the Bureau of Home Economics, Department of Agriculture, Washington, D. C.

3. The Household Refrigeration Bureau of the National Association of Ice Industries, Chicago, Ill., issues pamphlets on household refrigeration and related subjects.

4. Bureau of Standards Circular No. C376, "Thermal Insulation of Buildings", contains a brief discussion of refrigerator insulation. This publication may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for five cents (stamps not accepted).

5. The Refrigerating Data Book, published by the American Society of Refrigerating Engineers, 37 West 39th St., New York City, has excellent technical chapters on such subjects as insulation, domestic refrigerators, as well as on commercial systems, 430 pages. $3.50.

6. National Bureau of Standards Letter Circular LC-421, "Thermal Insulation", may be obtained free, upon request, from the National Bureau of Standards, Washington, D. C.

Numerous papers on this subject may be found in the refrigeration journals listed:

Journal	Published	Publisher	Address
Refrigerating Engineering	Monthly	Am. Soc. of Refrig. Engrs.	37 W. 39th St.,N.Y.C.
Refrigerating World	Monthly	The Ice Trade Journal Co.	Woolworth Bldg.,N.Y.C.
Ice & Refrigeration	Monthly	Nic erson & Collins Co.	5707 W.Lake St., Chicago.
Electric Refrigeration News	Bi-weekly	Business News Publishing Co.	554 Maccabees Bldg., Detroit, Mich.

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