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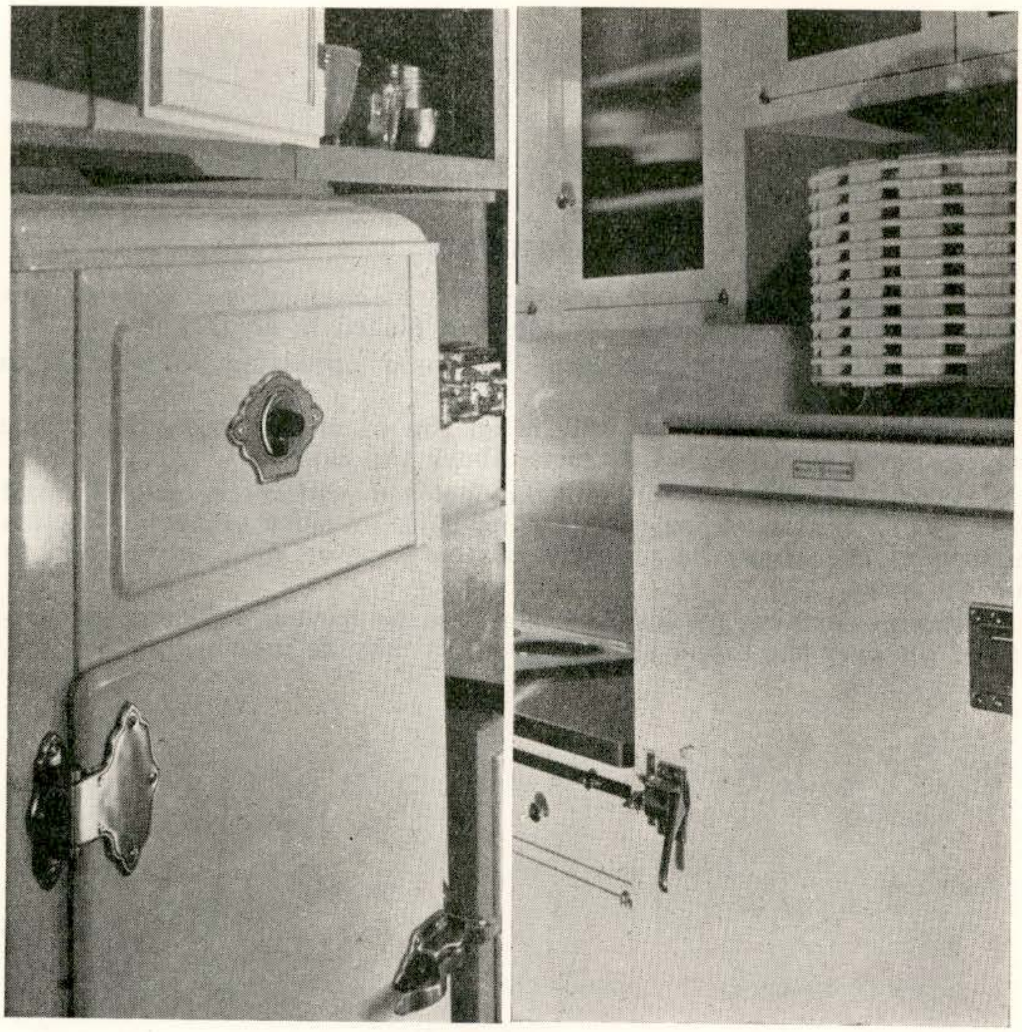

Examples of crowded refrigerators

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SUMMARY

1. The operating characteristics of the mechanical refrigerator are often disregarded when refrigerators are placed in alcoves.

2. Thirty-five to fifty per cent increased operating costs may be incurred by faulty enclosures.

3. Where the compressor unit is on top of the cabinet, the alcove ceiling should be 12 inches or more above the coils.

4. Where the compressor unit is enclosed within the cabinet and receives ventilation either through the back or sides of the cabinet, a three-inch space must be provided at the back or sides in addition to the top space.

5. Where curtains, grilles, or other objects prevent sufficient circulation of air over the top, a special air shaft may be installed.

Fitting the Mechanical Refrigerator into the Home

E. B. LEWIS AND M. P. BRUNIG

Within the last five years the mechanical refrigerator has become a popular piece of household equipment. Its year-round use has caused architects and others interested in planning for the convenience of the housewife to recommend placing the new cabinet in kitchens and other convenient places, with little thought about the effect on the operation of the refrigerator. The purpose of this publication is to point out some of the conditions under which the refrigerator has been expected to operate successfully, and some of the effects of these conditions upon the operation of the machine.

The effects on operation were studied in homes and in the laboratory, where duplications of proposed settings were reproduced.[1] Service calls on refrigerators were often found to have been necessary because the cabinet had been placed in special alcoves, pantries with low ceilings, crowded corners,

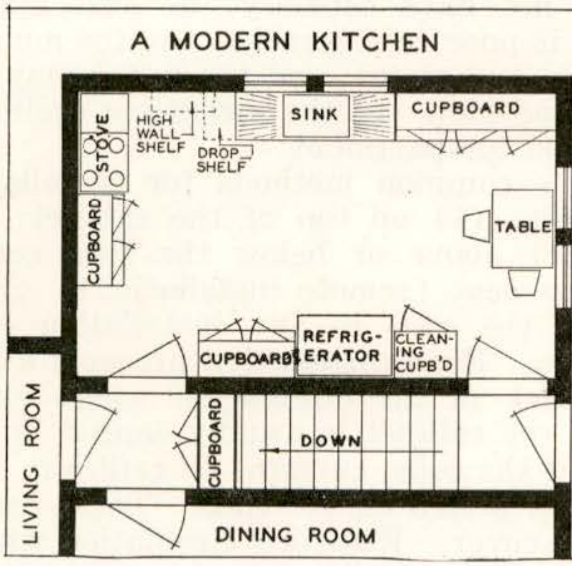

FIG. 1.—Some plans place the refrigerator to save steps. The mechanical refrigerator in such position may be too nearly enclosed. (Designed by R. M. Loper.)

or other places so built that ventilation or cooling of the compressor and condenser coils was hindered. Pictures such as those on the front cover and plans similar to Figure 1 have appeared in magazines and advertising matter. Often there was no warning or suggestion as to possible effects on the operation of the refrigerator.

[1] Many of the experimental placements were constructed by F. D. Yung in preparing a thesis for an advanced degree in Agricultural Engineering at the University of Nebraska. This work was done under the supervision of the authors.

In an ordinary ice box the heat taken from the storage space is carried away by the water from the melting ice. In most mechanical refrigerator cabinets, heat is absorbed from the storage space when the liquid refrigerant expands into a gas as a result of a change in pressure. When the gas has absorbed some of the heat, it is drawn into the compressor and condenser coils where it is liquefied and the heat dissipated. The liquid is then returned to the expansion equipment. This process is repeated over and over and thus removes heat from the storage space to produce the low temperature desired.

For this reason heat can not be removed from a storage space in greater quantity or with greater rapidity than it can be driven from the condenser coils. If there is any lack of circulation of air or if the air is too warm over the coils, condensation is not complete and the mixture of gas and liquid returning to the expansion chamber in the cabinet is warm and does not have capacity for absorbing sufficient heat. The result is poor refrigeration and too much operation of the compressor and motor, and the latter may become excessively warm and stop. In the meantime cooling has been delayed in the food compartment.

There are three common methods for installation of the condenser-coil unit: (1) on top of the cabinet; (2) within the cabinet, either above or below the food compartment; and (3) in a basement (remote installation). Sufficient air circulation about the coils in any installation is necessary for good operation. Each installation presents a little different problem. Lack of air circulation where the coils are placed on top of the cabinet is usually caused by a shelf too close to the top of the coils, curtains or grilles in front of the coils, or something placed on the coils. These conditions are illustrated on the cover. Retarded circulation when the coils are within a cabinet is usually caused by placing the refrigerator close to a wall or other object so that air which must be drawn in and forced out the back or sides is baffled. When overhead cupboards or shelves are too close to the top of the cabinet, the air coming up from the back or sides is held back, also. Thus the warm air is slow in getting away and the compressor and coils are not given a chance to function properly. (See Figures 2B and 2C.) When the compressor unit is installed in the basement, the refrigerator box may be enclosed as much as desired; in fact, closer confinement of the box usually means better efficiency because of better insulation. Even with remote installation, the condenser unit must be exposed for free circulation of air.

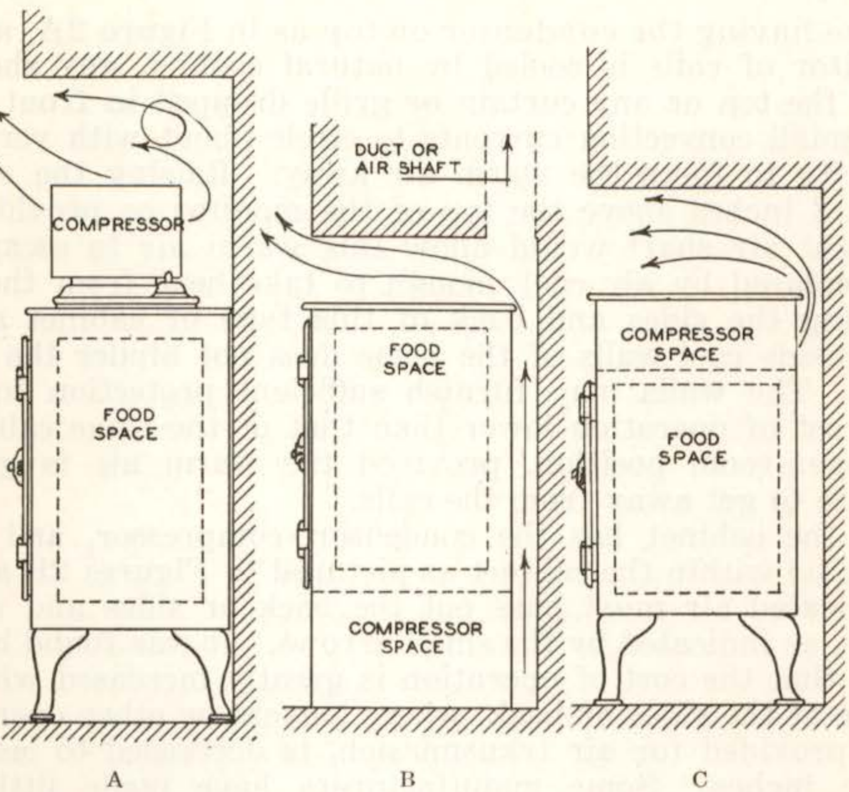

FIG. 2.—The type of cabinet in A would probably cease to function in an hour or two on a hot day if the shelf were low and a curtain or grille cut off air circulation. The cabinets in B and C would probably give trouble on a hot day if loaded and pushed back against the wall, unless other provision were made for the escape of warm air from the coils.

Trouble may be caused by covering this unit with a low table or other article which retards the escape of heat.

Observations both in the home and the laboratory show that the cost of operation may be increased at least 50 per cent when a cabinet is moved from an open position to a position in a crowded recess, and increased more than thirty-five per cent by changing the shape or size of the recess. These increases are often produced without causing mechanical trouble. Much greater increases may be incurred temporarily, but the causes would soon bring mechanical difficulties with the motor, compressor, or any of the thermal protective devices.

Experiments have shown that where heating radiators are enclosed by screens and grilles in front and shelves over the top, some spacing is necessary at the back and top. Too great interference of convection currents and poor heating result unless these spacings are definite for each type of radiator or enclosure.[2] Similarly, if the refrigerator cabinet

[2] Allen, John R., and Walker, J. H.: Heating and Ventilation, 2nd edition.

is one having the condensor on top as in Figure 2A, and the monitor of coils is cooled by natural cooling, any shelf low over the top or any curtain or grille dropped in front causes the small convection currents to circle about with very little velocity to force the warm air away. Raising the shelf at least 8 inches above the top of the monitor or providing an upright air shaft would allow this warm air to escape and be replaced by air cool enough to take heat from the coils. Placing the sides and back of this type of cabinet against the inside cool walls of the home does not hinder the operation. The walls may furnish sufficient protection to make the cost of operation lower than that of the same cabinet in an open-room position, provided the warm air is given a chance to get away from the coils.

If the cabinet has the condenser, compressor, and motor installed within the cabinet as pictured in Figures 2B and 2C, the heated air must pass out the back or sides and up and away, as indicated by the small arrows. It was found by trial tests that the cost of operation is greatly increased when the space at the sides or back, where louvers or other open space was provided for air transmission, is decreased to less than three inches. Some manufacturers have made little projections to prevent placing their cabinet so close to walls that the warm air can not escape readily. The warm air has a chance to rise when space is provided, but provision must still be made for this warm air to escape over the top of the

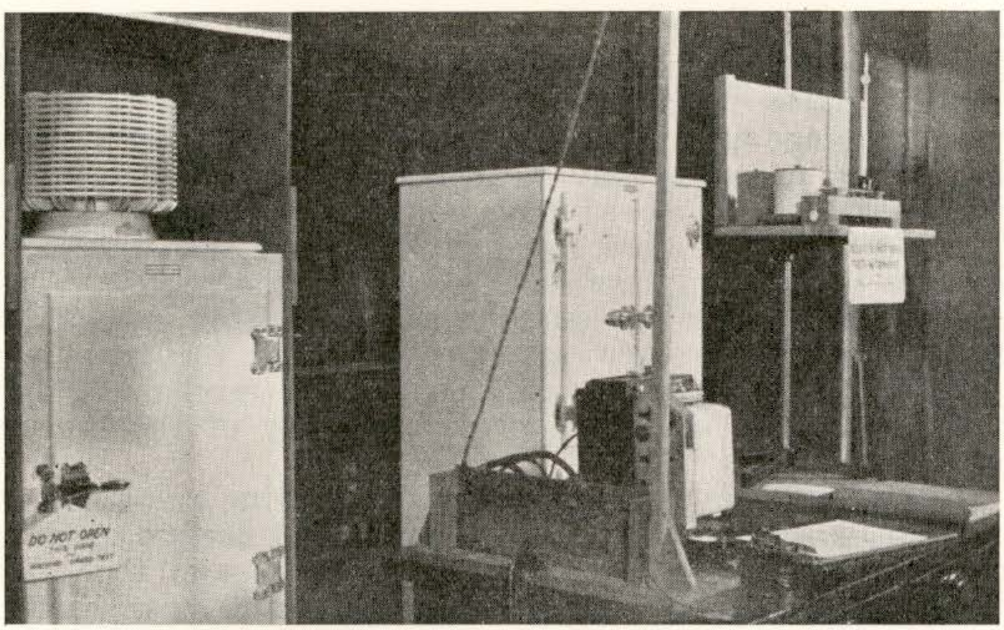

FIG. 3.—A partial view of instruments and refrigerator cabinets used for the tests.

cabinet as illustrated or up through some air duct to the roof or a cool upper room space.

Figure 3 shows part of the set-up for the laboratory test runs. Room temperatures were controlled automatically, with electric heating units for raising the temperature, and water radiators and ice for lowering the temperature. In each case fans were used to give quick adjustments and to hold temperature gradients within a narrow range. Recording thermometers and precision mercury thermometers recorded all temperatures; a graphic watt-meter and a watt-hour meter showed energy consumption. Controls on the cabinets were checked and set for definite storage space temperatures for open-room tests. Any variations from these temperatures during the runs while cabinets were enclosed are indicated by the solid lines shown in Figures 4, 5, and 6. The average temperatures here were very little different from the check-run temperatures and were governed entirely by the automatic controls installed as regular equipment in the cabinets.

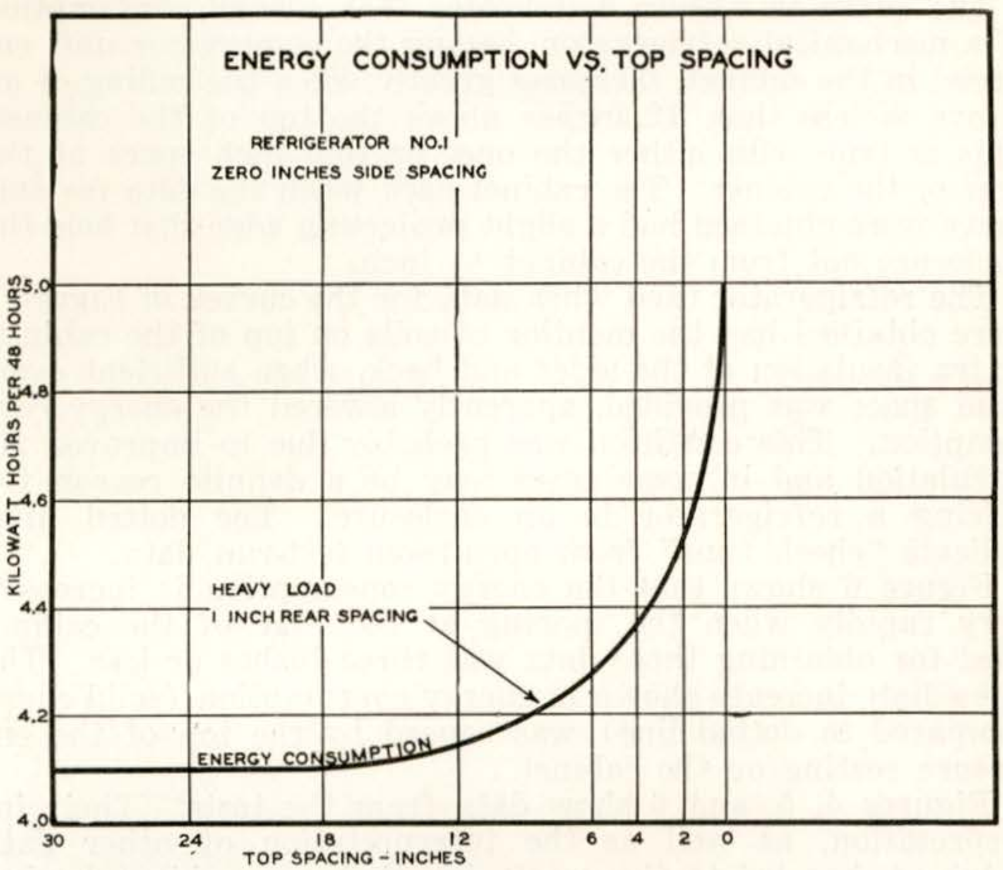

FIG. 4.—Changing the space over the top of the cabinet changed consumption of electricity as much as 25 per cent. Room temperature was maintained at 80° F. in these tests, while many kitchens in Nebraska have summer temperatures exceeding 90°.

Figures 4, 5, and 6, made from a small part of the test data, give some indication of the effect any change in air circulation space may have on the cost of operation of typical cabinets. In obtaining the data from which the curves were made, cabinets were first operated in a constant-temperature room as near 80° F. as possible. Temperature regulation is indicated in Figures 5 and 6.

Each machine was given a definite load for a 48-hour operation in the open-room position. The machine was then enclosed in an alcove or recess made of insulating material and operated for the same length of time with the room temperature and the refrigerator load the same as during the open-room operation. On each of the two charts the dotted lines indicate the average controlled temperature in the room, the temperature in the refrigerator, and the amount of energy needed for the open-room check runs. The solid lines indicate the room and refrigerator temperatures and increased energy consumption caused by a change in the size or shape of the enclosure about the refrigerator in the test runs.

The curve in Figure 4 indicates that energy consumption of a mechanical refrigerator, having the compressor unit enclosed in the cabinet, increases greatly when the ceiling of an alcove is less than 12 inches above the top of the cabinet. This is true with either the one- or four-inch space at the rear of the cabinet. The cabinet used when the data for this curve were obtained had a slight projecting edge that held the enclosure out from the cabinet ½ inch.

The refrigerator used when data for the curves in Figure 5 were obtained had the monitor of coils on top of the cabinet. Extra insulation at the sides and back, when sufficient overhead space was provided, aparently lowered the energy consumption. This condition was probably due to improved air circulation and in some cases may be a definite reason for placing a refrigerator in an enclosure. The dotted lines indicate "check runs" from open-room test-run data.

Figure 6 shows that the energy consumption is increased very rapidly when the spacing at the rear of the cabinet used for obtaining these data was three inches or less. The immediate increase shown in energy consumption (solid curve compared to dotted line) was caused by the top of the enclosure resting on the cabinet.

Figures 4, 5, and 6 show data from the tests. Their interpretation, as well as the interpretation of other data obtained, has led to the conclusion that any cabinet having a compressor coil unit on top must have at least 12 inches

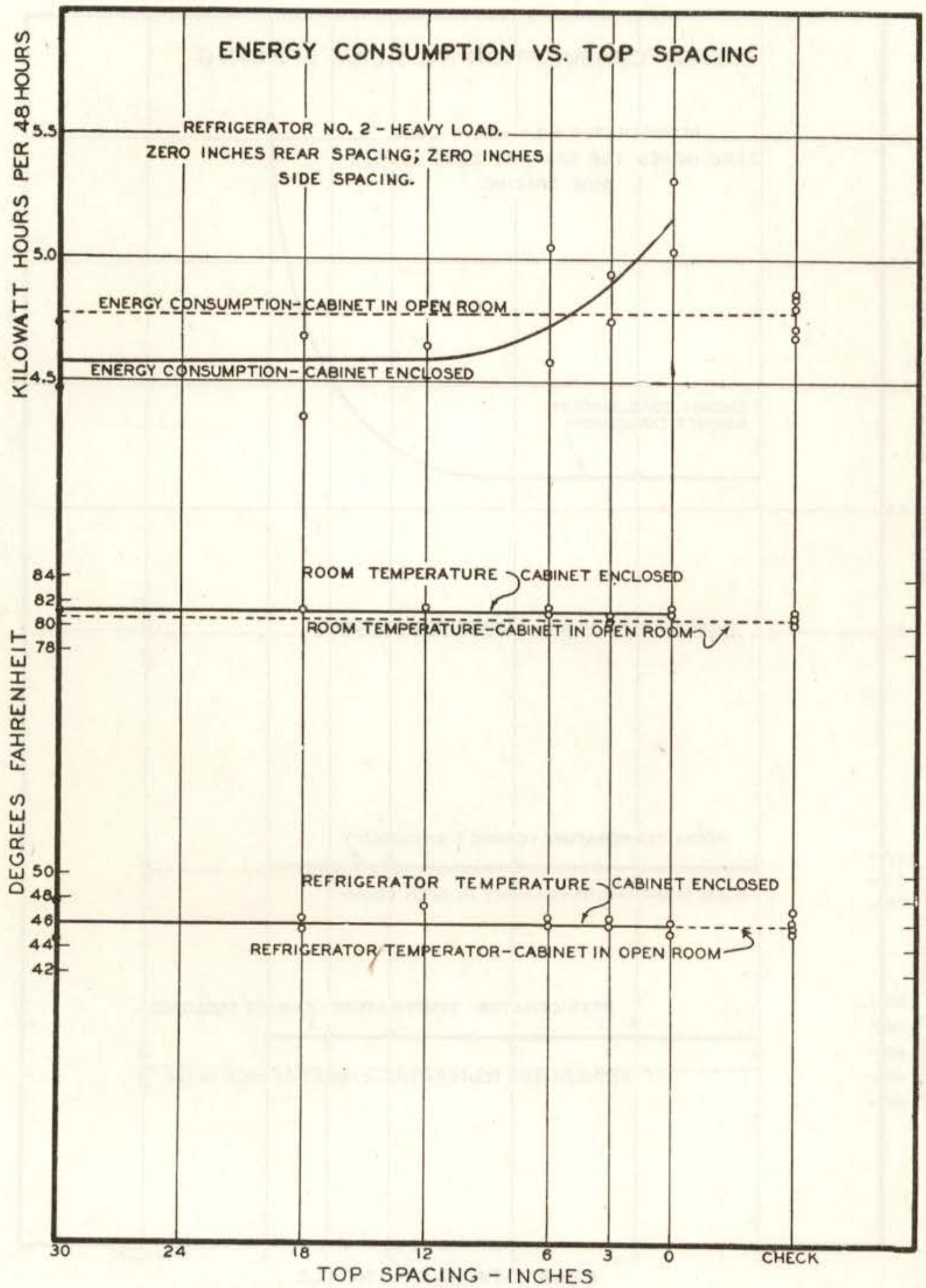

FIG. 5.—Most of the data for energy consumption were obtained when the room temperatures were not excessively high or the temperature in the cabinet very low. When freezing temperatures inside and high temperatures outside were used, the energy-consumption increase was much greater for each enclosure having a lower shelf.

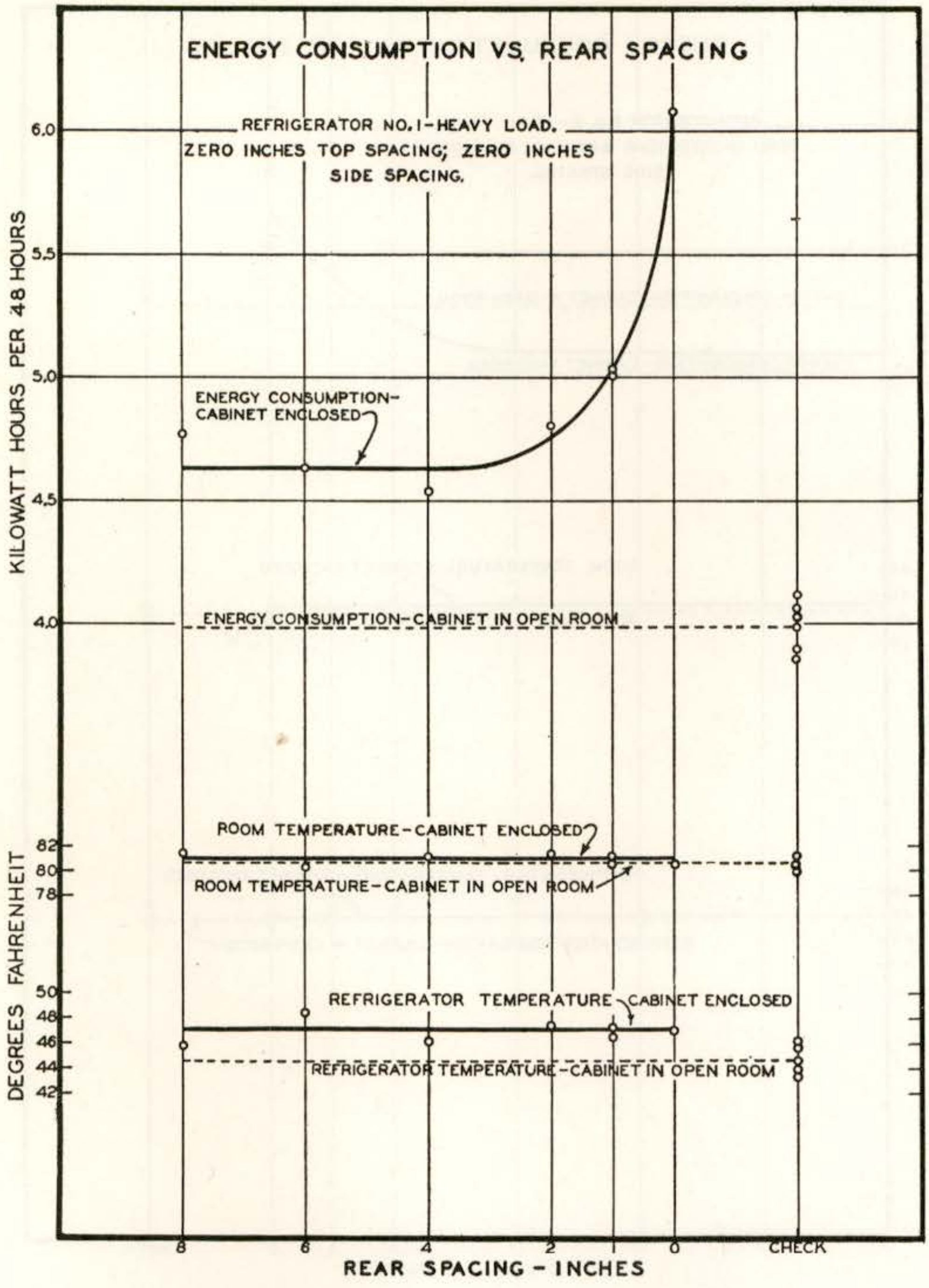

FIG. 6.—When the only air available to the compressor-coil unit must come from the rear, the use of electrical energy increases very fast when the cabinet is pushed against the wall. Similar increases would be shown if a wall at the side shut off air from a side ventilated unit.

of clearance over the top of the coils for circulation. If any grilles or curtains are placed in front of the coils, some air shaft similar to that indicated in Figure 2B should be provided. If the compressor is contained within the cabinet, there must be a clearance of at least three inches at the rear if the compressor unit gets ventilation from there, or at the sides if openings for air are at the sides. This must be in addition to the clearance on top or to an air shaft leading upward from the sides or rear. Forced circulation reduces the clearance needed. If proper air circulating and ventilating conditions are not provided, the user of the electrical or mechanical refrigerator cabinet can expect greater energy consumption than is necessary.

[5M]