NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT **NBS REPORT**

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

December 1, 1953 - July 31, 1954

1. INTRODUCTION

This report summarizes activities of the Heating and Air Conditioning Section, Building Technology Division, National Bureau of Standards, in behalf of the Mechanical Engineering Division, Headquarters, Quartermaster General Research and Development Command, U. S. Army. While this report covers a period of eight months, it has been proposed and agreed between NBS and QM, R & D, that future progress reports will cover periods no greater than one-quarter year.

The services of fourteen members of the staff of the Heating and Air Conditioning Section and specialized facilities of that group located in six buildings at the National Bureau of Standards have been directly utilized as required to further the work reported. The services and facilities of other sections at NBS have been drawn on as required. The principal activities on this program are itemized below, together with a discussion of the progress during the present reporting period or their status at the end of the reporting period.

Item 1.

A.S.H.V.E. Report No. 2956, covering activities in the period from July 1 through November 30,1953 was submitted on December 4, 1953.

Item 2.

The final report, A.S.H.V.E. Report No. 3057, entitled "Performance of Drifreez Driers in a Freon-12 Refrigerating System," was submitted on January 15, 1954. It covered results of tests and investigations made of a proprietary device for removing moisture from a refrigerating system, manufactured by the Perma Corporation, Richmond Hill, New York, and marketed under the trade name "Drifreez Dehydrator." Calcium Carbide was employed as the desiccant material and the test program was arranged to determine characteristics in three aspects:

1. Drying tests
2. Hazards
3. Resistance to vibration

An evaluation of the Fritreck drier is contained on page 39 of report No. 3057 referred to above.

<u>Item 3.</u> LIGHTWEIGHT COMPRESSOR

Tests were completed in the last reporting period of the prototype light-weight radial investigation compressor. The final report, NBS Report No. 3341, entitled "Calorimeter Tests of a Prototype 1/2 HP Five-Cylinder Radial Compressor" was submitted on June 11, 1954.

This compressor appeared to have potential value because of its light weight and small size. Undesirable characteristics were high power consumption, porosity of the casing, and vibration.

<u>Item 4.</u> 1/2 TON PLUG-TYPE UNIT

The previous progress report presented the essential results observed from tests of a Model N-10 Thermo King plug-type gas engine driven refrigerating unit when operated over a range of speeds.

A first draft of the final report of these tests has been completed.

The objective of these tests was to determine the practical range of capacities for 10°F and 35°F refrigerator temperatures at an ambient temperature of 110°F obtainable by varying the operating speed of the gas engine. The condenser and evaporator fans were not controlled at a constant speed for the range of tests but were operated at speeds proportional to the gasoline engine by the belt drive incorporated in the unit.

<u>Item 5.</u> 1/3 TON PLUG-TYPE UNIT, (K 15G)

A Thermo King Model K 15 G, plug-type gasoline engine driven refrigerating unit was tested under conditions as generally referenced under discussion of the 1/2 ton unit. (Item 4. of this progress report). Fan speeds were maintained constant at each of two values while engine speeds (and compressor speeds) were varied over a considerable range for one series of tests and were operated proportional to engine speed changes by means of the belt drive for another series of tests.

The increase in net refrigerating capacity as compared to proportional speeds was significant and has been reported previously. A decision to curtail further such investigation of this particular unit in this regard was made and the final report of this work is nearing completion.

<u>Item 6.</u> 1/3 TON PLUG-TYPE UNIT (K15G)

Tests were completed previous to this reporting period of a Thermo King 1/3 ton plug-type model [illegible] electric motor driven refrigerating unit and approximate capacities at ambient temperatures of 70°F, 90°F, 110°F and 125°F and at refrigeration temperatures of 0°F, 10°F, 35°F and lowest obtainable for each ambient.

The capacity ranged from 9700 BTU/hr at 35°F refrigerator temperature and 70°F ambient temperature to 2400 BTU/hr at -19.5°F refrigerator and 70°F ambient. At 110°F ambient temperature the capacity ranged from 2900 BTU/hr at 2.5°F refrigerator temperature to 6750 BTU/hr at 35°F refrigerator temperature.

A final report will be submitted on this series of tests.

Item 7. 1/3 TON [illegible]

A 1/3 ton gasoline engine-driven plug-type refrigerating unit manufactured by Carrier Corp. was tested prior to this reporting period to determine capacity at ambient temperatures of 70°F, 90°F, 110°F and 125°F and at refrigerator temperatures of 0°F, 35°F and lowest obtainable in the test warehouse. Observed capacities ranged from 2100 BTU/hr at 70°F ambient temperature and -23°F refrigerator temperature to 10,300 BTU/hr at 70°F ambient temperature and 35°F refrigerator temperature. At 110°F ambient temperature the capacity ranged from 2750 BTU/hr at -10°F refrigerator temperature to 6750 BTU/hr at 35°F refrigerator temperature.

A final report on this series of tests will be submitted.

Item 8. 18,000 BTU/hr [illegible]

Tests of a prototype sectional 2 H electric motor driven air conditioning unit designed for use with van type trailers and manufactured by General Electric Company were completed prior to this reporting period. During the period of testing difficulty was experienced with flexible lines, excessive air leakage and refrigerant control. The testing was held in abeyance pending a decision by the manufacturer to modify the unit. Before anything was done in this regard, Mr. H. L. Stiles, of [illegible] indicated that no further tests be made. A final report of this test series that was completed will be submitted. These tests included operation with the entire unit within the conditioned space, the entire unit outside the conditioned space and with the unit divided, i.e. with the condensing unit outside and the evaporator unit within the conditioned space.

This unit was similar to, but smaller than, the 3 H prototype sectional van type air conditioning units, one manu-

factured by General Electric Company, and the other by York Corp., tested during the past period for the Office of the Corps of Engineers, Fort Belvoir, Virginia.

Item 9.

No work was done on this project during this reporting period. The trailer has been equipped with thermocouples and the type of air flow measuring devices to be used have been selected. A simulated food load consisting of 1.1 cu. ft. cases of combat food rations has been placed in the trailer and the trailer has been installed in a test area suitable for the tests proposed. Work can be resumed at any time.

Item 10.

An extended series of tests of various components of three gasoline fired tent heaters were essentially completed prior to this reporting period and most of the information requested has been relayed to interested representatives of [illegible]. The final report for this series of tests is nearly completed.

Much of this work centered around the fans used to move the heating air through the heater assembly and included such items as position of the fans in the shrouds, pressure drop through the heater, comparison of competitive fans, calibration of test ducts, calibration of pressure measuring elements, as well as determining air moving ability and horsepower requirements of these various fans.

Item 11.

This project was instituted prior to this reporting period to determine the characteristics of the present defrosting arrangement of the Thermo King Model RS 51 gasoline drive warehouse refrigerating unit so that direct comparison could be made with proposed modifications of this system.

Work was completed earlier on the first phase of the tests, with an empty 600 cu. ft. prefabricated warehouse used as a calorimeter. The second phase, with a simulated load consisting of 1.1 cu. ft. cases of combat rations, was completed during this reporting period.

As was expected, there was less temperature rise within the warehouse during defrosting, and the time required for frost to accumulate to the extent that the warehouse could not be held at 0°F was increased.

These results will be reported as a basis for comparisons with future results in defrosting of the modified 1-ton unit.

Item 12.

The Model [illegible] 51 Thermo King gasoline engine driven unit referenced in Item 11 was converted to electric motor drive by means of a conversion kit manufactured for this purpose by [illegible] U. S. Thermo Control Company. It was presumed that this conversion was designed to produce capacity equivalent to the gasoline engine drive. The compressor operated at 2400 rpm design speed under gas engine drive but the electric conversion drive operated it at 1750 rpm. While this prevented direct comparison, significant operating data was derived from these tests. It is probable that the results of these tests will be reported in conjunction with other work currently in progress concerning the modification of the Model [illegible] 51 Thermo King unit.

Item 13.

Work being done under this item can also be identified as modification of the 1-ton gas engine plug-type warehouse refrigerating unit. Three Model [illegible] 51 Thermo King units are currently at [illegible] in connection with this work. The first unit, Serial No. [illegible] 200 (MRE 101-53) was shipped from Columbus Depot in 1953; the second, Serial No. 176 (MRE 108-54) was also shipped from Columbus Depot, but in 1954; and the third, Serial No. [illegible] 110-54) was received from J. Beardsley Smith of Baltimore, MD.

The first unit (MRE 101-53) is the one which has been converted to electric motor drive and which was used in the defrosting studies. The second (MRE 108-54) is currently being used in the modification studies. The third unit has apparently not been operated since it was originally packed for shipment by the factory.

Work is currently in progress on modification of the second unit (MRE 108-54) along lines outlined by the Refrigeration Equipment Branch. A prototype heat exchanger was fabricated and tested to determine feasibility of extracting waste heat from the gas engine exhaust and introducing it in the refrigerant circuit as a source of heat for either defrosting of the refrigerated coils or heating of the refrigerated space. The results of these preliminary tests were reported in a letter to Mr. David L. Sicks dated July 30, 1954.

The components and installation outlined by the Refrigeration Equipment Branch at a meeting between this group and representatives of the Heating and Air Conditioning Section, [illegible], at Natick, Mass., on May 6, 1954, (reported as Item 14.) have been installed and tests are currently in progress. The results will be reported on this work progress.

evaluation of the proposed methods for eliminating electric controls and automatic starting, providing automatic or manual for control of both cooling and heating and single-speed (or resultant) control of engine speed on a means of capacity modulation for both cooling and heating is currently in progress. Some of the areas requiring consideration were outlined in a letter to Mr. Ben Whittlesey dated June 18, 1954. Tests made with varying engine speeds, coupled with complete unloading of the compressor at conditions requiring neither heating or cooling have shown promise. This investigation is being continued.

Item 14.

Mr. E. C. Pitt, Chief, W. A. Scheubeck, Asst's Chief, and C. W. Phillips, Tech. Engr. of the Heating and Air Conditioning Section, NBS met with Mr. Welch L. Whittlesey, Chief, Refrigeration Equipment Branch, Military Planning Division, U. S. C. & G. Townsend and others of his organization at their offices at Natick, Mass., on May 6, 1954. The general purposes of the meeting were:

1. Presentation of ASHAE cooling, defrost and heating requirements.

2. Presentation of A. Hartley Walsh's theory on defrosting methods.

3. Presentation of U.S.A. proposal for reverse cycle heating.

4. Recommendations for testing program at NBS.

5. Establishment of target dates for completion.

Item 15. Federal Specification for Refrigerators, Electric, Self-Contained

Work was continued on the revision of Federal Specification ~~H-R-271c~~ (Refrigerators, Electric, Self-Contained). Two field trips by representatives of U.S.A., and the Public Housing Administration were made. The essential purpose of these trips was to seek out the direct opinions of users of refrigerators in regard to current and proposed trends in the products covered by the subject specification. Present thinking is that the domestic, or household-type refrigerators, up to and including 15 cubic feet, should be covered by a separate specification from the commercial or institutional-type refrigerators which range up to 100 cubic feet. Accordingly, manufacturers visited to date were consulted primarily in regard to the domestic refrigerators. Manufacturers visited during the two trips were Westinghouse, Frigidaire, Crosley, International Harvester, Admiral, and General Electric. Results of these conferences are currently being coordinated with other recommendations. One of the major items to be resolved in the

determination of a satisfactory temperature level for the freezer compartment in a domestic refrigerator. Two companies, Westinghouse and Frigidaire, have offered to submit samples of current items for study. An 8 cubic foot Frigidaire "Cyclematic" (self-defrosting) refrigerator has been received and is currently being tested to determine the degree to which existing A.S.A. and other standards for rating and testing household refrigerators should be referred to or incorporated into the proposed revision.

A memorandum enumerating the items or parts of Federal specification [illegible]-R-211c which need modification or which should be added to the present draft was prepared at a meeting July 12, 1954, at [illegible] between representatives of the Heating and Air Conditioning Section, NBS and Mr. E. V. Davidson, Asst. Engr. of the Refrigeration Equipment Branch, [illegible], Corps of Engineers, U. S. Army in charge of this project. A copy of this memorandum is attached.

Plans have been made for Mr. Davidson and L. L. Killam to meet with Mr. Frank T. Reinhardt, Chief, Organic Plastics Section, Division of Organic and Fibrous Materials, NBS on August 5, 1954, to outline the method of providing for the use of acceptable plastics in certain parts of refrigerator construction.

Item 16.

In request of Mr. Whittlesey, assistance was rendered to a representative of the Patent Section, [illegible] in regard to the 1/3-ton gas engine driven plug-type warehouse refrigerating manufactured by U. S. Thermo Control Company, Minneapolis, Minnesota and employing a combination starter-generator in connection with the gas engine. Descriptive information and photographs were furnished as requested.

Files of the Heating and Air Conditioning Section dealing with various items of portable gas engine driven units manufactured by U. S. Thermo Control Company, and tested for [illegible] by this section for the past ten years were structured for quick reference in response to a request of Mr. J. [illegible] Hillary, Chief, Mechanical Engineering Division, [illegible], Corps of Engineers, U. S. Army in connection with hearings being held in Washington relative to the combination starter-generator.

Item 17.

A program for the continuation of the studies of water vapor transmission in refrigerated warehouses was prepared and approved during this period. The insulation panel required for this program was constructed at the Natick Laboratory of [illegible], Corps of Engineers, U. S. Army and shipped to this bureau. This panel is currently being installed in the portable refrigerated warehouse for studies of water vapor movement in its construction.

Item 12.

A test procedure for investigating the performance of a new inverted gasoline lantern developed for the Military services and the proposed army gasoline lantern has been agreed upon in connection with representative [illegible] specimens of both types of lanterns have been received and the program will commence as soon as [illegible] kinds of gasoline are received. In the meantime some preliminary tests in high ambient temperature are being made to evaluate the performance of the pressure regulating valve in the inverted lantern.

Item 13. [illegible]

In response to a request of Mr. [illegible], a list of the M, [illegible] and G-[illegible] items on hand by the Heating and Air Conditioning Section, was prepared and submitted in a letter dated July 26, 1934. A copy of this list is [illegible].

Memorandum for the Record

Revision of Federal Specification AA-R-211c
(Refrigerators, Electric, Self-contained)

Meeting 7/12/54 at NBS, Washington, D. C.

Present: Mr. J. V. Davidson, QM R&D Command
C. W. Phillips)
Minoru Fujii) NBS
John A. Grimes)

The purpose of this memorandum is to enumerate the items or areas concerning Federal Specification AA-R-211c which need modification or which should be added to the present draft. The ideas presented are those with which there has been essential agreement on the part of representatives of the various manufacturers contacted on the two recent trips made for this purpose by representatives of QM R&D, NBS and Public Housing Administration. As presented, these items are not suggested wording for the proposed draft but are items which must be treated in the proposed draft.

1. The present draft of AA-R-211c deals with both commercial and domestic refrigerators. It is generally agreed that this should be divided into two separate specifications.

2. The domestic specification (or household) should include refrigerators up to and including 15 cubic feet.

3. Definitions of freezer conditions must be clarified. Temperatures of the frozen food below 12 degrees for all conditions of operation seem to be the apparent dividing line between suitable and unsuitable freezer storage. In regard to dimensions of freezer compartments, freezers capable of maintaining temperatures below 12 degrees may occupy a maximum of 30% of the total food storage volume and shall be a minimum of 10% of the total food storage volume. Evaporators not capable of maintaining 12 degrees may not occupy in excess of 15% of the total food storage volume. The proposed method of selecting refrigerators with or without frozen food storage would be by means of options available to the procuring authority.

4. Dimensions of refrigerators can be reduced from present table values except for depth. Consideration of door thickness must be included in establishing the overall depth. Consideration must be given to listing depth as the minimum opening through which the refrigerator can be taken with or without the door (including hardware) depending on the ease of removing the

door or hardware. The depth of the cabinet in any event should not exceed 25-1/2 inches from the overall rear projection (condenser duct, etc.) to the door closure face. This is to conform to the standard cabinet or work surface depth. The apparent trend in refrigerator doors is to a thicker door (usually with door shelves) which is hinged in such a manner that it could not be opened if the door itself were contained between cabinet edges or walls, etc.

5. The use of plastics must be permitted for general use for breaker strips, accessories, door liners, baffles, etc. but not for inner liners.

6. Inner liners of steel shall be finished with porcelain enamel. Consideration should be given to the use of other materials for inner liners. There seems to be general agreement that steel finished with organic enamel is neither desirable nor satisfactory for this application.

7. One-coat organic enamel exterior finish is satisfactory if in accord with a suitable performance specification. It is understood that this specification will have to be determined.

8. Present insulation requirement referring to "k" or "U" factors should be eliminated in preference to heat transfer performance under a suitable high humidity test condition. This is sometimes referred to as a sweating test.

9. Existing NEMA and ASA Standards dealing with the subject of electric refrigerators shall be incorporated wherever practical without change, to avoid industry confusion. It is understood that NBS will conduct certain tests to determine the advisability of recommending the use of these Standards, or at least the test portions of these Standards, entirely as presently written.

10. Values for minimum shelf area must be established and included in the tabular data for the various sizes to be listed in the specification.

11. Suitable definitions must be established for describing the function of the evaporator section (or frozen food storage section) within the refrigerator. The method of allowing the purchaser an option to procure a refrigerator in which there is a frozen food storage section, as compared to one in which there is a normal ice-making or evaporator section, must be determined. It appears that at present there is no satisfactory agreement, either written or implied, as to the proper division between the two basic types of evaporators. The gen-

eral opinion seems to be that frozen food maintained at or below 12 degrees will be suitable for storage periods of three weeks to a month, whereas the type of evaporator which will permit the frozen food to rise above 12 degrees as a result of cycling operation or which will not reduce the temperature of frozen food below 12 degrees under normal operation should not be considered as truly "frozen food storage".

12. At present, Type I refrigerators are listed only through 12 cubic feet. Consideration must be given to the number of sizes to be listed as well as the tolerance below listed sizes which will constitute acceptable total food storage volume. Minus tolerances in the order of 5% or 1/2 cubic foot, whichever is smaller, will apparently work no serious hardship on the products thus far surveyed in this project.

13. Automatic Defrosting. The subject of defrosting can apparently be best met by definitions of acceptable systems. No "automatic" defrosting systems controlled solely by need for defrosting have been observed. Principal systems observed were: (a) manual, in which the defrosting cycle was initiated by the user: (b) initiated by time, number of door openings, operating time, etc.; (c) defrosting following each "On" cycle of the system. Items (b) and (c) constitute the majority of the so-called automatic systems currently available. The question of necessity for defrosting freezer compartments needs further study.

14. Packing Requirements. Results of field investigations show that all manufacturers interviewed object to certain presently required packing specifications and requested consideration of the use of a performance type requirement permitting greater latitude in packing methods in which commercial packing as presently employed can be used.

15. Colors. The revised specification must incorporate some means for permitting the use of colored exteriors and interiors. Whatever method of selection as suitable colors, unless otherwise specified, all refrigerators on a single order should be of the same color.

16. Ice. All manufacturers interviewed stated present minimum ice requirements is greater than employed in current domestic shipment, and this requirement should be lowered accordingly.

17. Door Gaskets. The present specifications should be broadened to include polyvinylchloride as well as natural and synthetic rubber.

18. Referenced specifications must be brought up to date.

19. Requirements for door shelves must be defined in accordance with existing NEMA ratings.

20. The present rate of procurement of refrigerators by the Government appears to be on the order of [illegible]. This fact should be kept in mind since it appears desirable to purchase items under mass production for domestic consumption.

It is understood that the items in this memorandum do not constitute all of the items by any means which require deletion, addition or modification in preparing a useful, acceptable specification for household-type electric refrigerators. It is hoped that they will serve as a practical guide to those areas which will require the greatest amount of investigative effort in arriving at suitable requirements.

LIST OF [illegible] Items at NBS as of 7/23/54
Subject to recall under CCMS property accountability

1. 1 Helfrann Mod. 600 D Dishwashing Machine Ser #1100

2. 1 10 KW Onan Engine-Generator Model JVC 4-10-R2 (NBS 20-50)

3. 1 Therm-O-Matic Ice Cube Maker (no. [illegible])

4. 1 Fork truck, Clark Electric Lon 20-4 Ser [illegible] 200 (NBS 15-50)

5. 1 Thermo King 1/3 ton gas engine driven plug type refrigerating unit Mod. [illegible] Ser. FX (NBS 54-51)

6. 1 1/3 ton gas engine driven plug type refrigerating, Carrier Model D731 Serial #9644 (NBS 53-51)

7. 1 Therm-O-Matic Ice Cube Maker (NBS 39-50)

8. 1 1/2 ton gas engine driven plug type refrigerating unit, Thermo King Model D-35 Serial #2487 (NBS 16-50)

9. 1 600 cu. ft. refrigerated warehouse prefabricated, demountable Tuckman, 8 x 8 x 12 (NBS 15-50)

10. 1 150 cu. ft. refrigerator, walk-in, portable, Crown Model W-150 Serial [illegible]-565 (NBS 65-51a)

11. 1 1/3 ton electric motor driven Thermo King plug type refrigerating unit Model [illegible] 15[illegible], Serial #679 (NBS 65-51b)

12. 1 1/2 HP Longstreth compressor (NBS 77-52)

13. 1 Heater, Tent, Gasoline, Herman Nelson Model T8 3077 [illegible] Serial #103 (NBS 93-52)

14. 1 Heater, Tent, Gasoline, Herman Nelson Model T-3077 Serial #32603 (NBS 94-52)

15. 1 Heater, Tent, Gasoline, Silent Glow Model 3A 3077 Serial #352 (NBS 95-52)

16. 1 set of tent ducts for use with Heater, Tent, Gasoline, approx. 18 pieces in all (NBS 93a-f-52)

17. 1 600 cu. ft. refrigerated warehouse, prefabricated, demountable, Beco, identified as "Beco-Fab Metalply Freeze Cooler" (NBS 30-52)

18. 1 3000 cu. ft. refrigerated warehouse, prefabricated, U. S. Plywood (NBS 102-53) Note: This warehouse sent to [illegible] for use as field test structure.

1. [illegible]

2. [illegible]

3. [illegible]

4. [illegible]

5. [illegible]

6. [illegible]

7. [illegible]

8. [illegible]

9. [illegible]

10. [illegible]

11. [illegible]

12. [illegible]

13. [illegible]

14. [illegible]

15. [illegible]

16. [illegible]

17. [illegible]

18. [illegible]

19. 1 1/2 ton gas engine driven plug type refrigerating unit Thermo King Model [illegible] Serial [illegible] (Nos 100-54)

20. 1 7 1/2 ton 2-wheel semi-trailer, refrigerated, [illegible] MCT-1165 Serial [illegible] (Nos 103a-53)

21. 1 1/2 ton gas engine driven plug type refrigerating unit Thermo King Model [illegible] Serial [illegible] (Nos 103b-53)

22. 1 1/2 ton gas engine driven plug type refrigerating unit Thermo King Model [illegible] Serial [illegible] (Nos 101-53)

23. 1 ditto 22 Model [illegible] Serial [illegible] (Nos 109-54) Note: This unit from Army stock at Edgewood Arsenal.

24. 1 ditto 22 Model [illegible] Serial [illegible] (Nos 110-54). Note: This unit from J. Beardsley Smith, Baltimore, Md.

25. 1 Electric drive conversion assembly for [illegible] Thermo King refrigerating unit. (Nos 107-54) Note: This conversion has been assembled into Thermo King Model [illegible] Serial [illegible] (Nos 101-53) in place of the original modified Crosley gasoline engine.