NATIONAL BUREAU OF STANDARDS REPORT

4220

REFRIGERATION AND FIELD EQUIPMENT

PROGRESS REPORT

January 1, 1955 to June 30, 1955

To

HEADQUARTERS, QUARTERMASTER RESEARCH & DEVELOPMENT COMMAND

NATICK, MASS.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section is engaged in specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside of the back cover of this report.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Process Technology. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Measurements. Thermodynamics. Cryogenic Physics. Engines and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion.

Mineral Products. Porcelain and Pottery. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems.

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services.

Radio Propagation Engineering. Frequency Utilization Research. Tropospheric Propagation Research.

Radio Standards. High Frequency Standards. Microwave Standards.

- Office of Basic Instrumentation
- Office of Weights and Measures

NATIONAL BUREAU OF STANDARDS REPORT

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NBS REPORT
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REFRIGERATION AND FIELD EQUIPMENT

PROGRESS REPORT

January 1, 1955 to June 30, 1955

by

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for

HEADQUARTERS, QUARTERMASTER RESEARCH & DEVELOPMENT COMMAND
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PROGRESS REPORT

Jan. 1, 1955 to June 30, 1955

1. Refrigeration and Field Equipment

NBS Report No. 3929, summarizing progress on the research and testing program of the National Bureau of Standards for the Quartermaster Research and Development Command during the period Aug.1, to Dec. 31, 1954, was submitted under date of Feb. 3, 1955.

2. 1/3-Ton Thermo-King Unit, Model Q15G

On request of the Quartermaster Research and Development Command a supplementary report was issued on the 1/3-Ton Thermo-King Unit, Model Q15G, furnishing information not contained in NBS Report 3790 on this same unit. This supplementary report, transmitted under date of April 1, 1955, provided details on the power used by the evaporator and condenser fans at various speeds, a description of the instruments used for the observations, the heat transmission coefficients of the warehouse used as a calorimeter, observed values of temperature at various points in the refrigerant circuit, and comments on the performance of the thermostatic expansion value during this investigation.

3. Federal Specification AA-R-211c

A complete revision of Federal Specification AA-R-211c covering Self-Contained Electric Refrigerators was transmitted to the Quartermaster Research and Development Laboratory on Jan. 11, 1955. After circulation of the draft to government departments and to industry for comment then suggestions were evaluated and incorporated into the revision where appropriate in collaboration with QMR&D personnel during a conference on July 7, 1955.

4. 1/3-Ton Carrier Refrigerating Unit

The report on the performance of the 1/3-ton gasoline-driven warehouse refrigerating unit, Model D731 manufactured by Carrier Corporation is under review and will be transmitted by Aug. 31, 1955.

5. 1/2-Ton Thermo-King Refrigerating Unit

Review and revision of the report on the 1/2-ton gasoline engine driven Thermo-King warehouse refrigerating unit, Model K-10, is about completed and the report will be submitted by Aug. 31, 1955.

6. Standardization of Refrigeration Components

Section personnel participated in a two day meeting at the Quartermaster Research and Development Laboratory on Jan. 11 and 12 to review in detail the test procedures for standardization of open type compressors as submitted by Consultants, Inc.

A project proposal for evaluating the test procedures and testing several compressors under the standardization program was prepared and submitted to the Quartermaster Research and Development Laboratory.

Engineering assistance and recommendations on test methods and procedures and the fundamental concepts in standardizing condensers for refrigerating units were furnished to representatives of Consultants, Inc., under contract to QMR&D, during three conferences requested by the contractor.

7. Heat Transmission of Refrigerated Trailer

A heat transmission test was completed on a specimen 7 1/2-ton semi-trailer manufactured by the Kentucky Manufacturing Co. The Trailer was tested for compliance with a purchase specification requirement that the heat leakage should not exceed 52 Btu/hr (°F temperature difference between inside and outside). The test results showed that the heat leakage averaged 63.0 Btu/hr (°F) during two tests with mean temperature of about 60°F. The results of these tests were reported under date of June 30, 1955.

8. Vapor Transmission Studies

A third test was made in the water vapor transmission apparatus using the first panel with gaskets on both sides of the panel joints corresponding to Part II of the project proposal submitted on this project under date of Dec. 21, 1953. The test conditions were approximately 110°F dry bulb temperature and 50% relative humidity on the warm side

and -3°F dry bulb temperature and 55% relative humidity on the cold side. Approximately 73 days were required to transfer 4.9 lb of the 5 lb of water available in the humidifier on the warm side of the panel. About 38% of the water vapor released on the warm side was absorbed by the desiccant on the cold side of the panel and an additional 2.6% was mopped up as free water on the floor of the warm side of the test apparatus. Presumably the remainder of the water was in the test panel and joint construction.

The following observations were made on the panel when it was dismantled at the end of the 73-day test.

1. All five of the plexiglass windows covering inspection holes in the cold skin were dry and clear.

2. There was no evidence of rust on the pieces of bare iron wire installed beneath the plexiglass windows.

3. The insulation felt dry to the touch adjacent to the cold skin.

4. The humidity elements installed under the plexiglass windows indicated that condensation was not imminent on the cold skin.

5. There was ice in the joint at one side of the outer panel reaching down about 1 foot from the top. The ice was about 1/2-inch in width and was attached to the metal where it overlapped the breaker strip.

6. There was ice formation on the top edge of the center panel reaching about 2-inches from the same corner that revealed ice in the vertical joint.

7. The wooden breaker strips were damp on the other side of the center panel covering an area of about 2 sq. in. near the point where the center panel and top and left border panels meet.

8. The panel fasteners functioned satisfactorily.

The weight of water vapor entering the panel on the warm side in 73 days corresponded to an average permeance of about 0.5 grams/hr (sq.ft)(in Hg pressure difference) or to a vapor transmission rate of about 0.35 grains/hr (linear foot of gasketed joint). The latter figure is probably more significant since nc water vapor could pass

through the metal skins on the two sides of the panel thus making the length of gasketed joint a primary factor in the transfer of water vapor across the construction. The water vapor transmission rate entering the panel on the warm side with the double gaskets was approximately 1/20 of that observed on the same panel with a gasket on the cold side only for similar temperature conditions on the two sides of the panel.

9. Exhaust gas heat exchangers for 1-ton gasoline engine-driven refrigerating unit.

Performance of prototype heat exchangers at temperatures above 0°F had been determined and reported in previous progress reports.

In order to evaluate the performance of the heating operation of the MQ51 Thermo-King gasoline engine driven refrigerating unit at temperatures below 0°F, and with an air-cooled engine in place of the original liquid-cooled engine, special test facilities were constructed in the Section's Test Bungalow.

Tests were made of operation with the heat exchanger selected by QMR&D and with the one developed at the NBS. The first series of tests were made with the original liquid-cooled Crosley engine.

Tests of the NBS heat exchanger were made using it both in the suction line as a direct expansion device and in the discharge line where it was employed as a superheating device.

The heat exchanger manufactured by the Heat Exchanger Company, suggested by QMR&D, became plugged with decomposed oil, carbon, etc., when installed in the engine exhaust gas passage and efforts to clean it were not successful. The NBS exchanger can be cleaned by rodding, since exhaust gas tubes are straight and accessible from both ends.

Although the NBS exchanger was designed primarily for use in the discharge line as a superheating device, tests were made using it as a direct expansion device in the suction line.

Because of the relatively large amounts of heat given off into the test space by the air-cooled engine as compared with the liquid-cooled engine, additional provisions were made to increase the refrigerating effect within the test area. A separate test enclosure surrounding the engine-driven unit under test was constructed and ducts connecting this directly to the air cooling units in the Bungalow shell were constructed.

Despite precautions to the contrary, Mr. Peter F. Orban, a laboratory mechanic working on this project, lost his life on May 20, 1955 as a result of carbon monoxide poisoning. Improved safety measures are being incorporated in the testing procedure and the remaining low-temperature tests will be resumed shortly. A report of this accident was made to members of the staff of the Mechanical Engineering Division of QMR&D Command at Natick on July 7, 1955.

A summary of the test results will be prepared on completion of the low temperature tests. The results indicate that use of the engine exhaust gas heat exchanger will provide adequate heating for operation of the 600 cu. ft. warehouse at 35F in an ambient temperature of -40°F. Operating characteristics of the liquid-and air-cooled engines will be reported, including difficulties in starting at low temperature, freezing of breather openings, etc.

10. Development of Thermo-Mechanical Controls for 1-ton Gasoline Engine-Driven Refrigerating Unit

Work has continued on the modification of the MQ51 Thermo-King warehouse refrigerating unit. The work on controls is a companion project to that dealing with the engine exhaust gas heat exchangers. The overall objective is the development by QMR&D of a 1-ton gasoline engine-driven unit which can satisfactorily cool a 600 cu. ft. warehouse to 0°F in 110°F ambient, heat the same warehouse to 35°F in -40°F ambient, modulate heating or cooling capacity as required, and operate with thermo-mechanical controls. Expressed in more detail, the specific objectives and associated problems are:

Objectives:

1. Conversion of refrigeration unit into a heat pump, capable of cooling and heating.

(a) Use of the gasoline engine exhaust gas as heat source for heating.

(b) Determing the optimum circuit for heating cycle.

(c) Heating the discharge vapor in a vapor-to-vapor heat exchanger.

(d) Switch-over of cyle between heating and cooling by means of pilot and master valves.

(e) Devising a means to bypass the exhaust gas during non-heating cycle.

(f) Providing high temperature safety for refrigerant vapor leaving the heat exchanger.

2. Eliminate electrical control and provide simplified control by mechanical means.

(a) When temperature is satisfied the gasoline engine will be idled instead of being stopped.

(b) While idling of the engine, the refrigerant will be bypassing from the high side to the low side.

(c) Engine speed will be variable according to load requirement either for cooling or heating cycle.

(d) Engine speed will be adjusted by changing the speed setting of the governor automatically.

(e) Devise a cam for automatic speed adjustment and for automatic switch-over of heating, bypassing and cooling cycles.

(f) Design a liquid filled temperature sensing bulb and power element to actuate the above cam.

(g) Provide safety means for the temperature sensing bulb for a storage temperature of up to 160°F.

(h) Provide a charge in the power element to prevent it from flashing at high temperature in the engine ambient.

(i) Design a pilot valve to be actuated by the above cam.

(j) Select a master valve to be actuated by the pilot valve.

3. Provide manual defrosting

(a) Defrosting will be initiated and terminated manually. When defrosting is required heating cycle will be turned on manually.

(b) Evaporator damper will be closed during defrosting by diaphram valve which is operated by pressure.

Much of this work is well under way. For example; performance of prototype heat exchangers has been evaluated and is reported separately. The refrigerant circuit for both heating and cooling has been studied and modification of the evaporator to prevent accumulation of liquid refrigerant and oil during heating has been made. A Thermo-sensitive pilot valve and governor control has been designed and a prototype model constructed. Master control valves for heating and cooling circuits have been selected and purchased. Necessary modifications to the VE4 Wisconsin engine governor to permit speed modulation from 700 to 2400 rpm have been made. Means to prevent oil breather freezing have been studied.

A summary of this phase of the work concerning the modification of the MQ51 unit will be included with the reporting of the heat exchanger phase.

11. Conversion of MQ51 Thermo-King to Electric Motor Drive

The final draft of the report of the tests to determine performance characteristics of the MQ51-E kit for conversion of this unit to electric motor drive has been completed and is currently under review. The final report will be transmitted by August 31, 1955.

12. Insulated Food Containers

Three insulated food containers were tested to determine their relative ability to maintain food temperatures

above freezing in an ambient temperature of -40F. One unit was insulated with block insulation, one with shredded insulation and the third with air spaces for insulation. The time required for water in each container to drop from approximately 200°F to 32°F was about 17 hours for the unit using an air space for insulation, 27 hours for the one with shredded insulation and 29 hours for the one with block insulation.

The draft of the report of these tests has been completed and is currently under review. The final report will be submitted by August 31, 1955.

13. QMR&D Test Items Shipped to Natick

Sixteen crates of QMR&D test items were shipped to Natick as requested by Mr. Augustus C. Baker, Research Property Officer, OQMG, in April 1955. The following list, by crate number, shows items which were returned.

Crate No.	Description	Weight	Cubage
1	(Part of Item 16) 1 section of test duct 18" dia. x 50-7/8" long with 3 square flanges and air straightener insert. 1 test duct transformation piece 54" long, single 18" dia. on one end x 2 - 12" dia. openings on opposite end. 11 18" dia. test duct orifice plates	319	57.8
2	(Part of Item 16) 1 section of test duct 18" dia.x30" long, with one square flange. 4 12" dia. flexible ducts for tent heaters	93	9.3
3	(Part of Item 16) 1 section of test duct 18" dia. x 31-1/2" long	56	7.7
4	(Part of Item 16) 1 section test duct 18" dia. x 36-1/2" long. 1 section test duct 12" dia. x 36-3/4" long, with orifice plate	67	9.1

Crate No.	Description	Weight	Cubage
5	(Part of Item 16) 1 section test duct 18" dia.x 37-1/2 long. 1 section test duct 12" dia. x 36-3/4" long, with orifice plate	67	9.1
6	(Item 13) Tent Heater, Herman Nelson Model VB 3077 CS Ser. # 103 NBS 93-52 less fan	350	46.2
7	(Item 15) Tent Heater, Silent Glow Model 3G 3077 Ser.#352 NBS 95-52 less fan	350	46.2
8	(Item 14) Tent Heater, Herman Nelson Model GT 3077 Ser.#32603 NBS 94-52, less fan and fan shroud	350	46.2
9	(Part of Items 13, 14, & 15) Fans for tent heaters	57	4.2
10	(Item 3) Thermomatic Ice Cube Maker (No NBS number) (in original crate)	645	55.3
11	(Item 19) 1/2 ton Thermo-King Model K-10 Ser.#GB 109QS NBS #100-53	945	73.4
12	(Item 11) 1/3 ton Thermo-King Plug type unit, Model Q15E	680	43.0
13	(Item 7) Thermomatic Ice Cube Maker NBS #39-50)	678	53.7
14	(Item 2) 10 KW Onan Engine Generator, Mod. JWC-4-10M2	1450	50.2
15	(Item 6) 1/3 ton Carrier Plug type unit, Mod.D-731 Ser.#9644	860	58.8
16	(Item 8) Thermo-King Plug type unit, Mod.D-35 NBS #16-50 Ser.#2487	1140	62.2

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.


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