NATIONAL BUREAU OF STANDARDS REPORT
2134

MODEL 320-CQ ELECTRIC DRINKING WATER COOLER
manufactured by
Filtrine Manufacturing Company

by

Henry Karger
C. W. Phillips
P. R. Achenbach

NBS

U. S. DEPARTMENT OF COMMERCE
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NBS PROJECT		NBS REPORT
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Manufactured by
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Henry Karger
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Heating and Air Conditioning Section
Building Technology Division

to

Philadelphia Quartermaster Depot
U. S. Army
Philadelphia, Pennsylvania.

NBS

Model 320-CQ Electric Drinking Water Cooler

by

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C. W. Phillips
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Abstract

Performance tests were made of the cafeteria-type electric drinking-water cooler, model 320-CQ, manufactured by Filtrine Manufacturing Company to determine compliance with Federal Specification 00-C-566b with Amendment 2, as modified by Quartermaster Invitation to Bid QM 11-009-52-1263, amended, and by Quartermaster Contract DA 11-009-QM-18279. Two specimens were utilized for the tests because the initial specimen melted the fusible plug in the receiver during the course of the tests and became inoperative. The second specimen met the requirements of three of the performance tests and failed to meet the requirements of four other performance tests. The test results indicated that insufficient cooling was provided by the air-cooled condenser in the machinery compartment which directly affected the ability of the coolers to meet the requirements of the Overload test and the Maximum Operating tests and probably the Capacity and Peak Draw tests as well.

I. INTRODUCTION

In accordance with a request from the Chicago Quartermaster Depot, Chicago, Illinois, in a letter dated July 15, 1952, performance tests were made of the cafeteria-type electric drinking water cooler, Model 320-CQ, manufactured by Filtrine Manufacturing Company, Brooklyn, New York, to determine compliance with Federal Specification 00-C-566b, and Amendment 2 dated January 21, 1952, as modified by exceptions noted in Invitation to Bid #QM 11-009-52-1263 dated March 26, 1952, Amendment #1 dated April 21, 1952, and contract DA 11-009-QM-18279 dated May 13, 1952. Two specimens of this model water cooler were utilized in the tests. The performance of the specimens was determined by direct tests as required in the Federal Specification. Special tests described herein were made to determine the performance of certain components. Analyses of materials and inspection of construction was not requested in the letter mentioned above; however, certain construction features were noted during the performance tests and some comments on these are included in this report.

II. DESCRIPTION OF TEST SPECIMENS

The two water cooler specimens submitted for test were identified as follows:

NBS Test Specimen 87-52, Specification Type III, Size 20
Filtrine Mfg Company Model 320-CQ
Identified in this report as specimen F-1

NBS Test Specimen 92-52, Specification Type III, Size 20
Filtrine Mfg Company Model 320-CQ
Identified in this report as specimen F-2

Specimen F-2 was submitted after Specimen F-1 developed a refrigerant leak and became inoperative because of loss of refrigerant during a performance test. Both specimens were of the cafeteria type with two glass-fillers mounted on the upper part of the front side on each. They were housed in formed steel enclosures which constituted the back and sides of the coolers. This housing enclosed the condensing unit compartment and evaporator section and provided structural support for the unit. The lower front panel could be removed after loosening three screws and pulling out and up on it, providing access to the condensing unit and all electric controls and connections.

A front view of specimen F-1 is shown in Fig. 1. Fig. 2 shows a rear view of the cooler, and the machine compartment is shown in Fig. 3. Fig. 4 shows a front view of the cooler specimen F-2.

The dimensions and weight of the coolers were as follows:

Height, in.	39
Width of cabinet, in.	26-1/4
Depth of cabinet, in.	17-1/2
Depth of cooler including drain tray, in.	25
Weight, including wood shipping base, lbs.	359

The weight of the wooden shipping base was approximately 20 lbs.

III. TEST PROCEDURE

The laboratory investigation of the specimens were made to determine compliance with the performance requirements of the following paragraphs of the specification, some of which were modified in the Invitation to Bid or the contract:

1)	D-1, E-3, F-32	Capacity Test
2)	D-1a, F-3d	Peak Draw Test
3)	D-1b, F-3b	Maximum Operating Test
4)	D-10d	Refrigeration Control Test
5)	D-10d(1), F-7	Freezing Test
6)	D-11b	Motor Overload Protection Test
7)	D-11a, F-3c	Overload Test

All performance tests listed above were conducted in a temperature-controlled room under steady-state conditions as set forth in paragraph F-3a of the Federal Specification, except where the paragraph applicable for a specific test called for a different set of conditions. Temperatures were measured by means of calibrated thermocouples using an electronic, constant-balance type of potentiometer. Accuracy of this instrument was checked at intervals during the test by means of ice-bath references. Inlet and outlet drinking water temperatures were measured by thermocouples in thin-walled stainless steel wells four inches long, mounted so that the thermocouple junctions were approximately in the plane of the exterior surface of the cooler cabinet. Supply water temperatures and pressures were controlled by close-differential mechanical devices.

Additional information on the test procedure for particular tests is included with the report of the test results to further clarify how the results were obtained in cases where the specification did not provide adequate details.

IV. TEST RESULTS

The following paragraphs show the results obtained on specimens F-1 and F-2 during the performance tests listed under the section on Test Procedure.

(1) <u>Capacity Test</u> (Paragraph D-1, E-3, F-3a)

Table 1, which follows, summarizes the results obtained during the capacity tests on both specimen F-1 and F-2 and compares the observed performance with the specification requirements. The entry entitled "Drinking Water Flow Rate at 30°F Temperature Difference, Gallons per Hour" gives the calculated water flow rate for a 30°F difference between supply and drinking water temperature when the actual difference during the test was not exactly 30°F.

Table 1 shows that neither specimen F-1 nor specimen F-2 met the capacity requirements for Type III, Size 20 coolers.

The automatic expansion valve adjustment was changed on specimen F-2 to raise the evaporator pressure and increase the cooler the cooler capacity. It is believed that this accounts for the greater capacity and higher current and power input shown in Table 1 for specimen F-2 than was observed for specimen F-1.

TABLE 1. CAPACITY TESTS OF SPECIMENS F-1 AND F-2.

Performance Characteristics	Required Performance	Observed Performance Specimen F-1	Observed Performance Specimen F-2
Ambient Temperature, °F	90	90.5	89.8
Electric Power Input, watts	-	796	1007
Terminal Voltage	115	115	115
Total Current Input, amps	-	9.4	11.6
Drinking Water, Inlet Temp., °F	80	80.9	80.0
Drinking Water, Outlet Temp., °F	50	50.6	50.1
Drinking Water, Temp. Diff., °F	30	30.3	29.9
Drinking Water flow rate, observed, gph	-	13.6	16.5
Drinking Water flow rate, corrected for a 30°F temp. diff., gph	18.0 (minimum)	13.7	16.4

(2) <u>Peak Draw Test</u> (Paragraph D-1a modified, F-3d)

Paragraph D-1a of the specification, as modified by exception in the contract, specified that 65 percent of the required hourly capacity shall be drawn off in 15 minutes during the peak draw test. The water temperature at the beginning of the 15-minute period must be neither lower than 45°F nor higher than 50°F and the temperature rise shall not exceed 10 degrees at any time during the 15-minute period. The water must be drawn off, beginning immediately after the compressor-motor cuts off in a normal cycle, in not less than three nor more than six equal intervals per gallon of required draw-off capacity. The water must be drawn off at a rate of not less than 1/2 gallon per minute per glass filler.

The peak draw test was made with cooler specimen F-2. The required amount of water, 11.7 gallons, was withdrawn through the glass fillers in 54 equal samples, with an initial outlet water temperature of 49.2°F. The highest subsequent outlet water temperature observed during the 15-minute period was 59.9°F. This rise in temperature of 10.7°F exceeded the permissible rise of 10 degrees, hence cooler specimen F-2 did not comply with this requirement of the specification.

(3) <u>Maximum Operating Test</u> (Paragraphs D-1b, F-3b)

The specification required that the cooler should operate satisfactorily for at least 8 hours under conditions of 110°F ambient temperature, 100°F inlet water temperature, and 50°F outlet water temperature and should start satisfactorily under these same conditions.

Both cooler specimens were subjected to these test conditions. Specimen F-1, after being operated for 6-1/2 hours under the above conditions developed a leak in the refrigerant system and lost its charge of refrigerant. Investigation revealed that the fusible plug in the receiver outlet fitting had melted. Fig.5 shows this fitting after it had been repaired by representatives of the manufacturer. By mutual agreement between manufacturer and the purchaser a second specimen was submitted for test, rather than continue the tests on the repaired cooler.

An attempt was made to run the Maximum Operating Test with cooler specimen F-2. This test could not be completed because the motor overload protective device disconnected the compressor motor from the circuit before steady state conditions had been reached. Just prior to the time of cutout, the following conditions were noted:

Discharge Pressure, psig	301
Motor Case Temperature, °F	202
Current, amps	12.1

Subsequently the front panel was removed from the cooler, and it was then able to operate without causing the overload protector to function. The failure of the fusible plug in specimen F-1, and the excessive discharge pressure observed with specimen F-2, showed that the design of the air circuit for cooling the condenser and machinery compartment needed improvement. These observations show that neither of the test specimens complied with the requirements of the Maximum Operating Test.

(4) <u>Refrigeration Control Test</u> (Paragraph D-10d)

The Refrigeration Control Test was made with cooler specimen F-2. The cooler was equipped with a thermostat which controlled the operation of the compressor motor. The thermostat was readily accessible for adjustment and servicing when the front panel of the cooler was removed; however, it could not be replaced without removing the top of the cooler cabinet and part of the insulation in the cooling unit housing.

Adjustment of the thermostat could be effected by turning a knob, which had a dial divided into seven positions, numbered from 1 to 7. An arrow on the dial indicated that the thermostat would cause the cooler to deliver colder water when the knob was turned to the higher numbers on the dial, i.e. position number 1 would be the warmest position and position number 7 would be the coldest position.

The specification requirement, as modified in Amendment 2, stated in part:

"Unless otherwise specified, the temperature control of the water shall be adjustable between 45°F and 55°F. and shall have a differential of not more than plus or minus 5°."

This requirement was interpreted by this Bureau to mean that a thermostat would be in compliance if at some condition of flow it would produce water at a control point temperature of 45°F at some setting of the knob, and at a control point temperature of 55°F at some other setting of the knob, with a differential not to exceed plus or minus five degrees. In accordance with previous tests made at the Bureau for water coolers purchased under the same specification requirement, the rate of water withdrawal for this test was set at 1/2 of the required hourly capacity of the cooler, or approximately 9 gallons per hour.

Two 9-fl.oz. samples of water were withdrawn from the cooler every two minutes through one of the glass fillers for the duration of the thermostat test. The first of these samples was discarded into the drain of the cooler, and the temperature of the second sample was recorded. The test was thus continued for one hour, which was sufficient time to cause several thermostat cycles to occur for the highest setting of the thermostat and to indicate steady outlet water temperatures for the lowest setting of the thermostat. The test was conducted in an ambient temperature of 90°F and the inlet water temperature to the cooler was maintained at 80°F.

Under the above conditions, the average of the water temperatures observed at the highest setting of the thermostat was 57.2°F, and the maximum observed deviation from this average was 0.4°F. At the lowest setting of the thermostat, the average of the water temperatures observed was 44.0°F, and the maximum deviation from the average was 0.7°F. This test indicated compliance with the requirement of the specification.

(5) <u>Freezing Test</u> (Paragraph D-10d(1))

Each cooler specimen had an additional thermostat to serve as a protective device against freezing. The freezing tests were made with cooler specimen F-2. Three tests were made, the first in an ambient temperature of 50°F, the other two in an ambient temperature of 35°F. Each of the three tests was continued for 48 hours. The primary drinking-water thermostat was shunted, and the cooler was operated under the above conditions. No freeze-ups occurred during any of the three tests, and drinking water could be drawn from the cooler at the conclusion of each test.

(6) Motor Overload Protection Test (Paragraph D-11b)

Paragraph D-11b states in part: "Motors shall be protected in case of failure of the starting mechanism or excessive overload by a thermal protective device of proper current rating, which shall open the circuit before the motor windings reach a temperature that will injure the motor."

Each cooler specimen was equipped with such a device. Tests were made with specimen F-2. To determine the protection afforded, two tests were made, both in a 90°F ambient temperature, with supply water flowing steadily through the cooler at a rate slightly in excess of 60 gallons per hour. First, the power lead to the starting winding of the motor was disconnected. The cooler was then energized electrically, and measurements were made of the motor running winding resistance immediately following each cutout of the overload protector. The overload protector was allowed to function until successive resistance measurements observed at the time of cutout were no longer increasing, and the temperature rise of the winding was computed on the basis of the highest resistance observed. The highest motor winding temperature indicated under these conditions was 204°F. Second, the condenser fan was disconnected, the air flow over the condenser was blocked, and the cooler was allowed to continue in operation. Using the method described above, the highest motor winding temperature computed, based on resistance measurements, under these conditions was 201°F.

Based on present accepted practice in the design of hermetic motor-compressor units, it is the opinion of this Bureau that the compressor motor of this cooler was adequately protected against overload and against excessive temperatures caused by motor overload.

(7) Overload Test (Paragraph F-3c, D-11a modified)

Both cooler specimens were tested in accordance with the requirements of paragraph F-3c of the specification, which called for 4 hours of continuous operation in 100°F ambient temperature with water drawn at the rate of 300 percent of the required hourly capacity. The inlet water temperature was held at approximately 80°F.

Cooler specimen F-1 operated satisfactorily and without any indication of breakdown. The temperature rise of the motor running winding was determined by the resistance method and computed by the formula given in paragraph 4.2.3 of Federal Specification CC-M-636a, dated October 29, 1951. The results of the test made with specimen F-1 are summarized in Table 2, which follows. Table 2 shows that the temperature rise of the motor windings

was below the permissible rise for totally enclosed motors in this specification. It is pointed out that Federal Specification CC-M-636a does not carry any reference to motors of hermetically-sealed motor-compressor units. It is believed, however, that the coil-winding temperature-rise limit for totally-enclosed type motors in this specification should serve as a guide in judging hermetic motors.

TABLE 2. OVERLOAD TEST OF SPECIMEN F-1

Performance Characteristics	Required Performance	Observed Performance
Ambient Temperature, °F	100	99.7
Drinking Water Inlet Temp., °F	-	80.0
Drinking Water Outlet Temp., °F	-	72.9
Ratio of Drinking Water Flow to Required Capacity, %	300	303
Electric Power Input, watts	-	800
Terminal Voltage	115	115
Temperature Rise of Motor Windings, °C	65* (maximum)	54.4

* Permissible temperature rise for totally-enclosed fractional-horsepower motors in Federal Specification CC-M-636a.

An attempt was made to run the Overload Test with cooler specimen F-2. As in the case of the Maximum Operating Test, the Overload Test could not be made because the motor overload protective device disconnected the compressor motor from the circuit before steady state conditions had been reached. The operating conditions observed just prior to cutout of the protective device and the temperature rise of the running windings just after cutout were as follows:

Discharge Pressure, psig	320
*Motor Case Temperature, °F	199.2
Current, amps	12.5
Motor Winding Temperature Rise, °C	65

* Under the protective device

The front panel was then removed from the cooler, after which the motor was able to operate without exceeding the temperature setting of the overload protective device. As already pointed out in section 3 under Maximum Operating Test, the results indicate that the design of the air circuit of the cooler needed improvement to reduce the discharge pressure and the load on the compressor motor.

The change in expansion valve setting made on specimen F-2 to increase the water-cooling capacity of the specimen during the capacity test caused higher power consumption of the compressor meter and greater temperature rise of this specimen than for specimen F-1 during the Overload test. The change in expansion valve setting undoubtedly was the reason why specimen F-2 failed to meet the Overload test requirements whereas specimen F-1 did meet them. However, the coolers should probably be judged on the basis of performance of specimen F-2 because the expansion valve adjustment was necessary to increase the capacity of the coolers. It should be noted that even with the expansion valve adjustment used on specimen F-2, it did not meet the requirements of the capacity test.

(8) Housing and Insulation (Paragraph D-9d modified)

Although inspection of the cooler construction was not requested by the Chicago Quartermaster Depot some deficiency was observed in the vapor sealing of the cooling unit housing while making the performance tests. It was noted that the vapor seal of the cooling unit housing of neither cooler specimen met the requirements of paragraph D-9d of the specification. This paragraph required that the entire cooling unit housing should be sealed against infiltration of moisture. The vapor seal on each of the two coolers covered about three-fourths of the cooling unit housing. Part of the storage tank was exposed to the ambient air and moisture collected on the tank surfaces when they were below the dew point of the ambient air.

V. CONCLUSIONS

The performance tests of the two cooler specimens indicated important deficiencies in both units. The observed capacity of specimen F-1 was only 76 percent of that required by the specification and this specimen melted the fusible plug in its receiver during the Maximum Operating test.

The capacity of specimen F-2 was 91 percent of that required by the specification and it failed to pass three other tests out of a total of seven performance tests. This specimen complied with the specification requirements of the Refrigeration Control test, the Freezing test, and the Motor Overload Protection test but failed on the following four requirements:

1. Capacity Test
2. Maximum Operating Test
3. Overload Test
4. Peak Draw Test

The discharge pressures observed during the Maximum Operating Test and the Overload Test indicated insufficient cooling was being provided by the air-cooled condenser within the machinery compartment. The performance of the specimens during the Capacity Test and the Peak Draw Test was probably affected adversely by the deficiency in the air-cooling circuit.

In view of the failure of the cooler specimens to meet several of the major specification requirements, it is recommended that the coolers not be purchased by the Government unless satisfactory design changes are made.

FIG. 1

FIG. 2

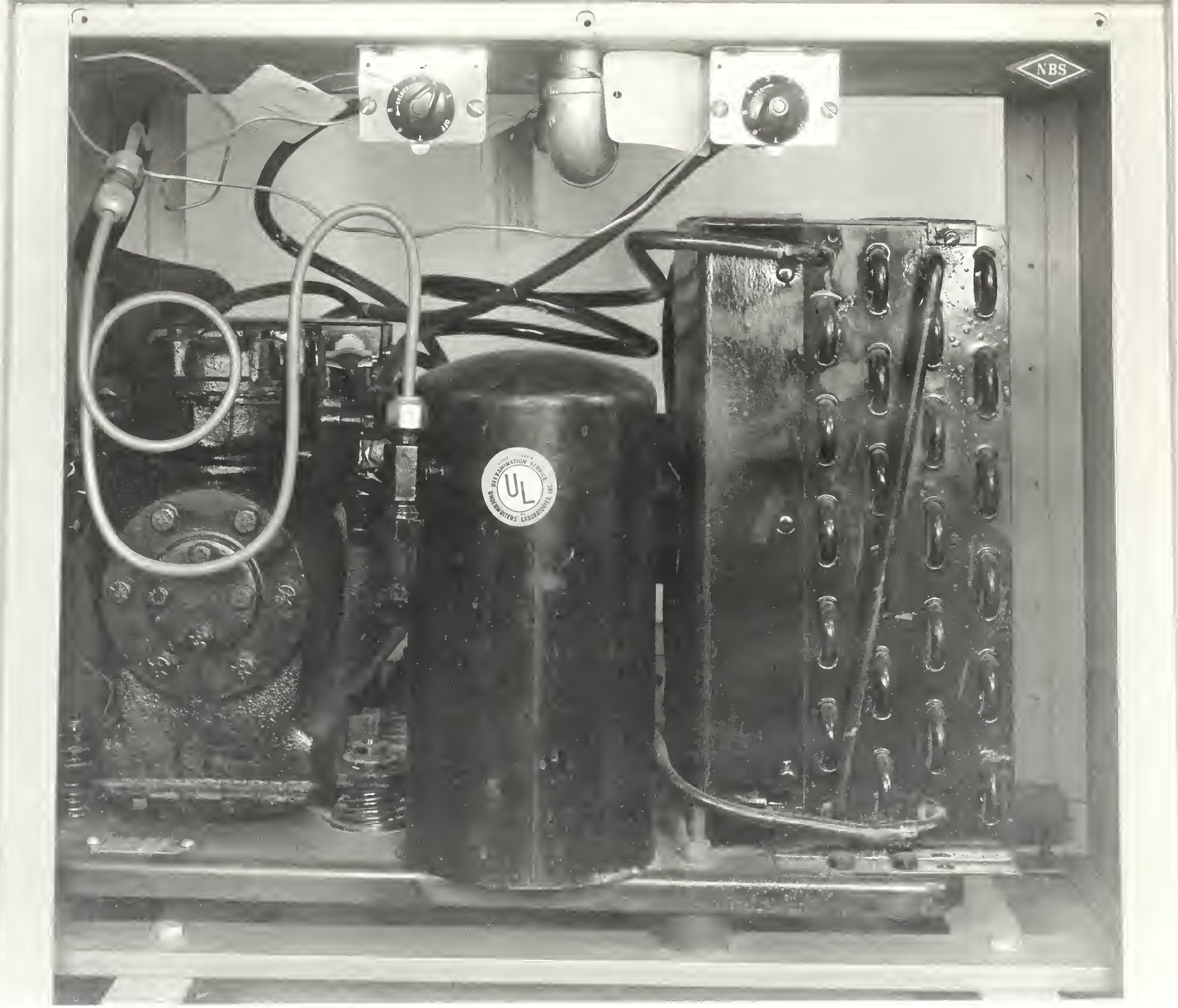
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FIG. 3

FIG. 4

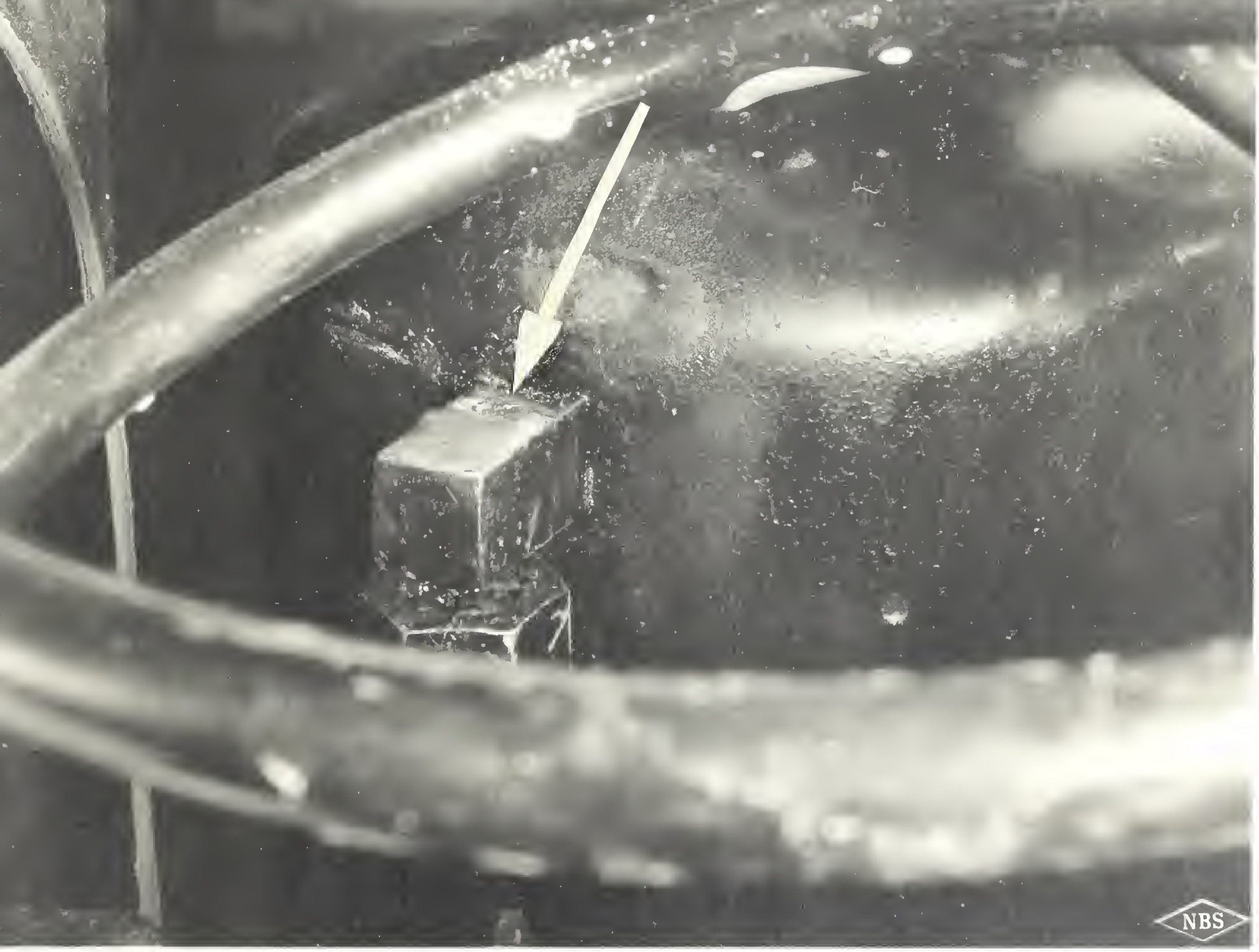

FIG. 5

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