NATIONAL BUREAU OF STANDARDS REPORT

2238

PERFORMANCE OF A YORK 3/4 HP WINDOW AIR CONDITIONING UNIT, MODEL 24-1

by

Henry Karger
Paul R. Achenbach

U. S. DEPARTMENT OF COMMERCE
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for

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Performance of a York 3/4 HP Window Air Conditioning Unit, Model 24-1

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Abstract

Performance tests were made of a 3/4 HP window air conditioning unit, Model 24-1, manufactured by York Corporation to determine compliance with Federal Specification 00-A-372, dated July 26, 1951, and Amendment 1 dated May 20, 1952. Performance was evaluated with respect to the paragraphs of the specification entitled capacity-rating test, overload test, condensation test, low refrigerant temperature test, minimum air quantity, and outside air quantity. The capacity tests, made in accordance with the requirements of Standard 16-R of the American Society of Refrigerating Engineers, showed that the capacity was 88.6 percent of the required value as received and 94.5 percent of the required value after sealing some air leaks and adding a running capacitor to the compressor motor. The running capacitor was required to permit satisfactory operation at 90 percent of rated voltage. All other specification requirements on performance were met.

I. INTRODUCTION

In accordance with a request from Headquarters, United States Marine Corps, dated September 4, 1952, tests of a 3/4 HP electric, self-contained, window-type air conditioning unit were made to determine compliance of this unit with the performance requirements of Federal Specification 00-A-372, dated July 26, 1951, modified in Amendment 1, dated May 20, 1952, as outlined in Contract NOm-63744, issued by the United States Marine Corps on June 30, 1952. The air conditioning unit was manufactured by York Corporation, York, Pennsylvania. The tests were made in accordance with the requirements of paragraph 4.3 of Federal Specification 00-A-372.

II. DESCRIPTION OF TEST SPECIMEN

Two air conditioning units were submitted for tests by the manufacturer. The first sample submitted was returned to the manufacturer because of three obvious deviations from the requirements of the specifications:

1. The condenser fan of the unit was bent out of shape.

2. The refrigerating system of the unit contained service valves. Such valves are not permitted on a hermetic refrigerating system, which was required by the contract.

3. The unit contained a capacity modulating device. The manufacturer stated that this device would not be furnished on units for delivery under the contract.

The second sample submitted for tests was identified as follows:

(NBS Test Specimen 90-52)
York Corporation, York, Pa.
Model 24-1
Serial A142729
3/4 Horsepower

All tests were made with this specimen. The unit was built for operation on alternating current, 115 volts, single phase, 60 cycle. It was designed for installation in a window, with the condenser section of the unit on the outside of the window and the evaporator section on the inside of the window in the space to be cooled. The unit was enclosed in a sheet steel housing, and a decorative housing made of steel and plastic surrounded this on the room side of the unit.

The electrical controls for operation of the air conditioning unit were located on the top of the evaporator section, under a small flap mounted flush in the decorative cover. A three-position control switch was used which could be placed in the "Fan", "Off", or "Cool" positions. If placed in the "Fan" position, only the single motor driving both condenser and evaporator fan would operate. If placed in the "Cool" position, the compressor as well as the fan motor would operate. The flap under which the electrical control switch was located, can be seen in Fig. 1.

A fresh-air damper was located at the bottom edge of the front of the evaporator section, as can be seen in Fig. 2 just below the filters. The damper was hinged at the bottom and could be opened by pulling outward and downward on the handle shown in Fig. 2. The discharge grill was made of plastic and was rotatable on horizontal pivots in the top of the front section of the decorative cover.

The condenser fan was of the propeller type and a water slinger was located in front of this fan to throw the condensate from the evaporator coil against the condenser for evaporation on the outside of the conditioned space. A capillary tube was used as the refrigerant flow control.

A view of the unit from the room side is shown in Fig. 1. Fig. 2 is the same view of the unit, with the top of the condenser section and the decorative cover of the evaporator section removed. A view of the condenser and part of the machine compartment is shown in Fig. 3. Fig. 4 is a top view of the unit, showing the location of the compressor, the fan motor, the fans, and the insulated partition separating the evaporator section from the condensing unit compartment.

The physical dimensions of the unit were as follows:

Length, inch	33 3/8
Width, inch	26 1/4
Height, inch	14 3/8
Weight, including sill adapter plate, lbs.	179

The unit was equipped with a York motor-compressor, Model 646D, Series B, rated at 3/4-horsepower, 10 amperes, and 115 volts. The fan motor was a Delco Model A-5153 motor rated at 1/9-horsepower, 2.8 amperes, and 115 volts.

III. TEST PROCEDURE

Circular No. 16-R, published by the American Society of Refrigerating Engineers, entitled "Methods of Rating and Testing Air Conditioners", was used as a general guide in selecting the procedure to be used in determining the capacity of the air conditioning unit. The ASRE circular states that the capacity rating of self-contained air conditioning units shall be the net total room cooling effect in British Thermal Units per hour. The following apparatus was used to determine this net room cooling capacity:

A protable, 150 cu. ft. warehouse normally used for the refrigerated storage of various materials was used as a calorimeter. The air conditioning unit was mounted in an opening in one wall of the warehouse in such a manner that the evaporator side of the unit was on the inside of this warehouse, and the condenser side was on the outside of the warehouse. The warehouse, with the unit in place, was calibrated to determine the heat transmission per degree temperature difference between the inside and outside, which constitutes part of the sensible heat load. Electric heaters were placed on the inside of this warehouse-calorimeter to provide the remainder of the sensible heat load for the air conditioning unit. A humidifier consisting of an electric heating element immersed in water was also placed inside the calorimeter to provide the necessary humidity. The calorimeter was made as airtight as was considered necessary, and provisions were made to measure the amount of air which was introduced into or exhausted from the warehouse-calorimeter by the air conditioning unit during operation. This was done by

removing air from or introducing air into the calorimeter through a pipe by means of a blower. The air quantities were measured by calibrated gas meters or a pitot tube placed inside of the pipe. The amount of air flowing through the pipe was regulated by a throttling valve so that the pressure difference between the inside and the outside of the calorimeter was zero ± 0.002 in. W.G. Calibrated watthour meters were used to measure all electric energy consumption. Temperatures were measured by means of calibrated thermocouples using an electronic, constant-balance type potentiometer. Humidity measurements were made utilizing calibrated lithium-chloride-coated elements in conjunction with a micro-ammeter. Humidity measurements observed with this electric hygrometer were checked regularly with a 24" mechanical psychrometer.

The results obtained with this testing method will be essentially the same as the results obtained by following the testing method outlined in ASRE Circular 16-R even though a less elaborate calorimeter was used. The most important difference is that the amount of heat rejected by the condenser of the air conditioning unit was not measured to compare with and check the total net cooling effect measured in the calorimeter because such additional apparatus has not been available at this Bureau. ASRE Circular 16-R requires that this heat balance should be obtained to check the accuracy of the capacity determination made on the room side of the air conditioning unit. However, a constant check of all instruments used during the test made here, such as comparing watthour meter readings with voltage and current readings taken simultaneously on the electric heaters used to provide the sensible and latent heat loads, checking of the electric hygrometer elements before and after each test with a precision mechanical psychrometer, and frequent checking of the potentiometer against an ice-bath reference, are believed to make the accuracy of the results obtained as good or better than the accuracy of the results obtained using the test method outlined in ASRE Circular 16-R.

In the test apparatus used by this Bureau, the condition of the air (i.e. dry bulb temperature and relative humidity) on the room side of the air conditioning unit were determined at the entrance to the evaporator itself because of the limited space in the calorimeter. Circular 16-R requires that the dry and wet bulb temperature (or relative humidity) of the room air be measured at a little distance away from the evaporator inlet, so that any short-circuiting of the conditioned air from the discharge to the inlet of the unit, which may be inherent in the construction of some air conditioners, would not result in a higher capacity rating than was justified. However, since there was practically no possibilityof short-circuiting between the outlet and inlet of the evaporator in the York unit under test, this difference in location of the measuring instruments is believed to have had no effort on the measured capacity of the unit.

Measurements of the quantities of air circulated were made by means of a pitot tube located inside a smooth, round duct. This duct was connected to the outlet of the evaporator or condenser fan by means of a plenum chamber and an exhaust blower was attached to the other end of the duct. The air flow through the duct was regulated by a throttling device so that the static pressure at the evaporator or condenser fan outlet was zero ± 0.002 in W.G. with respect to the pressure in the test room to determine the free-air delivery of the fans.

IV. TEST RESULTS

Tests were made of the air conditioning unit to determine compliance with the requirements of the following paragraphs of Federal Specification 00-A-372:

(A) Capacity Test (paragraph 4.3.1)
Performance Factor (paragraph 3.5.1.1)
Sensible Heat Ratio (paragraph 3.5.1)
(B) Overload Test (paragraph 4.3.2.1)
(C) Condensation Test (paragraph 4.3.2.2)
(D) Low-Refrigerant-Temperature Test (paragraph 4.3.2.4)
(E) Minimum Air Quantities (paragraph 3.9.1)
(F) Outside Air Quantity (paragraph 3.9.1.1)

The results of the above tests are discussed in the following paragraphs.

(A) Capacity Test

The results of the capacity tests are summarized in Table 1. Test number 1 was made with the unit as received from the manufacturer. After this test, a representative of the manufacturer sealed up some air leaks in the partition on the unit to cut down the undesired air exchange between condenser and evaporator compartments. Test number 2 was made after the sealing was done. At a later date, it became necessary to install a 17.5 mfd running capacitor in the electrical circuit of the unit in order to enable it to meet the requirements of the Overload Test of paragraph 4.3.2.1. This running capacitor was furnished by the manufacturer and was installed by Bureau personnel under direction of a representative of the manufacturer. The capacity test was then repeated and the results of this final run are tabulated under test number 3. As can be seen from Table 1, the unit did not meet the requirements of the contract for Total Net Cooling Capacity, the capacity being 437 BTU/hr less than the required 8000 BTU/hr in test number 3. The air conditioner did meet the requirements of Sensible Heat Ratio and Performance Factor, as is shown in Table 1 for test number 3.

TABLE 1

Capacity Tests of York Model 24-1 Window Air Conditioner, NBS Specimen 90-52

	Specification and Contract Requirement	Observed Performance		
Test Number		1	2	3
Ambient Air Conditions				
Dry Bulb Temp., °F	95.0	95.4	95.2	95.6
Wet Bulb Temp., °F	75.0	73.8	74.0	74.8
Relative Humidity, %	40.0	36.5	37.7	38.5
Dry Bulb Temp. at Condenser Outlet, °F	--	118.6	117.8	118.2
Air Conditions at Evaporator Inlet				
Dry Bulb Temp., °F	80.0	79.5	79.9	79.7
Wet Bulb Temp., °F	67.0	66.6	67.0	66.8
Relative Humidity, %	51.0	50.6	51.0	51.2
Air Conditions at Evaporator Outlet				
Dry Bulb Temp., °F	--	62.9	63.3	63.8
Wet Bulb Temp., °F	--	60.0	60.4	60.8
Compressor Power, watts	--	1062	1077	1011
Fan Motor Power, watts	--	172	170	169
Total Power, watts	--	1234	1247	1180
Total Net Cooling Capacity, BTU/hr	8000	7084	7566	7563
Latent Heat Load, BTU/hr	--	1250	1580	1716
Sensible Heat Load, BTU/hr	--	5834	5986	5847
Sensible Heat Ratio, %	70-80	82	79	77
Performance Factor, BTU/hr per watt	5.5 (minimum)	5.7	6.1	6.4
Terminal Voltage	115	115	115	115

(B) Overload Test

The specification requires that tests be made of the air conditioning unit at 90 percent, 100 percent, and 110 percent of rated voltage by operating the unit continuously for four hours at the following conditions:

Temperature of ambient air
115°F dry bulb, 80°F wet bulb

Temperature of air entering evaporator
95°F dry bulb, 75°F wet bulb

After the 4-hour test periods, the current shall be turned off for 10 seconds and then reapplied, and the unit shall resume normal operation within 5 minutes. In addition, during the tests the unit shall operate without interruption caused by tripping of the motor-overload devices. The average conditions maintained during the three tests are summarized in Table 2.

TABLE 2

Overload Tests of York Model 24-1 Window Air Conditioner, NBS Specimen 90-52

Test Number	1	2	3
Ambient Air Conditions			
Dry Bulb Temp., °F	115.7	115.5	115.6
Wet Bulb Temp., °F	80.0	80.1	80.0
Air Conditions at Evaporator Inlet			
Dry Bulb Temp., °F	94.5	95.0	94.9
Wet Bulb Temp., °F	74.4	74.6	74.6
Terminal Voltage	103.5	115.8	126.2
Percent of rated Voltage	90.0	100.7	109.7
Power Consumption, watts	1453	1390	1405
Current, amperes	17.0	15.3	15.4

As submitted, the unit would not operate satisfactorily at 90 percent of rated voltage. A running capacitor was then installed on the unit, after which no further operational troubles were encountered. No tripping of the overload mechanism occurred during the tests, and the unit started satisfactorily after each of the 10-second interruptions of electric current.

(C) Condensation Test

As required by the specification, the unit was operated for six hours under the following conditions:

Temperature of ambient air
80°F dry bulb, 70°F wet bulb

Temperature of air entering evaporator
80°F dry bulb, 75°F wet bulb

All condensate collected on the evaporator coil was diffused by the unit in a satisfactory manner, and the condensate receiver did not overflow at any time during the test. The average conditions maintained during the test were summarized in Table 3.

TABLE 3

Condensation Test of York Model 24-1 Window Air Conditioner, NBS Specimen 90-52

Ambient Air Conditions	
Dry Bulb Temp., °F	79.9
Wet Bulb Temp., °F	75.3
Air Conditions at Evaporator Inlet	
Dry Bulb Temp., °F	80.6
Wet Bulb Temp., °F	76.1

(D) Low-Refrigerant-Temperature Test

Federal Specification 00-A-372 requires that a unit equipped with a capillary tube to control refrigerant flow should be operated under conditions of ambient air and air entering the evaporator of 75°F dry bulb, 63°F wet bulb to determine whether or not any evidence of ice formation is shown on the evaporator coil of the unit. In addition, a superheat of at least 5°F must be evident in the lowside refrigerant circuit. The unit was operated in accordance with this requirement under the above conditions. No evidence of ice formation was observed, and the superheat observed was 36.9°F. The average conditions maintained during the test are shown in Table 4.

TABLE 4

Low-Refrigerant-Temperature test of York Model 24-1 Window Air Conditioner, NBS Specimen 90-52

Ambient Air Conditions	
Dry Bulb Temp., °F	75.4
Wet Bulb Temp., °F	62.8
Air Conditions at Evaporator Inlet	
Dry Bulb Temp., °F	76.5
West Bulb Temp., °F	64.2
Superheat, °F	36.9

(E) Minimum Air Quantities

The air quantities circulated by the evaporator and condenser fans were determined on this unit. Paragraph 3.9.1 of the specification requires a minimum air circulating capacity for each fan of 30 cfm per 1000 BTU/hr required cooling capacity, or, for this unit, a minimum of 240 cfm. As can be seen from Table 5, below, the air conditioning unit met these requirements adequately.

TABLE 5

Air Circulating Capacities of York Model 24-1 Window Unit, NBS Specimen 90-52

	Specification Requirement cfm	Air Capacity cfm	Temp. of Air °F DB	WB
Evaporator Fan	240 (minimum)	320	79	62
Condenser Fan	240 (minimum)	450	81	62
Ventilating Air	40 (minimum)	110	99	76

(F) Outside Air Quantity

The amount of outside ventilating air introduced by the unit into the conditioned space through the fresh air damper was measured and found to be in compliance with the requirements of paragraph 3.9.1.1 of the specification. The results are summarized in Table 5, above. In addition, the amount of unwanted ventilating air which leaked through the air conditioner operating with the damper closed but not sealed was measured during the capacity tests. This amounted to 10.5 cfm during the first capacity test. After the unit was sealed, however, as described in the section on capacity tests, there was no measurable leakage of air through the unit.

V. SUMMARY AND CONCLUSIONS

As received, the York air conditioning unit tested had a capacity of 88.6 percent of the specified value and would not operate satisfactorily at 90 percent of rated voltage as required by Federal Specification 00-A-372. After the installation of a running capacitor and sealing of some air leaks in the partition between the evaporator and condenser sections, the unit operated satisfactorily at 90 percent of rated voltage and the total net cooling capacity was observed to be 94.5 percent of the required capacity. It is believed that the errors in the measurements made during the capacity test did not exceed 2 percent.

The air conditioner specimen met all other requirements of section 4.3 entitled Acceptance Test and Inspection of the Federal Specification on Air Conditioning Units 00-A-372 and Amendment 1.

FIG. 1

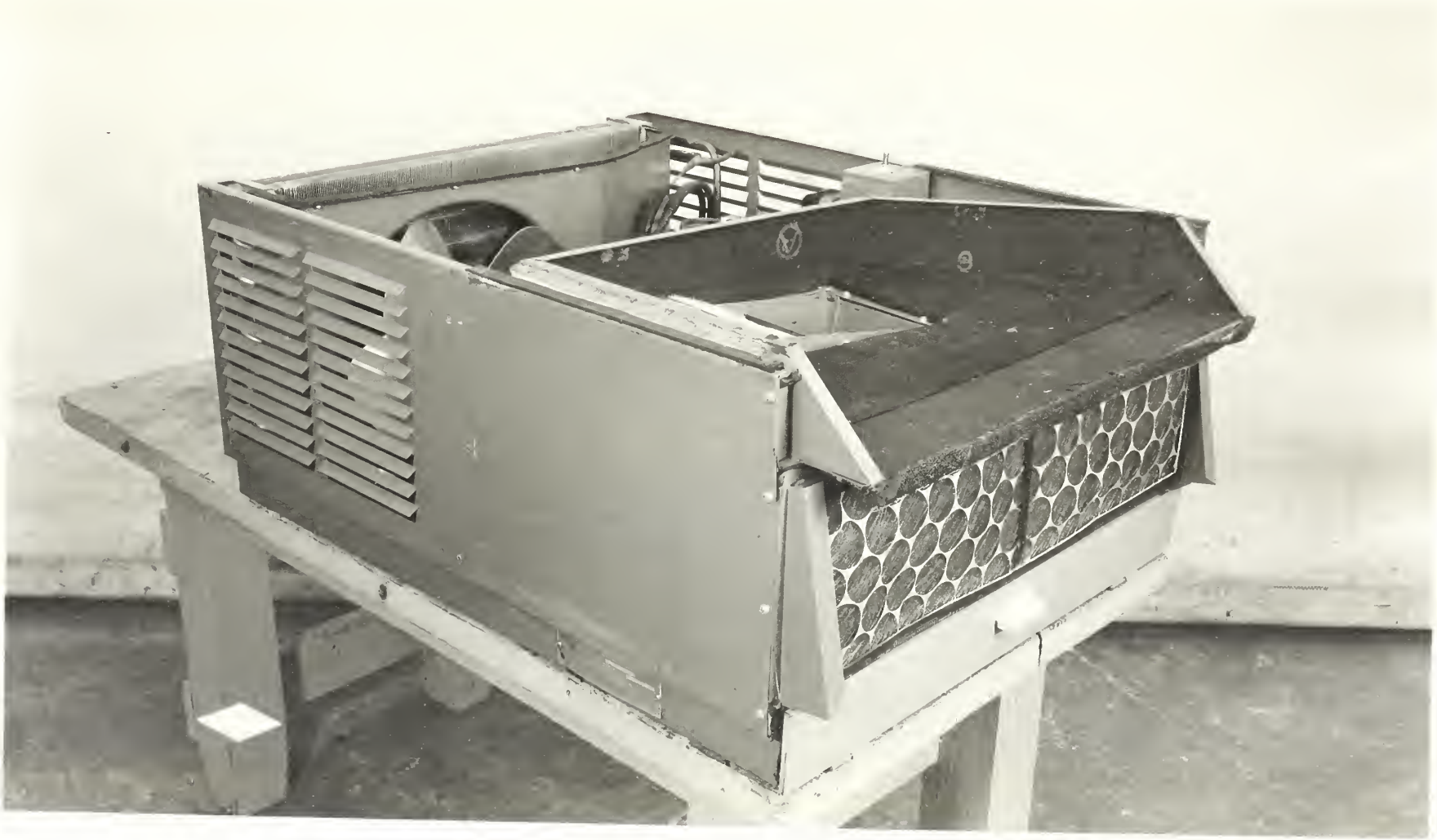

FIG. 2

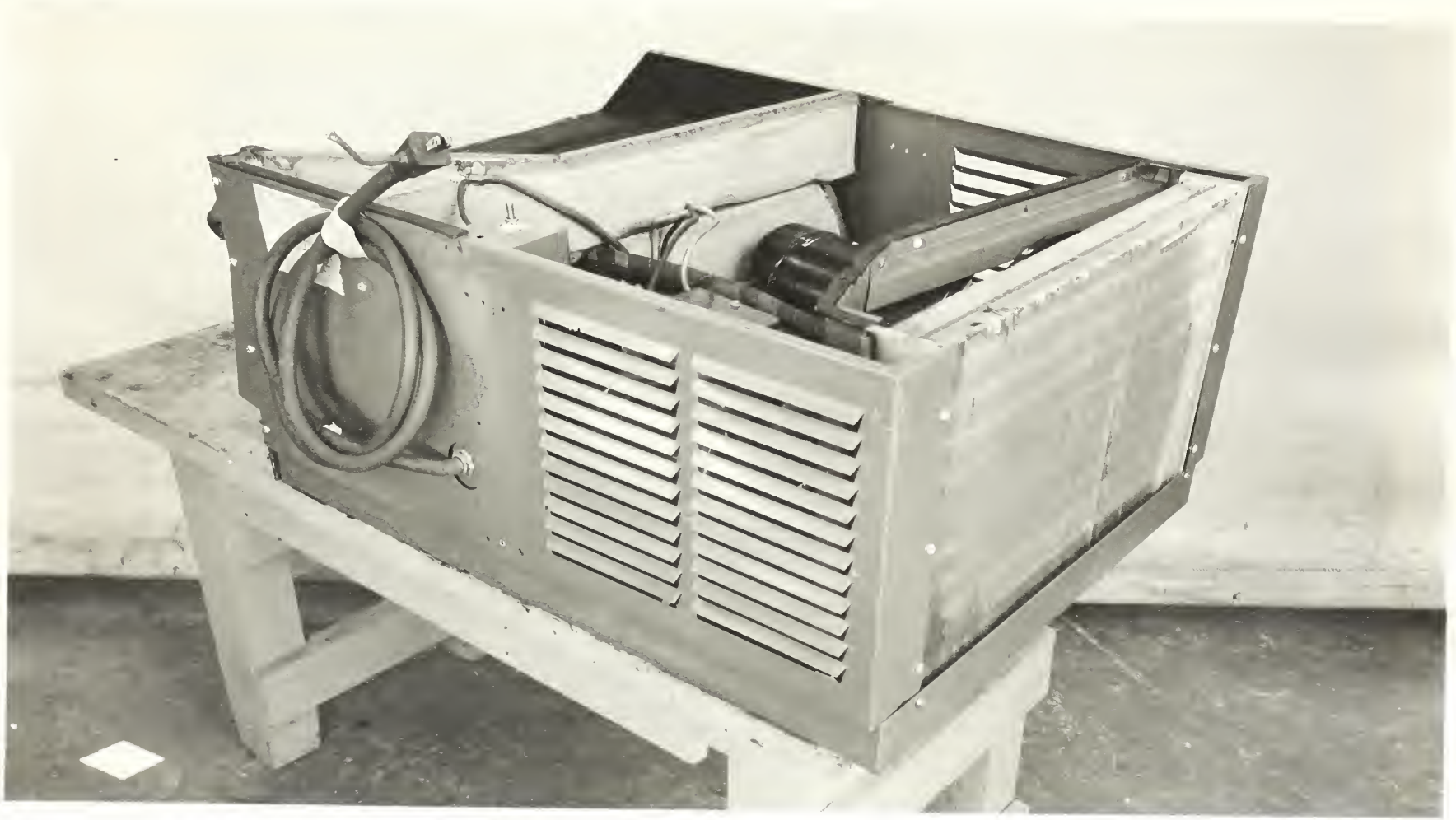

FIG. 3

FIG. 4

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