NATIONAL BUREAU OF STANDARDS REPORT

5336

CAPACITY OF A FEDDERS WINDOW-TYPE AIR CONDITIONER
MODEL 611-DG-53

by

C. W. Phillips
W. F. Goddard, Jr.

Report to
Quality Control Division
Public Building Service
General Services Administration

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

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U. S. DEPARTMENT OF COMMERCE
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CAPACITY OF A FEDDERS WINDOW-TYPE AIR CONDITIONER MODEL 611-DG-53

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C. W. Phillips and W. F. Goddard, Jr.

Abstract

A Fedders window-type room air conditioning unit, Model No. 611-DG-53, Serial No. 245-034 was tested to determine if the net total cooling effect or capacity, under standard specified conditions, exceeded a purchase contract requirement of 7500 Btu per hour. The unit had an observed capacity of 7850 Btu per hour, about five percent greater than required. Other performance characteristics relating to capacity, such as the ratio of the sensible cooling effect to net total cooling effect, cooling effect to power input ratio, and power factor were determined, but no determination of compliance with other requirements of the Federal Specification 00-A-372, referenced in the procurement contract, or requirements in the procurement contract itself, was made.

The capacity test reported required the construction and calibration of a special insulated calorimeter in which the air conditioner could be tested. This was constructed using the ASRE Standard No. 16-56, "Methods of Rating and Testing Air Conditioners" as a general guide, but it did not conform to all details of the standard.

INTRODUCTION

In accordance with Request No. 57-62 from the General Services Administration dated February 13, 1957, a test was made to determine whether the net room cooling effect of a Fedders room air conditioner, Model No. 611-DG-53, manufactured by the Fedders-Quigan Corporation, Maspeth, Long Island, N. Y., exceeded a bid requirement of 7500 Btu per hour minimum under specified conditions. This report presents the results

obtained when the sample air conditioner, Serial No. 245-034, was tested under standard rating conditions of 95F dry bulb, 75F wet bulb for the condenser (or outdoor) side and 80F dry bulb, 67F wet bulb for the evaporator (or indoor) side. The test procedure and apparatus was patterned after, but was not in exact conformance with the American Society of Refrigerating Engineers Standard No. 16-56 entitled "Methods of Rating and Testing Air Conditioners". The contract on which this conditioner was purchased required that the units furnished conform to Federal Specification 00-A-372, entitled "Self-Contained, Electric Motor Driven, Air-Conditioning Units" and Amendment No. 1.

DESCRIPTION OF THE TEST SPECIMEN

The air conditioning unit was identified as follows; Fedders-Quigan Corporation, Model 611-DG-53, Serial No. 245-034. It was assigned NBS No. 129-57. This particular model was known as "Fedders Weather Bureau Deluxe". Figures 1 and 2 show the assembled unit from front and rear, respectively. In Figure 1, the discharge air opening is the circular one on the left and the return air opening is on the right. The circular discharge grille could be rotated to direct air in any desired direction. Figure 3 shows the machine section withdrawn from the cabinet housing. The unit was designed for operation on alternating current 208 volts, single phase, 60 cycle. It was designed for installation in a window or similar wall opening, with the condenser section on the outside of such opening and the evaporator section on the inside in the space to be cooled. The electrical controls for operation of the air conditioning unit were mounted as push-buttons under the room air intake or return opening. They were labeled "Exhaust, Cooling, Ventilate, and Off".

The unit was equipped with a single motor driving both evaporator and condenser fans, rated at 1/20 horsepower. The evaporator fan was of the centrifugal type, whereas the condenser fan was of the propeller type.

The air conditioner was equipped with a hermetic motor-compressor with the symbol "1 HP" painted on the case, indicating that it was a nominal one-housepower unit. According to a name plate on the unit, the unit was charged with $CHClF_2$, the compressor was one horsepower, and the current requirement for cooling at 208 volts was 8.8 amperes, with 85 percent power factor. A heavy-duty cord with polarized plug was attached to the unit for connection to a suitable electrical receptacle.

TEST APPARATUS AND PROCEDURE

ASRE Standard No. 16-56, published by the American Society of Refrigerating Engineers, entitled "Methods of Rating and Testing Air Conditioners", was used as a guide in setting up the apparatus and procedure used in determining the capacity of the air conditioning unit. The net total room cooling effect of an air conditioner, as defined by the ASRE Standard, is the total useful capacity of the unit for removing heat from the space to be cooled, expressed in Btu per hour. Federal Specification 00-A-372, entitled "Air Conditioning Units (Room and Space Coolers) Electric, Motor-Driven, Self-Contained", referenced in the purchase specification, required a sensible to net total capacity ratio of from 70 to 80 percent. The apparatus was set up to provide this information.

An insulated calorimeter was constructed in a temperature-controlled test room, and the air conditioner was mounted in one wall of the calorimeter. Figures 4 and 5 show the calorimeter with the access door removed and in place, respectively. In Figure 4, which is a view through the calorimeter access door, the evaporator side of the air conditioner can be seen as placed for test.

Also in Figure 4, on the right, the duct which contains the heaters and a fan can be seen. The fan at the lower left was used to obtain satisfactory temperature distribution in the calorimeter. Figure 5 shows the access door of the calorimeter in place and shows some of the apparatus for sensing and controlling humidity and temperature of the test room in which the calorimeter was installed at the right side of the photograph. The exterior and interior surfaces of the calorimeter were covered with aluminum foil. All joints were taped or otherwise sealed to minimize transfer of water vapor. Figure 6 shows the evaporator side of the air conditioner as installed for test. The humidity sensing element for the discharge air can be seen on the left, and part of the grid arrangement of five thermocouples can be seen on the face of the return grille. The tube at the right contains the thermocouples and humidity sensing elements used to determine the air conditions of the calorimeter. Air was drawn through this tube by a small blower not shown in the Figure. The perforated plastic ball at the center right of Figure 6 is attached to one leg of a micromanometer used to determine the pressure difference between the calorimeter and the test room, and a

similar ball, attached to the other leg of the manometer, was positioned in the test room. Figure 6 also shows the control panel arrangement of the air conditioner.

The calorimeter was calibrated for heat transfer, first with a glass window in the opening for the air conditioner and then with the air conditioner in place. This calibration was used as a basis for computing the part of the sensible heat load of the air conditioner that was contributed by heat leakage through the calorimeter walls, floor and ceiling. Electric heaters were mounted in a vertical metal duct with a fan at the top to provide the remainder of the sensible heat load of the unit. A humidifier consisting of an electric heating element immersed in water was also placed inside the calorimeter to provide the necessary humidity. Make up water for the humidifier was supplied from a vessel mounted on a scale outside of the test room.

The calorimeter was constructed to be reasonably air-tight and provisions were made to assure equalization of pressure between the inside and outside by removing air from or introducing air into the calorimeter. This was done by means of a small blower whose air delivery was regulated so the pressure difference between the calorimeter and the test room was zero plus or minus 0.002 inch water guage. Calibrated watt hour meters were used to measure electric energy consumption. Temperatures were measured by means of calibrated thermocouples and an electronic constant-balance type of potentiometer. Calibrated lithium chloride-coated sensing elements and an electric hygrometer were used to measure humidity of the calorimeter and test room. These humidity measurements were checked with a 24-inch motorized psychrometer.

The calorimeter was calibrated by heating the interior to approximately 95F while holding the test room at about 75F and measuring the electric power required to hold this temperature difference. Tests of calorimeter heat leakage were made with the air conditioner in position and with a window in place of the air conditioner to compare the heat leakage of the air conditioner and the window. The capacity test of the air conditioner was continued for more than four hours at steady state conditions.

TEST RESULTS

The desired test conditions and the actual conditions observed during the steady-state test of more than four hours are given in Table 1. The air conditioner was tested with

TABLE 1

Capacity Test of Fedders Window Air Conditioner
Model 611-DG-53, Serial No. 245-034

Desired Test Conditions:	
Air Conditions on Condenser Side	
Dry Bulb Temp., °F	95
Wet Bulb Temp., °F	75
Relative Humidity, %	40
Air Conditions on Evaporator Side	
Dry Bulb Temp., °F	80
Wet Bulb Temp., °F	67
Relative Humidity, %	251
Voltage at Compressor Terminals	208
Observed Test Conditions:	
Air Conditions on Condenser Side	
Dry Bulb Temp., °F	95.3
Wet Bulb Temp., °F	75.2
Relative Humidity, %	39.7
Dry Bulb Temperature at Condenser Air Outlet, °F	121.9
Air Conditions on Evaporator Side	
Dry Bulb Temp., °F	80.1
Wet Bulb Temp., °F	67.2
Relative Humidity, %	51.3
Dry Bulb Temperature at Evaporator Air Inlet	73.9
Air Conditions at Evaporator Outlet	
Dry Bulb Temp., °F	56.2
Wet Bulb Temp., °F	54.0
Dew Point, °F	53.0
Air Conditioner Power Consumption, Watts	1482
Air Conditioner Current, amperes	8.1
Voltage at Compressor Terminals	209
Power Factor, %	87.6
Sensible Cooling Capacity, Btu per hour	5620

TABLE 1 (continued)

Observed Test Conditions:

Latent Cooling Capacity, Btu per hour	2230
Total Net Cooling Capacity, Btu per hour	7850
Sensible Heat Ratio, %	71.6
Cooling Capacity - power ratio, Btu per watt hour	5.3
Length of Steady-State Test, hours	4.57

the ventilating damper(s) closed but not sealed and some air had to be added to the calorimeter during the test to maintain the pressure in the calorimeter within 0.002 inch W.G. of the test room pressure. The amount of air added was not measured, and, therefore, no measure was made of the reduction of total net cooling capacity due to this ventilating air load.

The total net cooling capacity of the air conditioner was 7850 Btu per hour; the sensible cooling capacity was 5620 Btu per hour; the latent cooling capacity was 2230 Btu per hour. The sensible heat ratio was 71.6 percent and the cooling capacity-power ratio was 5.3 Btu per watt hour. The average power consumption of the unit during the test was 1482 watts at 209 volts. The current drawn was 8.1 amperes, and the power factor was 87.6 percent.

The temperature and humidity conditions during the test averaged 80.1F dry bulb, 67.2F wet bulb, 51.3 percent relative humidity inside the calorimeter and 95.3F dry bulb, 75.2F wet bulb, 39.7 percent relative humidity in the surrounding test room.

The temperature of the air entering the evaporator, measured at the grille face, averaged 73.9F, and the temperature of the air leaving the condenser averaged 121.9F.

The heat transfer rates of the calorimeter walls, floor and ceiling, determined by calibration first with the air conditioner in position and then with a window in place of the air conditioner were, respectively, 17.5 Btu per hour (^{o}F) and 17.8 Btu per hour (^{o}F).

No tests were made to determine any performance characteristics other than those described and relating to cooling capacity.

CONCLUSIONS AND DISCUSSION

The Fedders air conditioner tested had a total net cooling capacity in excess of 7500 Btu per hour, the minimum capacity requirement of the contract under which a number of air conditioners similar to the test specimen were procured. The observed capacity of 7850 Btu per hour exceeds this requirement by about 4.5 percent. Federal Specification 00-A-372, referenced in the contract, contains many requirements for these Type I air conditioners, but conformance with

requirements other than those relating to capacity was not determined as a part of these tests. The measured sensible cooling capacity ratio of 71.6 percent was within the range of 70 to 80 percent permitted by the specification and the computed power factor of 87.6 percent was satisfactory. The measured cooling capacity to power input ratio of 5.3 Btu per watt hour, however, fell short of the Federal Specification requirement for Type I units of 5.5 Btu per watt hour minimum.

Two factors may have been instrumental in holding the measured capacity to 7850 Btu per hour. First, some ventilation occurred when the ventilating dampers were closed requiring the introduction of test room air into the calorimeter to hold balanced pressures inside and outside of the calorimeter. Since this air flow was not measured, no figure can be given for the size of the penalty imposed. If, for example, 15 cubic feet per minute of unwanted ventilation occurred, at the test conditions, this would reduce the total net cooling capacity by approximately 450 Btu per hour. Secondly, apparent short-circuiting of some of the cold discharge air back into the return grille, causing the average inlet evaporator air at the face of the grille to be about 74F whereas the calorimeter air temperature, measured a short distance from the front of the grille was about 80F. If it is assumed that this difference of 6 degrees was directly reflected in a corresponding change in the compressor suction pressure, eliminating the short-circuiting of the cold air could have raised the cooling capacity a maximum of about ten percent. The use of a calorimeter somewhat smaller than the apparatus recommended in ASRE Standard 16-56 may have contributed to the short-circuiting but this is considered unlikely.

The small difference observed in the heat transfer rate of the calorimeter with the air conditioner in position as compared to that with a window in place of the air conditioner was interesting. The difference, 0.3 Btu per hour (°F), was probably smaller than the deviations that would have been observed in repetitive tests, but showed that, if the difference was real, the air conditioner did not cause greater heat leakage than the glass it replaced.

The total net cooling effect was determined by the following equation:

$$Q_{tr} = 3.41\xi E_r + Q_{lc} + (h_{w1} - h_{w2})w_r$$

where:
Q_{tr} = total net cooling effect, Btu per hour

ΣE_r = total power to calorimeter, watts

Q_{lc} = heat leakage of calorimeter, Btu per hour

h_{w1} = enthalpy of water supplied to the calorimeter to maintain humidity Btu per lb.

h_{w2} = enthalpy of condensed water leaving the calorimeter, assumed to be at 54F, Btu per lb

W_r = water evaporated in humidifier, lb per hour

The sensible cooling effect was computed using the following equation:

$$Q_{sc} = Q_{tr} - 1060\ W_r$$

where:
Q_{sc} = sensible cooling effect, Btu per hour

Q_{tr} = total net cooling effect. Btu per hour

1060 = latent heat of evaporation of water (from ASRE 16-56)

W_r = water evaporated in humidifier, lb per hour

Although many manufacturers advertise that "nominal 3/4 horsepower" air conditioners have a capacity of 7500 Btu per hour or more at the standard conditions of this procurement, the unit submitted for these tests contained a compressor marked "one horsepower" by the manufacturer.

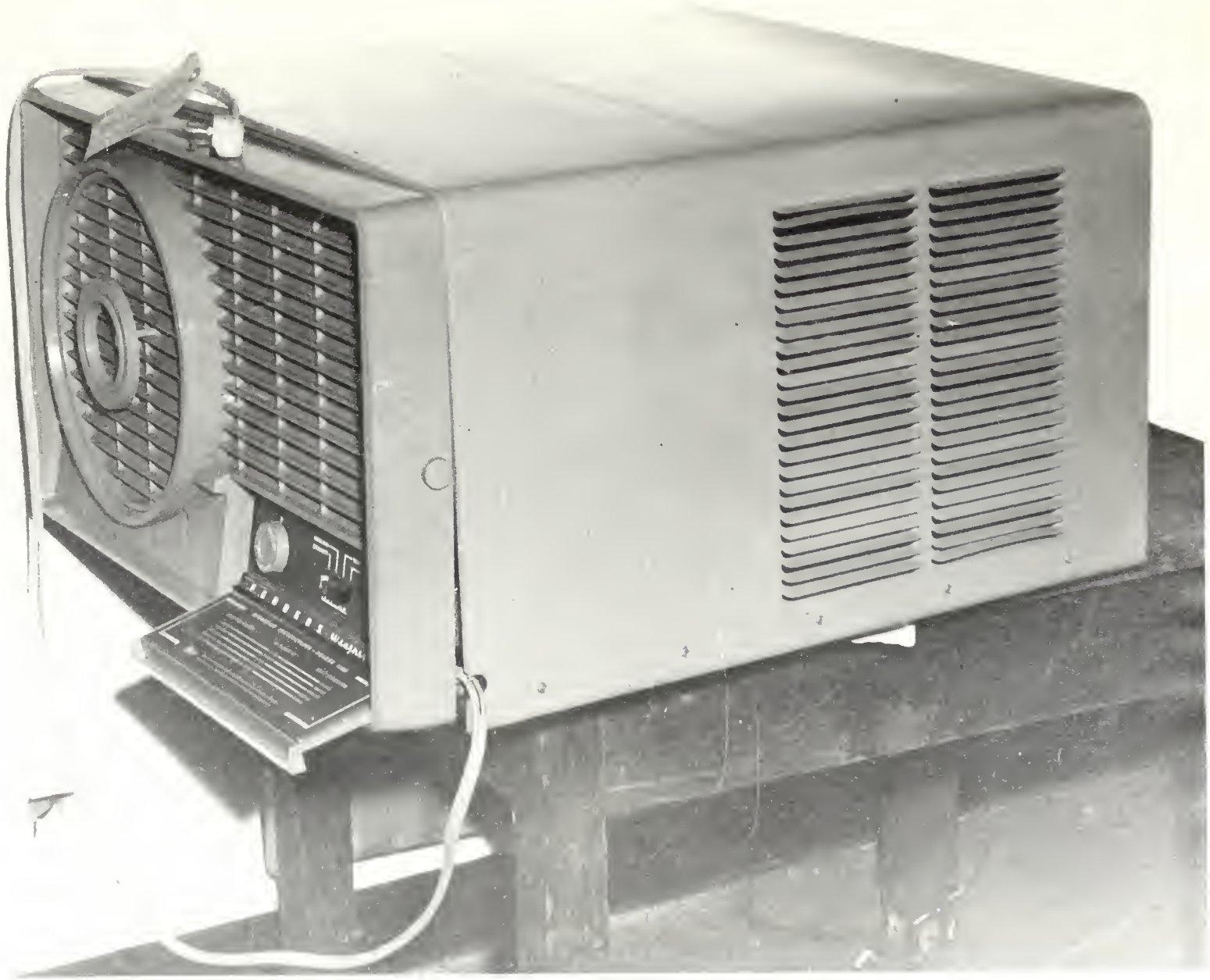


Figure 6

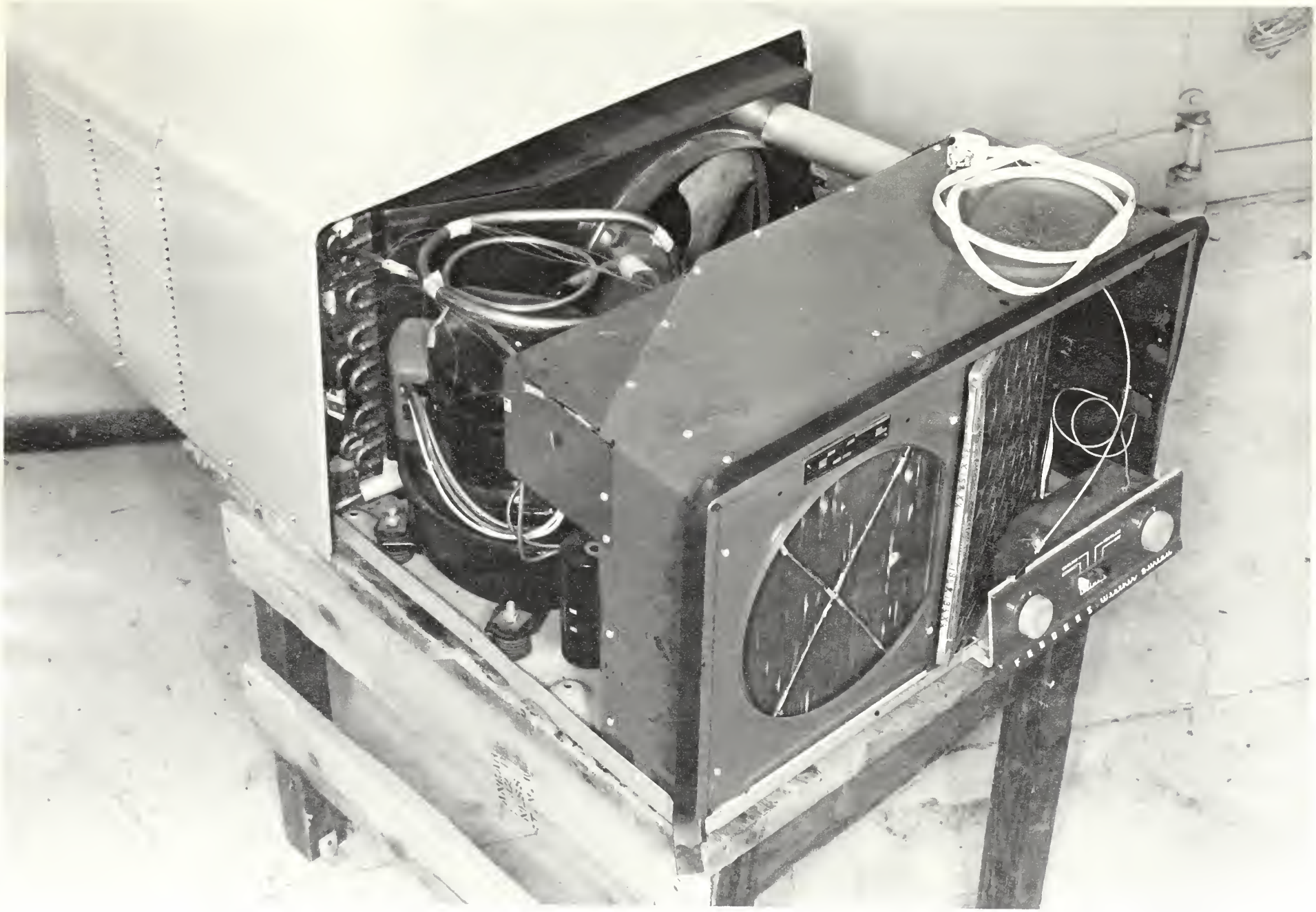
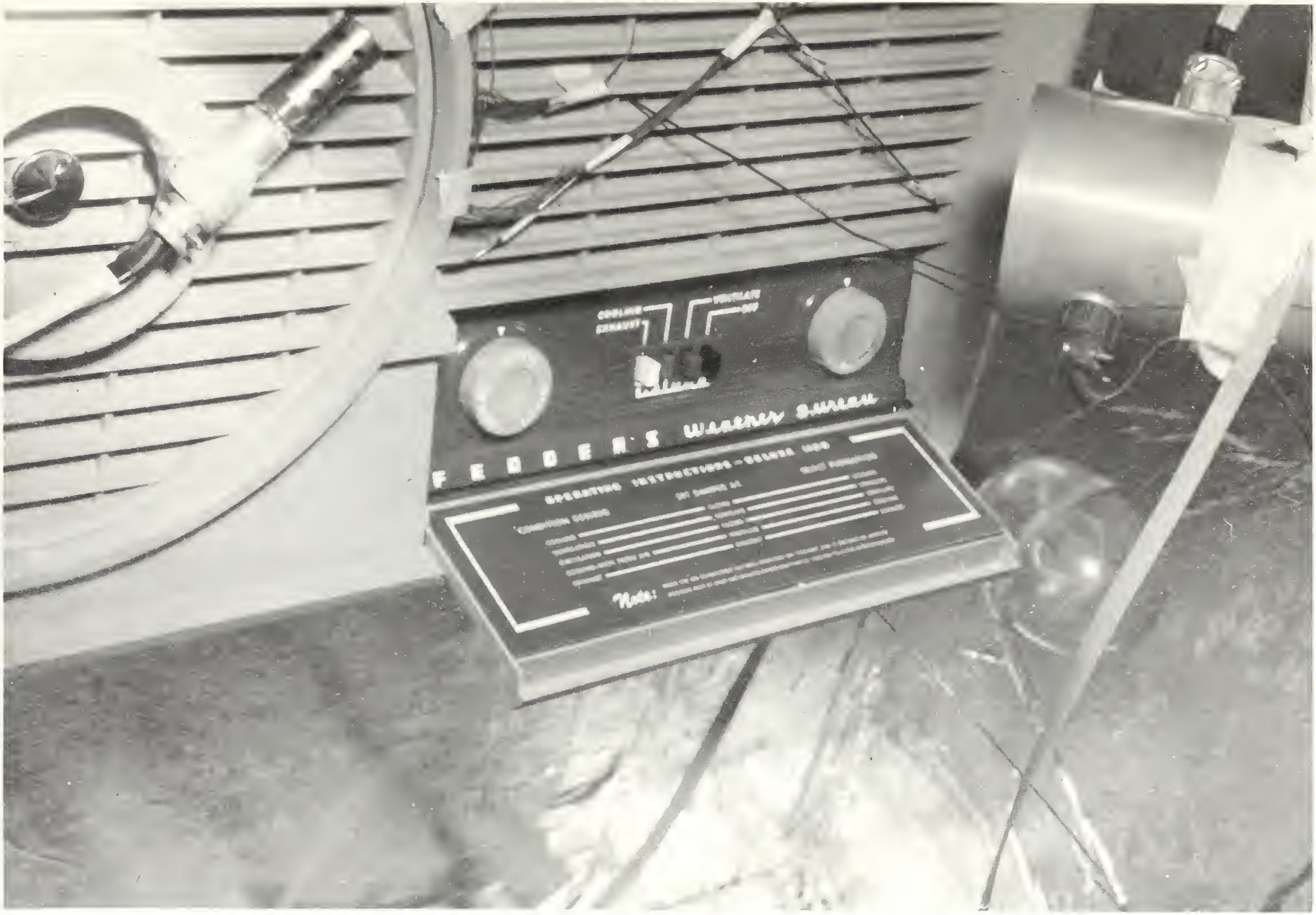


Figure 3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