NATIONAL BUREAU OF STANDARDS REPORT

5331

THE EFFECT OF A WEATHER-BAN SUN SHIELD
ON THE PERFORMANCE OF A WINDOW AIR CONDITIONER

by

C. W. Phillips
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Report to
Buildings Management Division
Public Buildings Service
General Services Administration
Washington 25, D. C.

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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Abstract

A device for partially shielding a window air conditioning unit from direct rays of the sun, known as "Weather-Ban", was tested to determine its effect on the performance of a 3/4 horsepower Fedders window air conditioner. The tests showed that the shield did not produce measurable effects on the capacity of the unit, the inlet and outlet air temperatures of the evaporator and condenser, nor in the suction and discharge pressures of the compressor, but it did reduce the surface temperature of the top of the condenser housing about 19 deg F. Analysis indicates that a sun shield would be of greater benefit on an air conditioner with an exposed condenser coil than on the Fedders unit which provided a housing over the entire condenser section. However, computations of the probable solar heat transfer at the time of day and for the direction of orientation that caused the greatest absorption of solar energy on an unhoused condenser, indicate that the capacity of a window air conditioner would probably be increased on the order of one percent by a shield like the specimen tested.

I. INTRODUCTION

At the request of the General Services Administration in a letter dated July 19, 1956, tests were made of a "Weather-Ban" protective shield for window-type air conditioners manufactured by Weather-Ban Products, Inc. The purpose of these tests was to determine whether or not this shield increased the cooling capacity of a window-type air conditioning unit by shading the unit from the sun's rays thus reducing the entry of solar heat into the condenser section of the unit.

II. TEST SPECIMEN AND TEST APPARATUS

The Weather-Ban shield was constructed of 0.05-in. thick aluminum, which was coated with a white enamel paint. It was 28" long, 22 1/4" wide, and 10" deep at the back. Fig. 1 shows the shield in place on the air conditioner used for the tests. The top surface of the shield was lined with a 2"x18"x28" piece of glass fiber insulation. A five inch lip was formed on the front part of the top. This shield was installed on the condenser portion of the air conditioning unit according to the manufacturer's directions.

The air conditioning unit used was a Fedders model NW7A5 which was supplied for the test by the General Services Administration. It was an open-type unit and had the following motor characteristics:

Evaporator fan motor	1/150 H.P.	0.3 Amps.	208 Volts
Condenser fan motor	1/25 H.P.	0.9 Amps.	208 Volts
Compressor motor	3/4 H.P.	6.6 Amps.	208 Volts

It should be noted that the air conditioning unit used had certain features which directly affected the extent to which some of the observations could be considered conclusive. This unit was equipped with a thermostatic expansion valve to control the flow of liquid refrigerant to the evaporator. This valve caused a modulating suction pressure at the compressor which would make it difficult to observe small variations in the suction pressure resulting from the presence or absence of the Weather-Ban shield. A capillary tube feed such as is common with many units, might have permitted more precise data on the possible effectiveness of the shield.

Also, the unit furnished for the tests was of such a design that the condenser coil itself was protected to a degree from direct sun rays by the louvred construction of the 0.053 inch steel condenser housing, as contrasted with the type of construction in which the condenser tubes and fins are directly exposed.

For the first of two major tests, indicating pressure gauges were installed to measure discharge and suction pressures of the air conditioning unit. For the second test recording pressure gauges were installed.

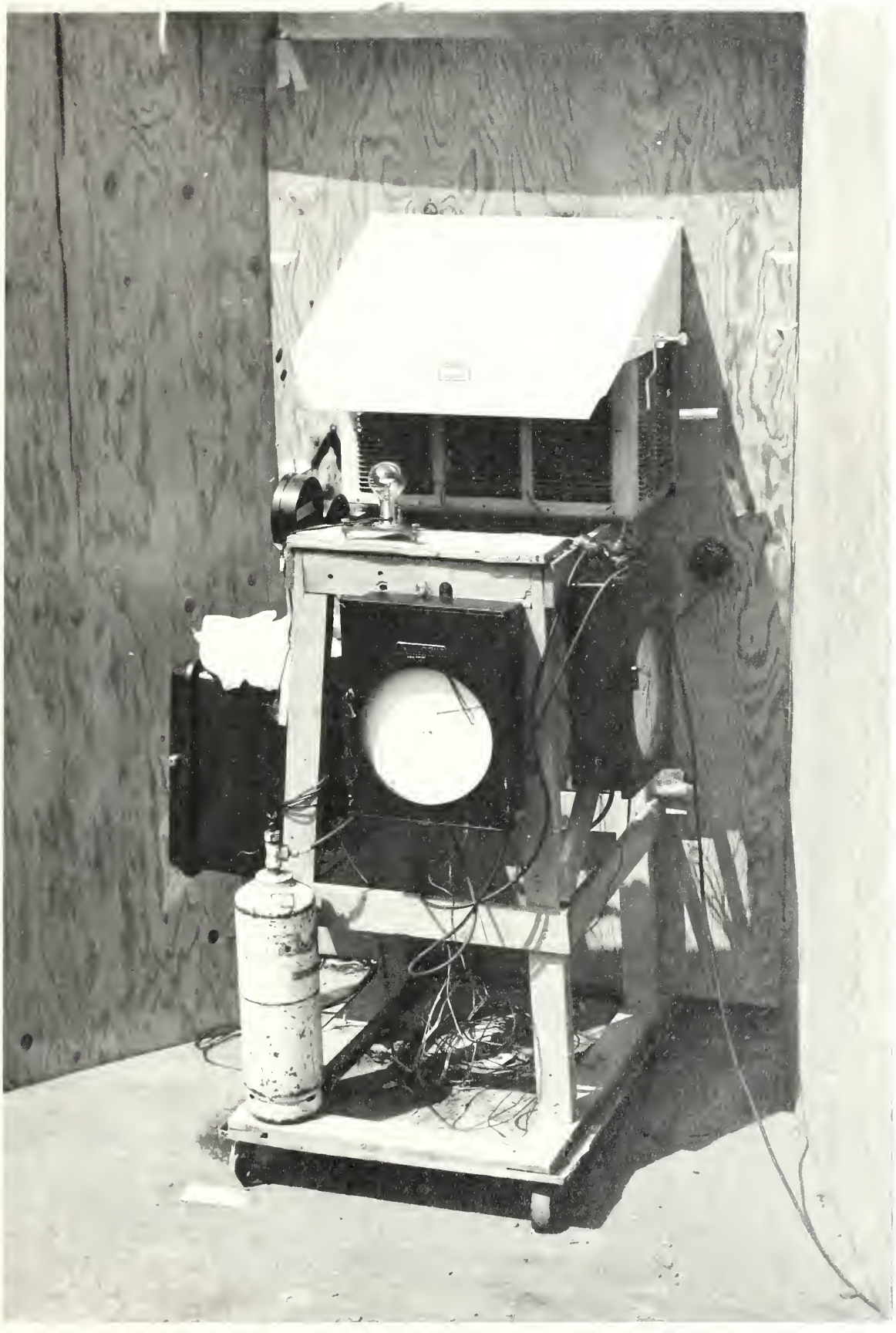


Figure 1

Thermocouples were installed at the following points to measure temperature:

1. Condenser air outlet
2. Condenser housing surface
3. Condenser air inlet
4. Evaporator air inlet
5. Evaporator air outlet

Ambient temperature was considered to be the same as the condenser air inlet temperature. For the first test, temperatures were measured with a hand potentiometer, and for the second, with a recording electronic potentiometer. For the second test a pyrheliometer was used to measure the solar radiation on a horizontal surface.

Fig. 1 shows the enclosure and the general setup for the second test. The pyrheliometer can be seen directly in front of the louvred grille of the condenser section of the air conditioning unit. Other instruments shown are the two indicating pressure gauges and the temperature recorder on the left and the two pressure recorders on the front and right.

Fig. 2 shows the evaporator side of the test setup. The small fan on the lower left corner of the enclosure over the evaporator portion of the air conditioning unit was used to create a constant evaporator load. The potentiometer used to check the recorder values for temperature and pyrheliometer output is located below the evaporator enclosure.

III. TEST PROCEDURE AND TEST RESULTS

Two major tests were made on the Weather-Ban shield, one on July 12, 1956, and the other on September 13, 1956. Both tests were made in Washington, D. C., during the afternoon under bright summer sun.

The July test was run with the air conditioning unit in an exposed test setup with no enclosure to eliminate or minimize wind currents. The purpose of this exposed setup was to simulate conditions similar to the installation of the conditioner in the window of a building. Pressure and temperature observations were recorded by an operator.

Figure 2

The July 12 test was run from 1:30 P.M. to 4:15 P.M., with readings taken at 3-minute intervals during various periods throughout the afternoon. Table I shows the maximum and minimum values observed with the shield on and off during this period.

TABLE I

Range of Temperatures and Pressures Observed on Fedders Air Conditioner With and Without Weather-Ban Shield During Test 1. 1:30 P.M. to 4:15 P.M., July 12, 1956

	Shield On		Shield Off	
	Min.	Max.	Min.	Max.
Condenser Air Outlet-Temp. °F	92.4	111.7	108.9	112.1
Condenser Housing Surface-Temp. °F	96.5	107.2	120.4	126.2
Condenser Air Inlet Temp. °F	85.4	95.3	86.9	90.2
Evaporator Air Inlet Temp. °F	86.3	93.8	88.4	91.3
Evaporator Air Outlet-Temp. °F	68.1	73.3	69.6	73.3
Discharge Pressure psig	164.	189.	178.	184.
Suction Pressure psig	30.	35.	32.	36.

Table II shows the average of the values observed at 3-minute intervals during typical periods with the shield on and off between 1:30 P.M. and 4:15 P.M. on July 12, 1956.

TABLE II

Average Temperatures and Pressures Observed on Fedders Air Conditioner With and Without Weather-Ban Shield During Test 1. 1:30 P.M. to 4:15 P.M., July 12, 1956

	Shield On	Shield Off
Condenser Air Outlet-Temp. °F	111.0	110.9
Condenser Housing Surface-Temp. °F	106.7	124.5
Condenser Air Inlet Temp. °F	92.1	88.4
Evaporator Air Inlet Temp. °F	92.4	99.6
Evaporator Air Outlet-Temp. °F	70.5	71.0
Discharge Pressure psig	185.	182.
Suction Pressure psig	33.	35.

It will be noted that in a number of instances the maximum and minimum values vary widely from the average values. In many cases the difference between the maximum or minimum reading and the average is far greater than the difference between the values observed with the shield on and with the shield off. For example, the minimum condenser air outlet reading with the shield on is 18.6°F lower than the average condenser air outlet reading with the shield on, and yet the difference between the averages for the condenser air outlet with the shield on and off was only 0.1°F. This serves to point out the big effect of changing conditions, primarily wind velocity and direction. The only reading which showed a significant change when the shield was removed or replaced during this test was the condenser housing surface temperature. The average values of the condenser housing temperature shown in Table II with and without the sun shield differed by 17.8°F.

The September test was run with the conditioner supported in a plywood structure designed to provide more stable testing conditions. All thermocouple readings taken in the previous test, plus an ambient temperature and a sun intensity observation were taken on a sixteen-point electronic constant-balance recorder. The suction pressure and discharge pressure readings were recorded. The sun intensity figures were obtained by attaching a pyrheliometer to one point on the sixteen-point recorder. The values which were recorded were not absolute values of solar intensity, but were relative. Two tests were made on the afternoon of September 13, running from 2:00 P.M. to 3:00 P.M. and from 3:00 P.M. to 4:00 P.M. Since the tests were of similar nature and the results were in agreement, only the first test has been reported here. From 2:00 P.M. to 2:30 P.M. the air conditioner was operated without the Weather-Ban shield, and from 2:30 P.M. to 3:00 P.M. it was in place. The maximum and minimum readings shown in Table III are for this entire period of time. The average values shown in Table IV cover a representative span of ten minutes with the shield off and ten minutes with it on.

TABLE III

Range of Temperatures and Pressures Observed on Fedders Air Conditioner With and Without Weather-Ban Shield During Test 2. 2:00 P.M. to 3:00 P.M. September 13, 1956

	Shield On		Shield Off	
	Min.	Max.	Min.	Max.
Evaporator Air Inlet Temp. °F	85.0	86.5	86.0	88.0
Evaporator Air Outlet-Temp. °F	66.0	67.0	66.0	68.0
Condenser Air Inlet Temp. °F	88.0	92.0	87.0	93.0
Condenser Air Outlet-Temp. °F	109.0	111.0	109.5	111.5
Condenser Housing Surface-Temp. °F	103.0	106.0	120.0	126.0

TABLE III (continued)

	Shield On		Shield Off	
	Min.	Max.	Min.	Max.
Sun Intensity	178.	216.	130.	214.
Ambient-Temp. °F	87.0	93.0	87.0	97.0
Discharge Pressure psig	172.	185.	175.	186.
Suction Pressure psig	29.	35.	29	34.

TABLE IV

Average Temperatures and Pressures Observed on Fedders Air Conditioner With and Without Weather-Ban Shield During Test 2. 2:00 P.M. to 3:00 P.M. September 13, 1956

	Shield On	Shield Off
Evaporator Air Inlet Temp. °F	86.3	87.0
Evaporator Air Outlet-Temp. °F	66.9	67.4
Condenser Air Inlet Temp. °F	190.1	190.4
Condenser Air Outlet-Temp. °F	110.1	110.7
Condenser Housing Surface-Temp. °F	106.0	125.1
Sun Intensity	204.	204.
Ambient-Temp. °F	89.9	91.2
Discharge Pressure psig	180.	180.
Suction Pressure psig	32.	32.

The differences between the maximum and minimum readings in the September test were considerably smaller than in the July test. These smaller differences between maximum and minimum readings still exceeded any differences in the readings produced by removing or installing the Weather-Ban shield. As in the July test, no significant change, other than in the temperature of the condenser housing surface, was observed in the September test with the Weather-Ban shield in place or removed.

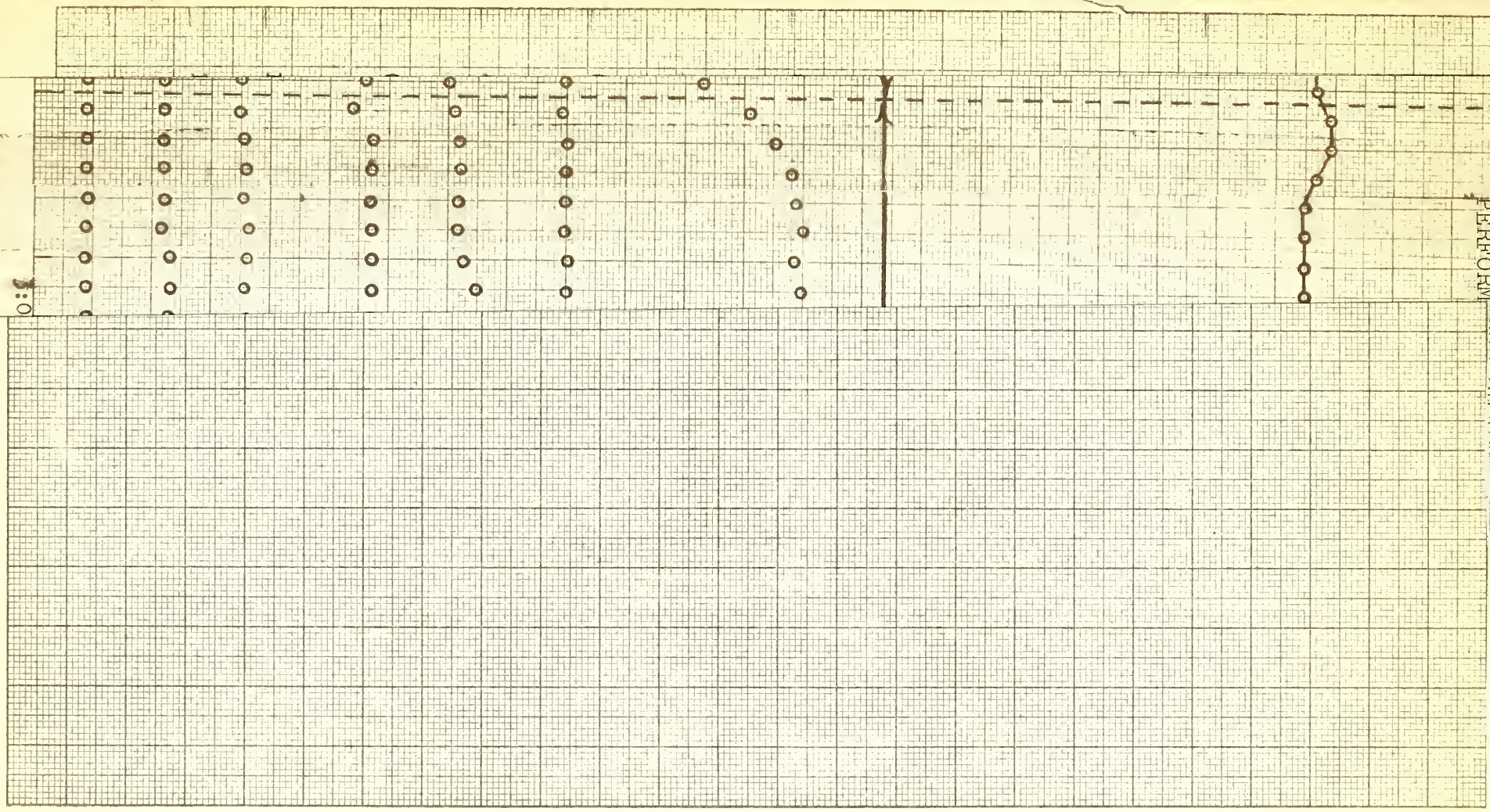
Table IV shows a difference in temperature of the air between evaporator inlet and outlet of 19.4 deg F with the sun shield on and 19.6 deg F with the sun shield off. The corresponding temperature rises of the condenser air were 20.0 degrees F and 20.3 degrees F respectively. If the sun shield had been beneficial to the capacity of the unit, the decrease in air temperature as it passed through the evaporator should have been greater with the shield on than with it off whereas the results show the reverse occurred. The differences in the cooling and heating effects of the evaporator and condenser with and without the shield are of the order of one percent, and are considered to be well within the variability of operating conditions during the tests.

During the summer when the two reported tests were made, many other test runs were also made, but were not reported because of excessive changes in ambient conditions such as wind, solar radiation, etc. The results of one of these additional tests, made on September 20, 1956 are shown in Graph I. Although the solar radiation varied considerably, no noticeable change, other than in the condenser surface temperature, occurred when the solar radiation changed, or when the shield was installed or removed.

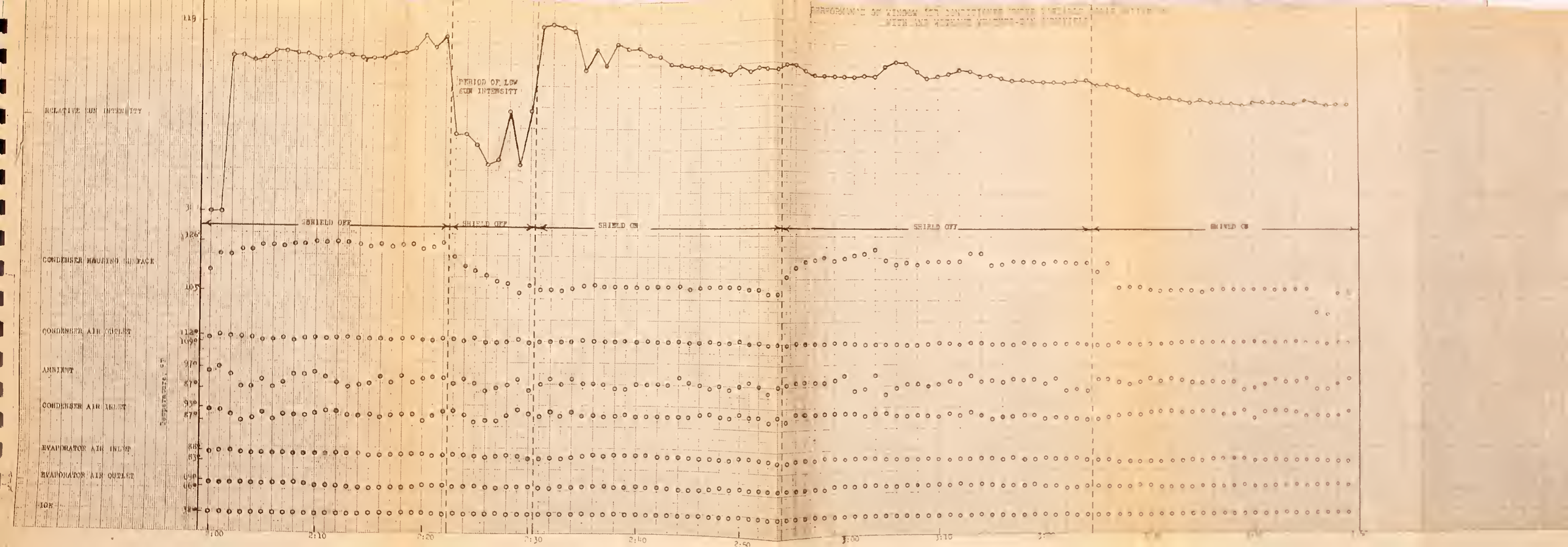
IV. DISCUSSION AND CONCLUSIONS

On the basis of the observations made during the tests reported, the installation of the Weather-Ban shield produced no measurable change in the operating characteristics or the capacity of the Fedders air conditioner furnished for the tests during operation of the air conditioning unit in bright sunlight.

It can be shown from the computed incident solar radiation and solar heat transmission that a very small change in operating conditions would be expected as a result of applying the Weather-Ban sun shield.



Graph 1


RELATIVE SUN INTENSITY
CONDENSER MOUNTING SURFACE
CONDENSER AIR OUTLET
AMBIENT
CONDENSER AIR INLET
EVAPORATOR AIR INLET
EVAPORATOR AIR OUTLET
ION
PERIOD OF LOW SUN INTENSITY
SHIELD OFF
SHIELD OFF
SHIELD ON
SHIELD OFF
SHIELD ON
2:00
2:10
2:20
2:30
2:40
2:50
3:00
3:10

Assuming that the air conditioner used for these tests had an air circulation rate of 400 cubic feet per minute through the condenser, and that the unit was rejecting a total of 9,000 Btu per hour, the temperature rise of the condenser air would be about 21 degrees F. From Table IV the temperature rise was observed to be 20 and 20.3 degrees F, respectively, for the two conditions of operation reported. The top surface area of the air conditioner housing was approximately four square feet, and assuming that the thermal conductance of the top was 0.6 Btu/sq.ft.(°F), the observed rise of 19.1°F in the temperature of the top surface when the shield was removed would cause an additional transfer of about 46 Btu per hour, and a temperature rise in the condenser air of about 0.1°F.

Air entered the condenser section through one third of the vertical front face of the housing and was discharged through the remaining two thirds of the front face. The front face was oriented due south during the tests and approximately 100 Btu/hr of direct and diffuse solar radiation would be absorbed by the one square foot of inlet grille at 2:30 P.M. eastern daylight time. If all of this heat were transferred to the ingoing condenser air the average air temperature would be increased an additional 0.23°F when the shield was not in use. Since the Weather-Ban shield did not shade the ends of the condenser section, its presence would not affect the transfer of solar radiation through these surfaces.

Thus it is expected that the solar shield would not have decreased the rise in condenser air temperature by more than about 0.33°F. Such a small change would be difficult to measure with certainty in this type of test. Published information on the performance of Refrigerant-12 compressors indicates that the decrease in capacity of such compressors is less than one percent for one degree rise in condensing temperature for the compression ratio involved in these tests.

The use of an air conditioner without a housing over the face of the condenser would have possibly been more favorable to the sun shield in that solar radiation falling on the condenser tubes and fins would have been absorbed to a large degree when the shield was not in use. This would have increased the amount of heat to be absorbed by the condenser air by a larger increment than for the Fedders

unit used for these tests. However, even this type air conditioner would probably increase the heat rejection of the condenser by only about 4 percent when operating unshaded at the time of day when the solar absorption would be the greatest. It is probable that this unfavorable set of conditions would not have decreased the cooling capacity more than one percent and, therefore, could not have been measured with certainty by the methods usually employed for rating air conditioners.

No determinations were made during these tests on any other claims of the manufacturer for the Weather-Ban shield.

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