NATIONAL BUREAU OF STANDARDS REPORT

2251

EVALUATION OF THERMOSCREEN TYPE NAX-1-46

by

H. R. Martin
R. S. Dill

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT **NBS REPORT**

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Heating and Air Conditioning Section
Building Technology Division

To

Bureau of Aeronautics
Department of the Navy
Washington 25, D. C.

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I. INTRODUCTION

The Weather Bureau type of wooden thermoscreen has served its purpose for many years and its continued use is probable particularly for some shore installations, where low cost is a factor or where electric power is not available. For shipboard use, however, it has been realized for some time that a different thermoscreen which should be smaller, less conspicuous, more convenient to use, more durable and, if possible, capable of yielding more accurate weather data was desirable. Also, to reduce cost, the number of spare parts and storage space, it was desirable that the same type of thermoscreen should serve both on board ship and ashore.

In preparation for formulating a new design, several shapes and sizes of thermoscreens were considered and several prototypes were made and tried in field experiments along with two wooden thermoscreens with designs accepted by the Weather Bureau. The size and, to a degree, the shape were determined by the dimension of the instruments which the thermoscreen had to accommodate to comply with Bureau of Aeronautics requirements. As a result of the experience gained, the Type NAX-1-46 thermoscreen was designed and six specimens were constructed on contract according to drawings and specifications prepared at this Bureau. Of these six, one was retained for further testing and the other five were delivered to various ships and shore stations for trial.

The performance of the Type NAX-1-46 thermoscreen, observed during these tests, was compared with that of the Large Wooden (Weather Bureau Type) thermoscreen which had proved best of those previously tested in point of accuracy of results.

II. SAMPLE AND TEST APPARATUS

The specimen NAX-1-46 thermoscreen retained at the National Bureau of Standards is shown in Figure 1. It is described in drawings already submitted to the Bureau of Aeronautics. The instrument space in this thermoscreen is about 20 inches wide, 21 inches high and 12 inches deep from front to back. The instrument space is surrounded by two annular air spaces formed by three metal walls or shells and these spaces as well as the instrument space are copiously ventilated by the fan at the top which draws air into the bottom and upward through the thermoscreen.

For tests, the specimen was set up in an open space on the Bureau grounds as shown in Figure 2. This photograph also shows the anemometer used for wind measurement and the four devices provided for evaluating ambient conditions. For convenience these devices were called "sensory elements" and each such element consisted of a horizontal tube containing a dry thermocouple and a thermocouple fitted with a wick, which was kept wet to serve the same purpose as the wet bulb thermometer in a psychrometer. A motor-driven blower drew air through the tube and around the thermocouples when the device was in use and the emfs of the thermocouples were registered by the potentiometer, in the instrument shelter, shown in Figure 3.

During the tests, the thermoscreen faced north and was supported with its bottom about four feet above the ground by a steel frame. The anemometer of the wind measuring set was mounted on a mast about 12 feet high and its indicating and recording instruments were also located in the instrument shelter.

Temperatures were measured with calibrated copper-constantan thermocouples in conjunction with the potentiometer, mentioned above, which was a Brown 16-point recording instrument. For air temperature measurement, the thermocouples in the sensory elements were fitted into small bronze spheres about 3/16-inch in diameter to afford some stabilization of the readings and these balls were coated with aluminum paint to minimize radiation effects.

The thermocouples were so connected that the differences between the emf of each thermocouple and that of thermocouple No. 15, in the west sensory element, were recorded on a strip chart at four minute intervals. This permitted the use of an open scale on which readings could be made readily with a precision equivalent to ± 0.1°F. The temperature differences reported herein are therefore the differences between the temperatures at various points and the so-called "true" temperature inside of the reference sensory element. A plus sign indicates that the temperature at any point was greater than that in the reference sensory element, whereas a negative sign indicates the reverse. For convenience this difference is called the "error" or the "temperature difference".

All leads from the thermojunctions to the recorder were shielded to minimize the effects of stray electrical fields. Location of the thermocouples are given in detail in Table 1.

The shelter for the recording equipment was approximately 4 feet square and 8 feet in height with well-insulated walls and door. A small window in the back of the shelter

was of double glass and faced north to minimize heat gain or loss. The temperature within the shelter was regulated by Mercoid controls in conjunction with suitable heating and air conditioning equipment to maintain the inside temperature at about 70°F. The power supply to the equipment was brought into this shelter through shielded and grounded cables.

Data on solar intensity were obtained from the U. S. Weather Bureau pyroheliometer located at 24th and M Streets, N. W., a distance of some two miles from the site of these tests. Solar intensity was measured and reported in Langleys. The Langley is defined as one gram calorie of energy per square centimeter received by a horizontal surface.

The anemometer of the wind measuring set, shown in Figure 2, was connected by special circuit so that the wind indications were recorded by the potentiometer mechanism on the same chart with the temperature data. This arrangement was calibrated in the Bureau's wind tunnel and found to require a correction of about plus 1-1/2 miles per hour at all speeds in the range of interest.

III. PROCEDURE AND OBSERVATIONS

Since the error in air temperature measurements depends on sun intensity and wind, most of the tests were made during the day and, for comparison of thermoscreens, data were selected which were obtained on days of strong sun and little wind.

The average values of temperature, temperature differences wind speed and solar intensity for each full hour of operation were considered an observation and the observations are averaged and summarized in Tables 2 and 3.

In Table 2, the data from the test of the Large Wooden Thermoscreen are included with those from the test of the Type NAX-1-46 thermoscreen for comparison while in Table 3 more detailed data on the Type NAX-1-46 thermoscreen are given. The same data were plotted in Figures 4, 5 and 6 for convenience, In Tables 4, 5 and 6, instrument readings are recorded which were selected between the same hours of the day to afford a comparison of the NAX-1-46 with the Large Wooden Thermoscreen. This was done to lessen the error due to differences in the altitude of the sun so that the two thermoscreens could be compared under as near similar circumstances as possible.

IV. RESULTS AND DISCUSSION

Field tests of thermoscreens are necessary because sunlight, wind and sky radiation cannot be reliably simulated in the laboratory. Preliminary tests can be conducted in a laboratory to avoid waiting for suitable weather and infra

red electric lamps can be used to simulate radiant heat from the sun but the results must be considered indicative only and should not be used to evaluate the performance of thermoscreens. Laboratory evaluation of thermoscreens may become feasible if and when knowledge of the subject is sufficient to permit it.

Any object exposed to sunlight assumes a temperature above that of the ambient air and the temperature within an enclosure like a thermoscreen depends on energy reception and heat dissipation which is caused chiefly by ventilation. An objective of thermoscreen design is to provide sufficient ventilation so that the instruments within it will indicate or record true ambient air conditions within an acceptable tolerance. For the wooden thermoscreen, natural wind has been relied upon to furnish ventilation; in models under development, including the type NAX-1-46, motor driven fans or blowers are being used.

Any instrument used to determine or evaluate outdoor air conditions is subject to the same difficulty and in this work it was met by means of the sensing elements mentioned in the Introduction and discussed in the Report on Thermoscreen Development Project submitted December 18, 1950. When exposed to sunlight, there is no doubt a difference between the temperature indicated by this instrument and the true air temperature, despite the large ventilating rate provided. Also, the magnitude of this difference is not known but it is undoubtedly small and it is much smaller than the short-time fluctuations in ambient air temperature indicated by the thermocouples. These short time fluctuations act to prevent precision and accuracy in air temperature measurement. In the present work the potentiometer reading was observed to wander over a range of one to three degrees in a period of four minutes or less. It is evident that a definition is needed and an average over some time interval must be used since the temperature is always changing. Perhaps a standard thermocouple fitted with a specified mass of metal to serve as heat capacity would be a practical solution to the problem. Some experimentation is essential but, as a first estimate, an arrangement for which the temperature indication does not change by more than one degree in five minutes in calm weather might be suitable.

Information on the essential accuracy in air temperature measurement for weather forecasting purposes has been sought in the literature and in conferences with authorities in that field and the indications are that the accuracy being currently attained is not known and that required has not been established. At sea or on the coast or with steady winds, the momentary fluctations in air temperature may be smaller or even insignificant but, as stated above, the indicated

variations under the test conditions were sometimes as much as three degrees in four minutes. The data in Tables 4, 5 and 6 show that the error was usually greater than 0.5 degree F and less than 1.0 degree F under low wind and intense sunlight conditions for either the Large Wooden or the NAX-1-46 thermoscreen. Based on this, an accuracy of one degree F is suggested as a criterion for extreme conditions such as those of the tests. Accuracy better than one degree F can be expected with either thermoscreen when it is in use on a ship under way since the ship's motion will create relative wind except in the rare case when she is proceeding in the same direction and speed as the wind. Also, accuracy better than one degree F for low wind and strong sun conditions may be a justifiable requirement in the future (1) when the art of weather forecasting has advanced sufficiently to require it and (2) when instruments are made available to attain it.

The data in the accompanying charts and tables show that either the Large Wooden or the type NAX-1-46 thermoscreen yielded data with an error of less than one degree F in the great majority of the tests. It was unfortunate that, during these tests, the maximum sun load usually occurred simultaneously with the maximum wind. If this had not been so, a better correlation between either error and wind or error and sun load could have been obtained. The indications were that the error in the temperature measurements with the Type NAX-1-46 thermoscreen were somewhat less than those occurring with the Large Wooden thermoscreen. The Type NAX-1-46 is therefore acceptable from the standpoint of accuracy and will be so as long as the results obtained with the Large Wooden thermoscreen are considered adequate. The question of its adoption for general use devolves, therefore, upon its conveniences, portability, adaptability to shore and shipboard installation, cost, and appearance.

In Figure 5, the number at each plotted point is the number of observations averaged to obtain that point. The results shown indicate that with the NAX-1-46 thermoscreen the error tended to be independent of the wind speed whereas with the Large Wooden thermoscreen the error, in general, increased as the wind speed decreased. Unfortunately no observations were obtained at wind speeds less than 1.5 mph. However, since the NAX-1-46 thermoscreen was provided with forced ventilation, it is believed that the error would not have increased significantly at the lower wind speeds.

Although no measurements were made of the intensity of the radiation incident on the vertical surfaces of the thermoscreens, it was recognized that this appeared to be an important factor. In the absence of such measurements, the observations were separated into groups in accordance

with the hour of the day in which the observations were made. The average values for these groups of observations are plotted in Figure 6. The number at each plotted point is the average of the number of observations averaged to obtain that point.

The results shown in Figure 6 indicate that there was very little difference between the errors obtained with the two types of thermoscreens for the same time of day. Assuming that the intensity of incident solar radiation on similarly oriented vertical surfaces at a given time of day and year was proportional to the observed intensity of radiation incident at the same time on a horizontal surface, the intensity of radiation on the vertical surfaces of NAX-1-46 thermoscreen was greater than that for the Large Wooden one. However, the data show that the wind speed was also greater during the tests of NAX-1-46 although as previously stated the performance of this unit was probably independent of wind speed.

It should be noted that the error for the NAX-1-46 thermoscreen was a minimum at about midday when the intensity of the radiation incident on the vertical surfaces was probably a minimum for the period in which the observations were made. Later in the afternoon when the intensity of the radiation incident on a horizontal surface had decreased, that on the west vertical surface had increased, thereby increasing the error. In the case of the NAX-1-46 thermoscreen there was little change in the average wind speed, consequently, the increase in the error must be attributed to an increase in the intensity of the radiation incident on the west vertical surface. In the case of the Large Wooden thermoscreen the wind speed decreased in the afternoon as the intensity of the radiation incident on the west vertical surface increased, both of which contributed to the increase in the error.

For this locality when these tests were made, it appears that on clear days, the wind speed reached a maximum about midday when the intensity of the solar radiation incident on a horizontal surface also reached a maximum, and that on a vertical surface reached a minimum, for the time of year at which these observations were made. The combined effect of these factors results in a minimum error at about midday. In the afternoon the decrease in the wind speed and the increase in the intensity of radiation on a vertical surface facing west, result in an increase in the error.

The basic construction of the Large Wooden Weather Bureau thermoscreen was such that it would be impossible to correlate the effect of solar radiation on the louvers of this unit with the protective shields of NAX-1-46, so, for this reason, the evaluation of the units was primarily based on the end effect; that is the error in the temperature of the air within the instrument shelter.

Temperature measurements were made in various parts of the NAX-1-46 thermoscreen to determine the effects of solar radiation and to provide information for further improvements in thermoscreens with mechanically circulated air. The data listed in Table 3 were taken between the hours of 10 A.M. and 4 P.M. EST. A vertical surface facing East during the months of May and June would be expected to receive the same amount of solar radiation at about 8 A.M. as a similar vertical surface facing West at about 4 P.M.; therefore the effect on the East inner shield at 8 A.M. should be similar to that on the West inner shield at 4 P.M. It was not possible to make measurements in the test area, however, during the earlier hours due to shading by buildings.

It will be noted in Table 3 that the temperature difference of the East inner shield (Column 1) was the greatest in the morning whereas that on the West inner shield (Column 3) was greatest in the afternoon. The air temperatures within the instrument space taken 1 inch from the East inner shield (Column 11) also showed the greatest temperature difference in the morning and the error in the air temperature taken towards the West center of the instrument space (Column 12,13) was greatest in the afternoon. The changes in the inner shield temperatures through the day and the corresponding effects on the air temperature in the immediate region indicate the necessity of providing more adequate thermal insulation and/or ventilation. During the tests, the mercury column in the maximum thermometer separated several times and the rider settled in the minimum thermometer apprently due to vibration communicated from the fan motor. Thin, sheet rubber separators under the supports of these thermometers ended these difficulties. Otherwise, continuous operation of the Type NAX-1-46 thermoscreen in the field from November 7, 1951 to July 28, 1952 without any other trouble indicated its satisfactory mechanical durability.

Reports on field trials of the NAX-1-46 thermoscreen have been received from the U. S. Naval Arctic Test Station, Point Barrow, Alaska, dated 30 April 1952, and from the U. S. Naval Air Station, Pensacola, Florida, dated 2 September 1952. Details can be obtained from these reports but, in general, the only unfavorable finding from the Florida Station concerns the durability of the hardware and the finish. If additional thermoscreens of this type are to be procured, better enameling of the case and corrosion resistant hardware should be assured. In the tests under arctic conditions, vibration, snow clogging of the insect screen and freezing on the wet bulb sufficient to hinder manipulation were caused of trouble. The vibration may have originated externally to the thermoscreen since the writer of the report suggested use of a telephone pole as a more stable mount. A precaution against vibration originating within the thermoscreen, found during test at the National Bureau of Standards, is described above. Snow clogging

of the insect screens was not anticipated although obvious after the fact. A possible remedy would be to remove this screen for arctic use to see if any snow entering the thermoscreen would blow on through without harming the instruments. The electric heater installed in the water reservoir was intended to prevent difficulty due to ice formation on or about the wet bulb thermometer. It would be interesting to know whether this heater was in proper operation or not when the reported freezing occurred. If so, some more effective preventive must be sought.

V. CONCLUSION

The type NAX-1-46 thermoscreen is considered to be an improvement over others in common use in regard to size, convenience, appearance and accuracy at low wind speeds. It is not subject to splintering if struck by a missile as a wooden structure would be. Tests of it are being discontinued and efforts are now concentrated on development of a smaller thermoscreen which will make it possible to read weather data from inside a protected shelter.

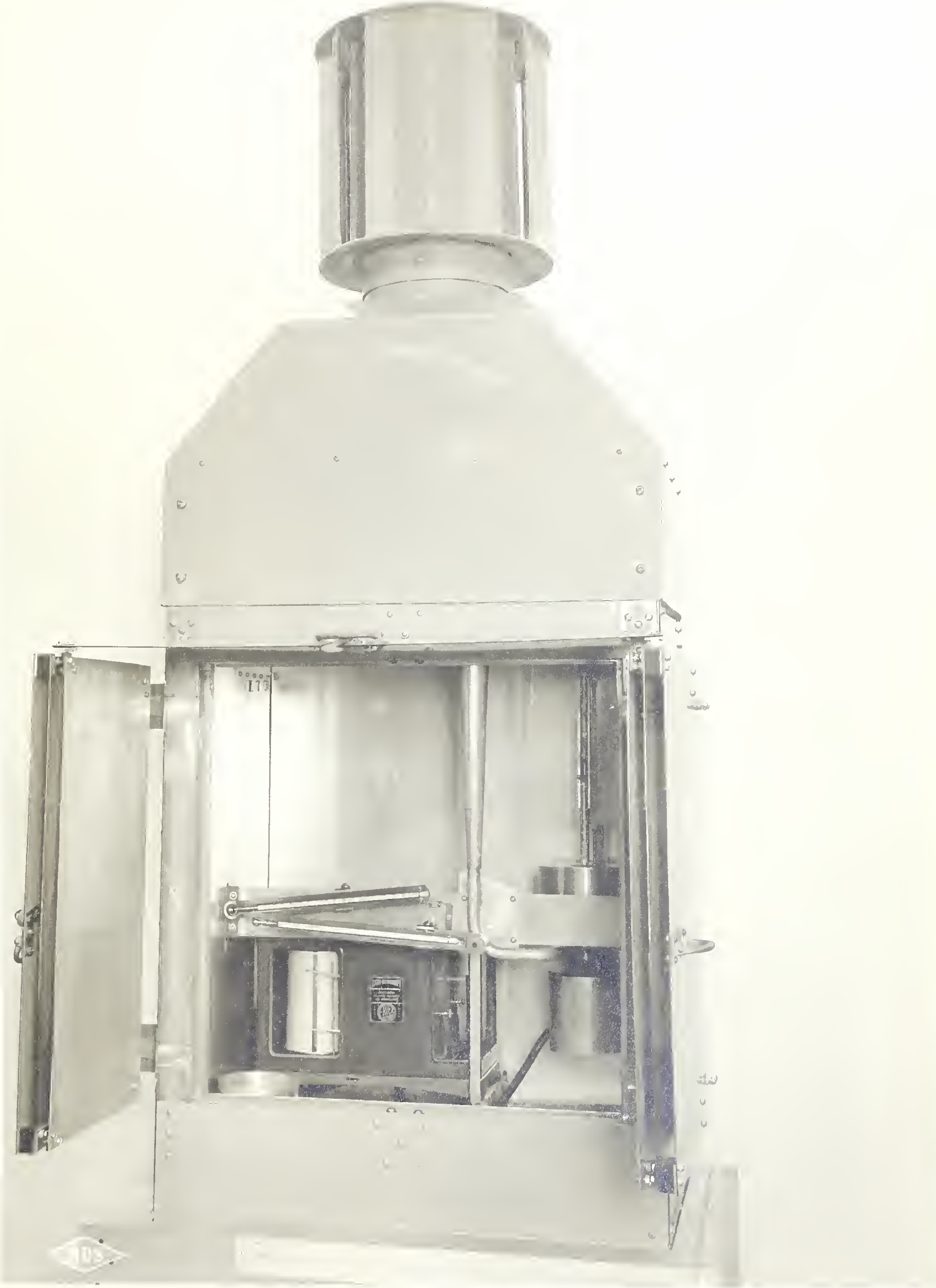

Figure 1. Thermoscreen M[illegible]-1-46

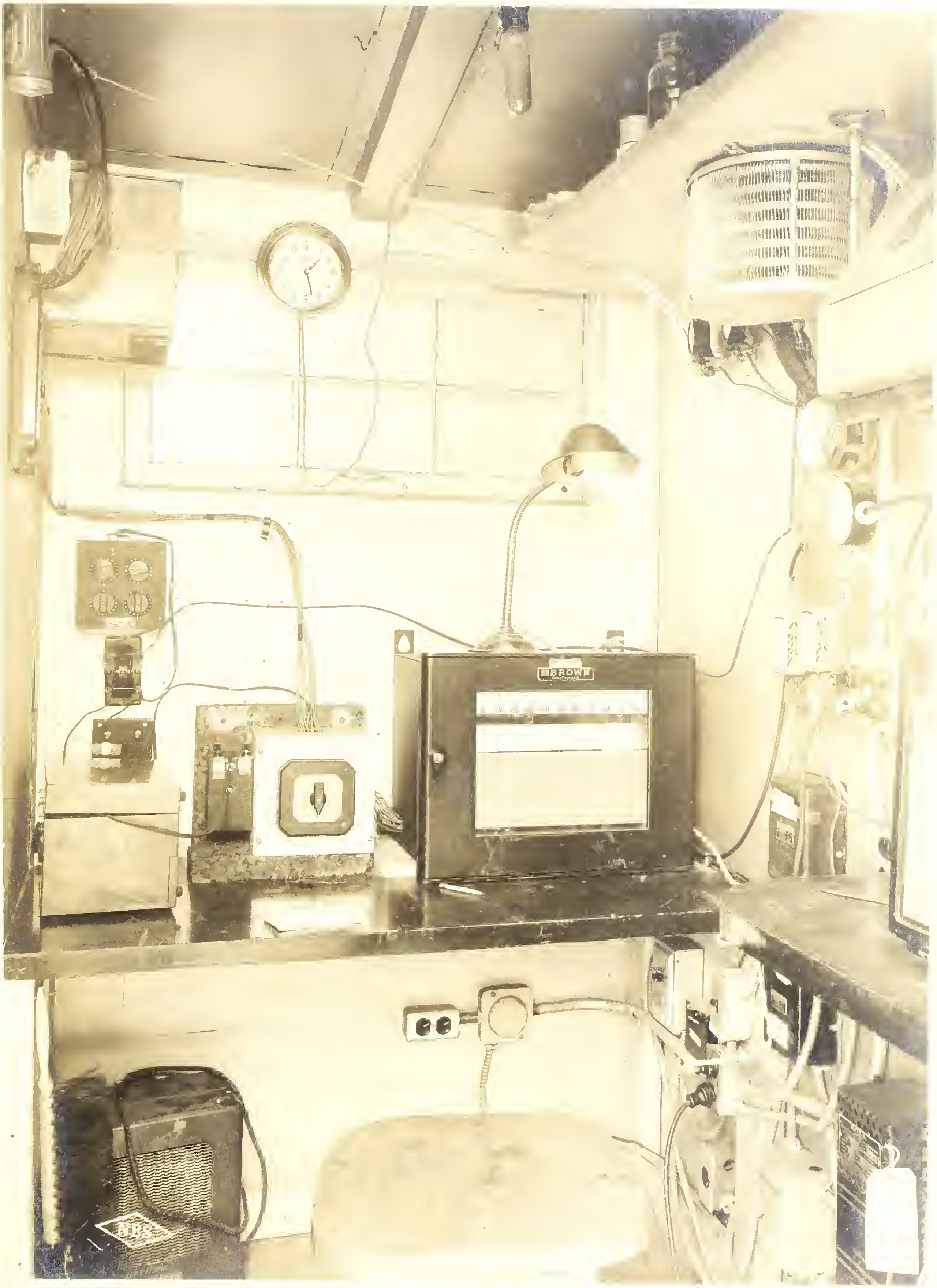

Figure 3. Interior View of Protective Shelter Showing Recording Equipment.

Table 1. Location of Thermocouples Used for Test

T.C. #1 - On inner (East) surface of inner aluminum shield in instrument shelter, 6 inches down from top, to left in Figure 1.

T.C. #2 - On inner (East) surface of inner aluminum shield in instrument shelter, 6 inches up from bottom, to left in Figure 1.

T.C. #3 - On inner (South) surface of inner aluminum shield in instrument shelter, 6 inches down from top, to back in Figure 1.

T.C. #4 - On inner (South) surface of inner aluminum shield in instrument shelter, 6 inches up from bottom, to back in Figure 1.

T.C. #5 - On inner (West) surface of inner aluminum shield in instrument shelter, 6 inches down from top, to right in Figure 1.

T.C. #6 - On inner (West) surface of inner aluminum shield in instrument shelter, 6 inches up from bottom, to right in Figure 1.

T.C. #7 - On outer (South) surface of middle aluminum shield in instrument shelter, at center back in Figure 1.

T.C. #8 - On inner (South) surface of outer aluminum shield of instrument shelter, at center back in Figure 1.

T.C. #9 - In space (East side) within instrument shelter near max-min thermometers, 10 inches up from bottom and 1 inch in from inner shield, to left in Figure 1.

T.C. #10 - In space (West center) within instrument shelter near Bourdon element, 4 inches up from bottom and 6 inches in from inner aluminum shield, to right in Figure 1.

T.C. #11 - In space (West center) within instrument shelter, 2 inches down from top and 6 inches in from inner aluminum shield, to right in Figure 1.

T.C. #12 - Wetted thermocouple consisting of 3/16-inch diameter aluminum-painted bronze ball in sensory element, about 6 feet south of unit in Figure 2.

T.C. #13 - Wetted thermocouple consisting of 13/32-inch diameter aluminum-painted bronze ball in sensory element, about 6 feet west of unit in Figure 2.

T.C. #14 - Wetted thermocouple consisting of 9/32-inch diameter aluminum-painted bronze ball in sensory element, about 6 feet east of unit in Figure 2.

T.C. #15 - Thermocouple reference junction (representing "true" ambient air temperature) taken in West sensory unit.

T.C. #16 - Air to melting ice temperature difference taken in North sensory unit.

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Table 2. Test Data Tabulation

Number of observations[1]	Wind speed[2] Range	Wind speed[2] Average	Average incident solar radiation in Langleys/hour[3]	Average error[4]
	MPH	MPH		Deg F
Thermoscreen NAX-1-46				
2	2.2 to 2.5	2.3	62.9	0.45
7	2.5 to 2.9	2.6	73.1	.67
4	2.9 to 3.3	3.0	79.6	.60
9	3.3 to 4.0	3.6	75.5	.83
5	4.0 to 4.5	4.2	84.8	.72
7	4.5 to 6.0	5.0	77.9	.83
5	6.0 to 7.5	6.4	89.0	.62
Large Weather Bureau Thermoscreen				
10	1.5 to 2.0	1.7	24.4	1.54
11	2.0 to 2.2	2.0	40.4	0.97
12	2.2 to 2.5	2.3	47.1	1.12
22	2.5 to 2.9	2.6	54.9	0.96
20	2.9 to 3.3	3.0	60.6	.81
10	3.3 to 4.0	3.7	62.5	.72
7	4.0 to 4.5	4.2	62.3	.54
11	4.5 to 6.0	4.8	66.0	.46
0	6.0 to 7.5	---	---	---

Footnotes on following page.

[1] An average of 15 readings were taken during each hour. The number of hourly observations so averaged are listed.

[2] Averaged by planimetering a continuous wind speed vs. time recording with an AM/UMQ-5 wind measuring set.

[3] Average value of incident solar radiation on a horizontal surface in gm cal/(sq cm-hr).

[4] Temperature difference between the average temperature of the instrument shelter thermocouples* and that of the reference "true" air temperature. A positive value indicates instrument space temperatures higher than "true" air.

*T.C. #9-10-11 as in Table 1 for NAX-1-46 and T.C. for the large Weather Bureau thermoscreen as follows: In hygrothermograph between hair and Bourdon elements, near max-min thermometers near bulbs of sling psychrometer, and centrally located in instrument shelter.

THERMOSCREEN NAX-1-46

Range of Hourly Average Values

Radiation	56.6 to 92.9 Langleys/hour
Wind	2.3 to 7.5 mph
Ambient temperature	64.9 to 90.2 °F
Relative humidity	30.0 to 69.0 percent

LARGE WEATHER BUREAU THERMOSCREEN

Range of Hourly Average Values

Radiation	3.2 to 84.5 Langleys/hour
Wind	1.6 to 5.9 mph
Ambient temperature	67.0 to 89.0 °F
Relative humidity	43.0 to 94.0 percent

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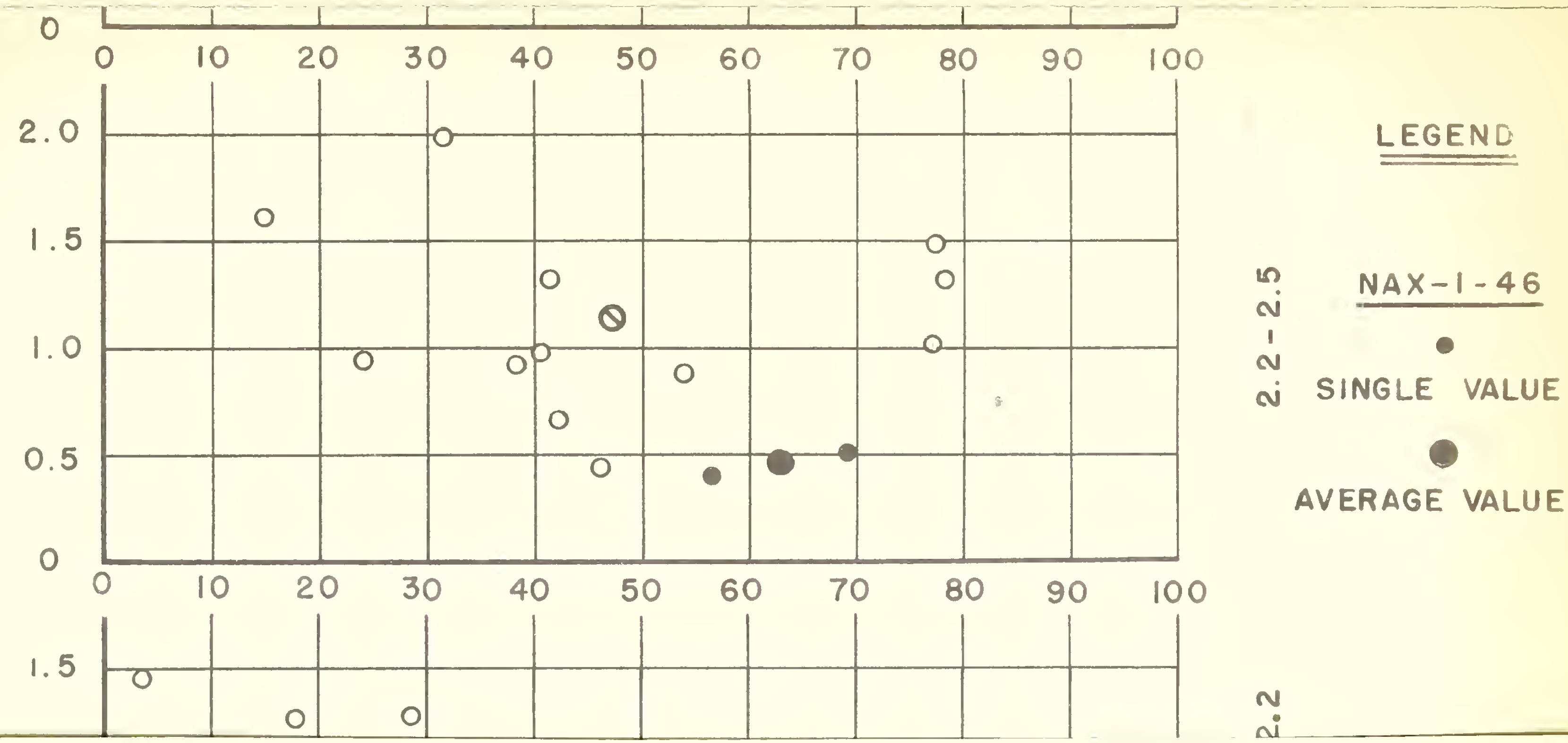


0
0 10 20 30 40 50 60 70 80 90 100
2.0
1.5
1.0
0.5
0
0 10 20 30 40 50 60 70 80 90 100
1.5
2.2 - 2.5
2.2
LEGEND
NAX-1-46
SINGLE VALUE
AVERAGE VALUE

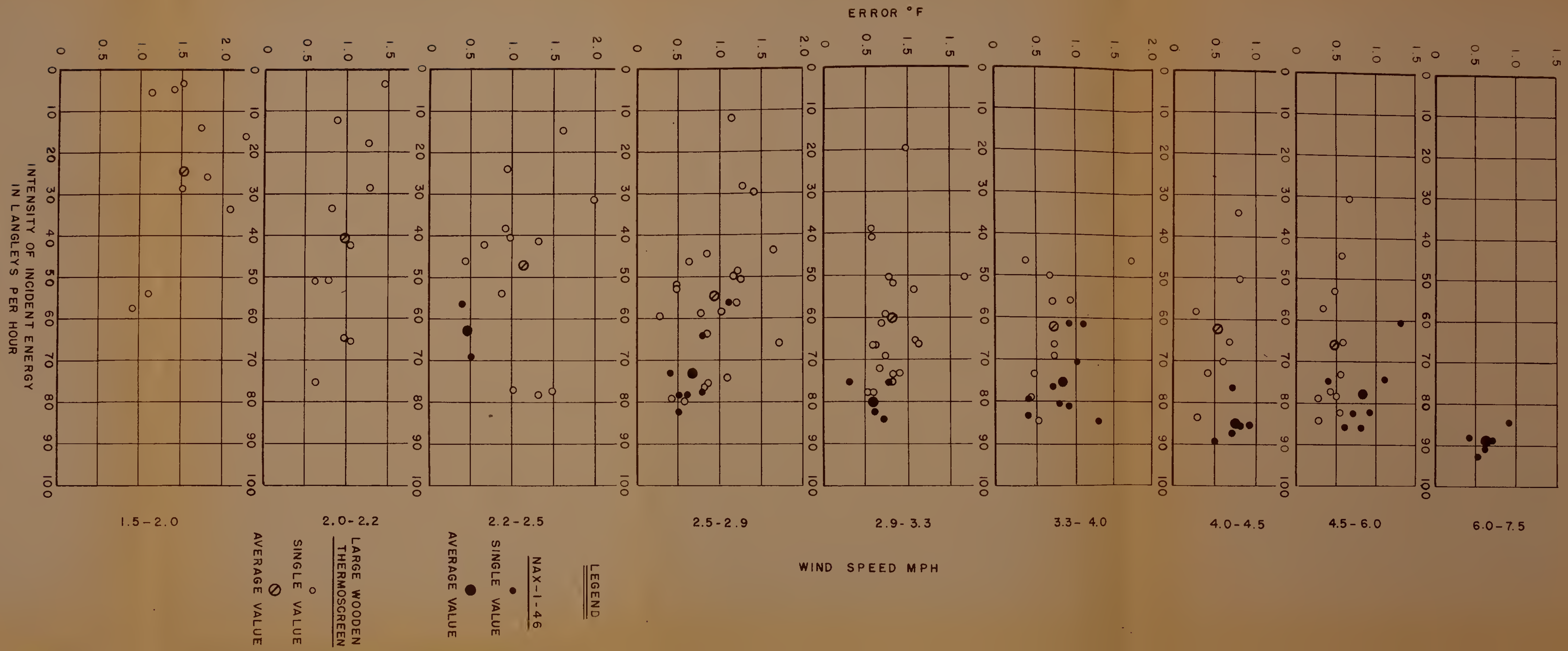
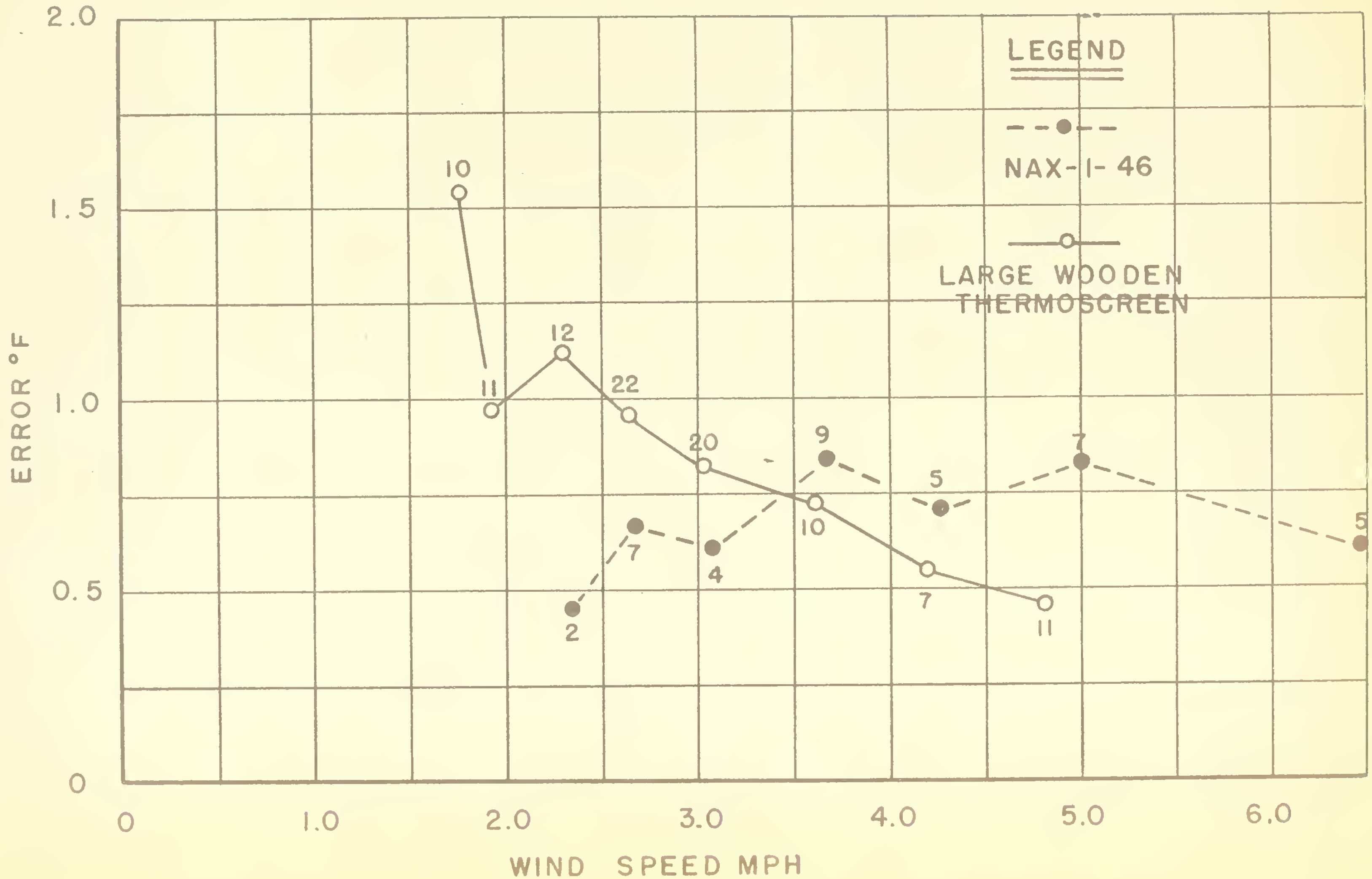

ERROR °F
INTENSITY OF INCIDENT ENERGY IN LANGLEYS PER HOUR
1.5-2.0
2.0-2.2
2.2-2.5
2.5-2.9
2.9-3.3
3.3-4.0
4.0-4.5
4.5-6.0
6.0-7.5
WIND SPEED MPH
LEGEND
NAX-1-46
SINGLE VALUE
AVERAGE VALUE
LARGE WOODEN THERMOSCREEN
SINGLE VALUE
AVERAGE VALUE

FIGURE 4



LEGEND
NAX-1-46
LARGE WOODEN THERMOSCREEN
ERROR °F
2.0
1.5
1.0
0.5
0
1.0
2.0
3.0
4.0
5.0
6.0
WIND SPEED MPH
10
11
12
22
20
10
7
11
2
7
4
9
5
7
5

FIGURE 5

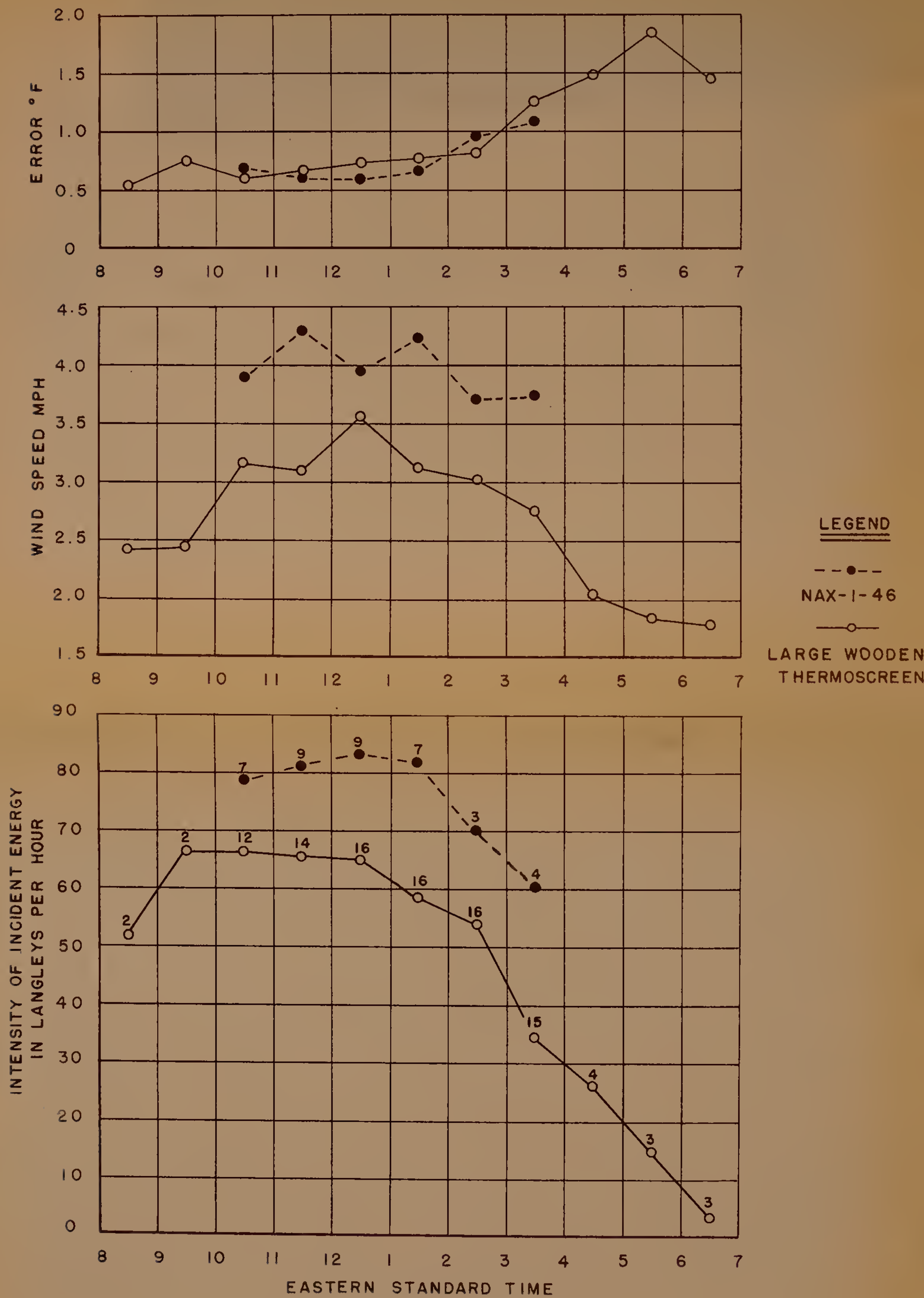

ERROR °F
WIND SPEED MPH
INTENSITY OF INCIDENT ENERGY IN LANGLEYS PER HOUR
EASTERN STANDARD TIME
LEGEND
NAX-1-46
LARGE WOODEN THERMOSCREEN

FIGURE 6

ff. ed, m 1 inus)	(9) Av. temp. diff. center middle shield, south (Av. of T.C. 7)	(10) Av. temp. diff. center of outer shield, south (Av. of T.C. 8)
	1.90	9.80
	1.90	11.10
	2.00	11.20
	2.10	11.10
	2.00	8.80
	2.00	6.00
	1.98	10.19

ff., ory av. 13 of)	(19) Av. temp. diff., east wet sensory element and av. (Av. of T.C. 14 minus av. of 12, 13, 14)	(20) Av. max. temp. diff. among wet sensory elements (Av. of T.C. 12, 13, 14)
	-0.06	0.26
	-0.03	.26
	-0.10	.22
	-0.18	.49
	-0.28	.52
	-0.28	.51
	-0.12	0.34

Table 3. Tabulation of Air and Shield Temperature Differences, °F, from Tests on NAX-1-46

Eastern standard time	Number of observations	(1) Av. temp. diff. inner shield, east (Av. of T.C. 1 and 2)	(2) Av. temp. diff. inner shield, south (Av. of T.C. 3 and 4)	(3) Av. temp. diff. inner shield, west (Av. of T.C. 5 and 6)	(4) Av. temp. diff. shields listed (Av. of T.C. 1 to 6 inc.)	(5) Av. temp. diff., top to bottom, inner shield east (Av. of T.C. 1 minus 2)	(6) Av. temp. diff., top to bottom, inner shield south (Av. of T.C. 3 minus 4)	(7) Av. temp. diff., top to bottom, inner shield west (Av. of T.C. 5 minus 6)	(8) Av. temp. diff. shields listed, top to bottom (Av. of T.C. 1 minus 2, 3 minus 4, 5 minus 6)	(9) Av. temp. diff. center middle shield, south (Av. of T.C. 7)	(10) Av. temp. diff. center of outer shield, south (Av. of T.C. 8)
10 to 11 a.m.	7	1.29	0.25	0.77	0.77	0.13	0.21	0.02	0.12	1.90	9.80
11 to 12 a.m.	9	0.91	.25	.67	.61	.13	.19	.04	.12	1.90	11.10
12 to 1 p.m.	9	.71	.39	.83	.64	.14	.18	.02	.11	2.00	11.20
1 to 2 p.m.	7	.75	.42	1.32	.83	.13	.19	.05	.12	2.10	11.10
2 to 3 p.m.	3	.86	.47	1.61	.98	.11	-0.03	.18	.10	2.00	8.80
3 to 4 p.m.	4	1.09	.78	2.72	1.53	.14	.47	-0.03	.19	2.00	6.00
Average		0.92	0.38	1.13	0.81	0.13	0.20	0.03	0.12	1.98	10.19

Eastern standard time	Number of observations	(11) Av. temp. diff. air in shelter, near max-min (Av. of T.C. 9)	(12) Av. temp. diff. air in shelter, near Bourdon tube (Av. of T.C. 10)	(13) Av. temp. diff. air in shelter, 18" above Bourdon tube (Av. of T.C. 11)	(14) Av. of air temp. diff. listed (Av. of T.C. 9, 10, 11)	(15) Av. temp. diff. air in shelter, near max-min and Bourdon tube (Av. of T.C. 9 minus 10)	(16) Av. temp. diff. air in shelter, 18" above Bourdon tube and Bourdon tube (Av. of T.C. 11 minus 10)	(17) Av. temp. diff., south wet sensory element and av. (Av. of T.C. 12 minus av. of 12, 13, 14)	(18) Av. temp. diff., west wet sensory element and av. (Av. of T.C. 13 minus av. of 12, 13, 14)	(19) Av. temp. diff., east wet sensory element and av. (Av. of T.C. 14 minus av. of 12, 13, 14)	(20) Av. max. temp. diff. among wet sensory elements (Av. of T.C. 12, 13, 14)
10 to 11 a.m.	7	0.93	0.55	0.55	0.68	0.38	0.00	0.14	-0.08	-0.06	0.26
11 to 12 a.m.	9	.76	.46	.55	.59	.30	.09	.13	-0.08	-0.03	.26
12 to 1 p.m.	9	.59	.57	.71	.62	.02	.14	.10	-0.02	-0.10	.22
1 to 2 p.m.	7	.63	.63	.85	.70	.00	.22	.23	-0.01	-0.18	.49
2 to 3 p.m.	3	.81	.89	1.10	.93	-0.08	.21	.23	.05	-0.28	.52
3 to 4 p.m.	4	.75	1.07	1.45	1.09	-0.32	.38	.18	.06	-0.28	.51
Average		0.73	0.63	0.78	0.71	0.10	0.15	0.15	-0.03	-0.12	0.34

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Table 4

Thermoscreen Errors Observed Between 10:00 and 11:00 O'clock

NAX 1-46 Thermoscreen

Test No.	Langley hour	Wind MPH	Amb. °F	R.H. %	Date	Error °F
6	73.1	2.8	73.9	64	5-29-52	0.4
12	76.7	4.2	75.4	46	5-28-52	.7
16	81.0	3.7	86.7	43	6-19-52	.9
17	75.5	3.2	85.0	69	6-17-52	.3
29	77.6	2.7	79.4	62	6-15-52	.8
33	84.8	6.2	64.9	48	6-11-52	.9
36	82.1	4.5	80.3	45	6-18-52	.9
Average	78.68	3.90	77.94	53.85		0.70

Large Wooden Thermoscreen

Test No.	Langley hour	Wind MPH	Amb. °F	R.H. %	Date	Error °F
A	41.0	2.9	67	71	7-21-50	0.57
B	70.2	4.2	80	55	7-25-50	.58
C	66.6	3.0	72	67	7-27-50	.61
D	69.2	3.1	80	64	7-29-50	.74
E	71.8	3.3	83	63	7-30-50	.47
F	61.4	3.1	87	66	8-1-50	.69
G	79.0	4.9	74	53	8-4-50	.27
H	79.0	3.8	78	58	8-6-50	.41
I	75.4	2.1	75	56	8-7-50	.63
J	74.4	2.6	77	56	8-8-50	1.10
L	59.2	2.9	80	70	8-31-50	0.74
M	46.2	2.3	77	94	9-10-50	.44
Average	66.11	3.18	77.50	64.41		0.60

Table 5

Thermoscreen Errors Observed Between 13:00 and 14:00 O'clock

NAX 1-46 Thermoscreen

Test No.	Solar Inten. Langley hour	Wind MPH	Air Temp. °F	R.H. %	Date	Error °F
1	75.5	3	80.7	43	5-25-52	0.8
9	85.5	4.4	73.5	34	5-27-52	.8
22	84.4	3.0	83.8	57	6-15-52	.7
34	82.8	5.5	84.9	37	6-18-52	.7
37	78.7	2.6	86.0	57	6-16-52	.6
39	90.4	6.2	69.0	45	6-11-52	.6
42	74.9	4.9	90.1	34	6-19-52	.4
Average	81.74	4.22	81.14	43.8		0.66

Table 5 - continued

Large Wooden Thermoscreen						
Test No.	Langley hour	Wind MPH	Amb. °F	R.H. %	Date	Error °F
1	33.5	2.0	71	62	7-21-50	0.81
2	73.1	4.5	82	49	7-25-50	.55
3	73.4	2.9	78	54	7-27-50	.90
4	73.8	3.0	85	52	7-29-50	.84
5	72.5	3.2	87	54	7-30-50	.66
6	19.8	2.9	85	80	8-1-50	.97
7	78.3	4.5	78	47	8-4-50	.50
8	53.0	5.9	80	50	8-6-50	.46
9	58.5	2.6	78	50	8-7-50	1.02
10	77.4	2.3	82	47	8-8-50	1.48
11	65.6	2.1	84	51	8-30-50	1.05
12	56.2	3.8	83	64	8-31-50	.70
13	50.4	2.0	81	77	9-10-50	.77
14	52.0	2.6	81	46	10-2-50	.83
15	50.7	3.1	79	53	10-3-50	.78
16	44.5	3.0	70	44	10-11-50	.56
Average	58.29	3.15	80.25	55.25		0.80

Table 6

Thermoscreen Errors Observed Between 15:00 and 16:00 O'clock

NAX-1-46 Thermoscreen

Test No.	Solar Inten. Langleys Hour	Wind MPH	Air Temp. °F	R.H. %	Date	Error °F
23	61.2	3.7	83.8	56	6-15-52	0.9
27	56.6	2.6	88.7	48	6-16-52	1.1
31	60.7	4.8	86.8	30	6-18-52	1.3
44	61.5	3.9	90.2	34	6-19-52	1.1
Average	60.0	3.75	87.37	42.0		1.10

Large Wooden Thermoscreen

Test No.	Solar Inten. Langleys Hour	Wind MPH	Air Temp. °F	R.H. %	Date	Error °F
1A	42.2	2.1	73	58	7-21-50	1.05
2A	55.9	3.6	83	45	7-25-50	.94
3A	50.4	3.1	77	50	7-27-50	1.68
4A	51.0	2.7	85	46	7-29-50	1.25
5A	50.0	2.7	89	51	7-30-50	1.19
6A	26.0	1.8	88	70	8-1-50	1.82
7A	50.7	4.3	78	46	8-4-50	.80
8A	30.9	4.9	79	49	8-6-50	.67
9A	17.9	2.0	77	52	8-7-50	1.26
10A	52.0	2.5	82	46	8-8-50	1.77
11A	43.9	2.5	85	47	8-30-50	1.65
12A	24.0	2.4	83	62	8-31-50	.94
13A	5.5	1.8	75	80	9-10-50	1.13
14A	31.5	2.4	80	45	10-2-50	1.99
15A	27.6	2.5	78	50	10-3-50	1.27
16A	12.0	2.7	69	54	10-11-50	1.14
Average	35.71	2.75	70.31	53.18		1.28

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