AN INVESTIGATION OF THE HEAT TRANSMISSION AND MECHANICAL PROPERTIES OF SEVERAL TYPES OF PERIMETER INSULATION UNDER DRY AND SATURATED CONDITIONS

Thesis for the Degree of M. S.

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Walter Wesley Treichler, Jr.

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THESIS

This is to certify that the

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"An Investigation of the Heat Transmission and Mechanical Properties of Several Types of Perimeter Insulation under Dry and Saturated Conditions"

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AN INVESTIGATION OF THE HEAT TRANSMISSION AND MECHANICAL PROPERTIES OF SEVERAL TYPES OF PERIMETER INSULATION UNDER DRY AND SATURATED CONDITIONS

By

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Grateful acknowledgment is also due to Mr. Donald R. Renwick for his cooperation in making the refrigeration laboratory facilities available for this investigation and to Mr. D. W. Sebel and Mr. C. M. Redman, of the Power Laboratory staff, for their assistance in assembling the necessary apparatus.

THE

LIST OF FIGURES AND TABLES

THE

INTRODUCTION

One of the new trends in home construction has been the basementless, slab foundation house in which a concrete slab poured above grade serves as the ground floor. While this method makes possible many economies in production, certain essential details must not be omitted if satisfactory results are to be expected. For example, at least four inches of gravel should underlie the concrete slab, and its lower surface should be sealed with a moisture-proof membrane. This is necessary to avoid the possibility of ground water seeping into the slab.

In addition, studies conducted by the National Bureau of Standards* and the Small Homes Council of the University of Illinois** have definitely proved that thermal insulation of the slab is required to prevent excessive heat losses during the heating season.

It was also discovered that the major portion of the heat loss from the slab occurred through the outer edges rather than the undersurface, and that the installation of suitable insulation around the slab perimeter reduced the total heat loss by as much as twenty-five percent. The minimum recommended thickness for this insulation is two inches. In cases where radiant heating ducts or pipes are incorporated in the slab, the insulation should cover the undersurface of the slab as well as the

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*Dill, Richard S., W. C. Robinson, and H. E. Robinson. Measurement of Heat Losses from Slab Floors. United States National Bureau of Standards, Washington, Building Materials and Structures Report BMS 103, 1945.

**Bareither, H. D., and J. T. Landrum. Concrete Floors for Basementless Houses. University of Illinois Small Homes Council, Urbana, Bulletin F. 4.3, 1948.

perimeter. Figure 1 shows various possible applications of perimeter insulation. Note application 1d which indicates a method of applying perimeter insulations to an existing structure.

An added benefit obtained by the use of perimeter insulation is a reduction in temperature gradient from the center to the outer edges of the slab surface by as much as thirty percent.

While no industry-wide standards have been established to date, it is fairly obvious that there are certain properties which an insulating material selected for this application should possess. First of all, the material should have a sufficiently low coefficient of thermal conductivity as installed and be capable of maintaining it. It should not absorb nor be appreciably affected by water or water vapor. It should preferably be available in board or block form, and should be crush-resistant whether damp or dry, with a compressive strength of not less than five hundred pounds per square foot. Finally, the material should be unaffected by soil chemicals and should not be a harboring place for vermin, molds, or mildew.

Four types of insulation--Styrofoam, Foamglas, Fiberglas and corkboard--were selected for the investigation on the assumption that they possessed all or most of the desired properties. The purpose of the investigation was to test each material under identical conditions, determine to what degree each possessed the desired properties, and compare all of the materials on this basis.

Tests for resistance to soil chemicals, vermin, and fungi were beyond the scope of this investigation, but determinations of compressive and flexural strength, impact resistance, moisture absorption, and heat transmission properties were undertaken.

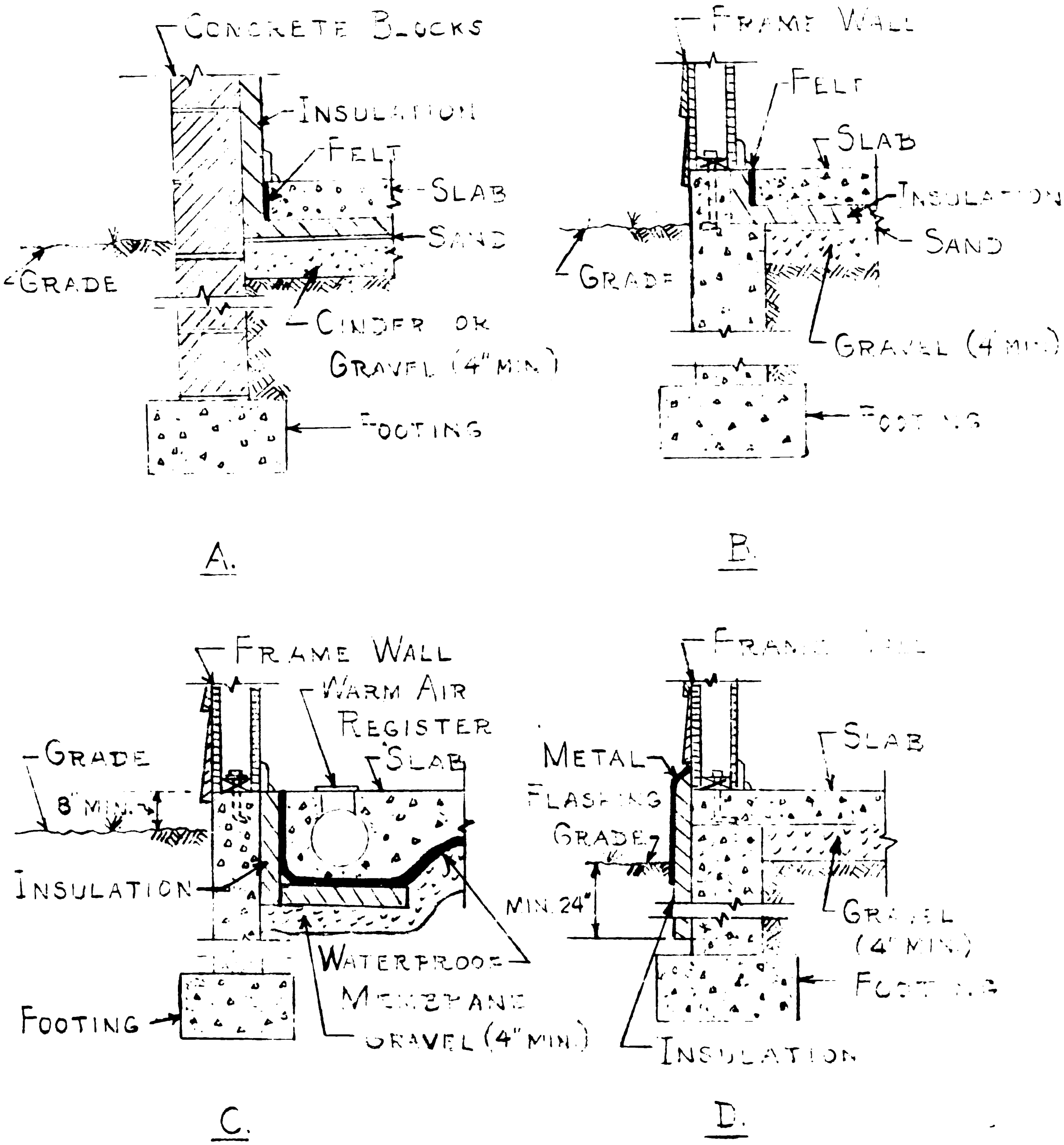

Fig. 1. Various Applications of Perimeter Insulation.

THE

Although an ideal perimeter insulation should absorb no moisture, none of the materials selected were absolutely moisture proof. Since exposure to moisture is a possible hazard in application, it was considered desirable to discover what effect (if any) the presence of moisture had on the various properties considered. This decision resulted in added complications in the test procedure, especially in the determination of heat transmission properties. The nature of these complications and the apparatus and test procedures developed to overcome them are discussed in the following chapter.

THE

APPARATUS AND METHODOLOGY

MOISTURE ABSORPTION

In this phase of the investigation, two lots of samples were prepared. One lot, after being oven-baked to the bone-dry state, was weighed and immersed in a tank of water. The second lot, also baked dry and weighed, was placed in a high-humidity chamber where saturated conditions were maintained at a temperature of approximately 115° Fahrenheit. Details of this chamber are as shown in Figure 2. Both lots were removed for weighing periodically, and the test was concluded after the completion of four hundred hours' exposure. Amount of moisture absorbed in any case was indicated by the difference between the bone-dry weights and the observed weights. It was necessary to allow excess liquid to drain from the samples before attempting to determine moisture absorption, particularly in the case of the corkboard and Fiberglas samples.

DETERMINATION of STRUCTURAL PROPERTIES

Because of the various ways in which the perimeter insulation might be stressed, it was felt that a determination of the compressive, flexural, and impact strength should be made for each material under investigation. Further, it was desired that the determination should be made for both normal and saturated conditions. Therefore, two identical lots of specimens were prepared, one lot to be tested in the normal state (less than 0.05% moisture content, by weight) and the other after immersion in water for two weeks. The compression and flexural tests were performed on a

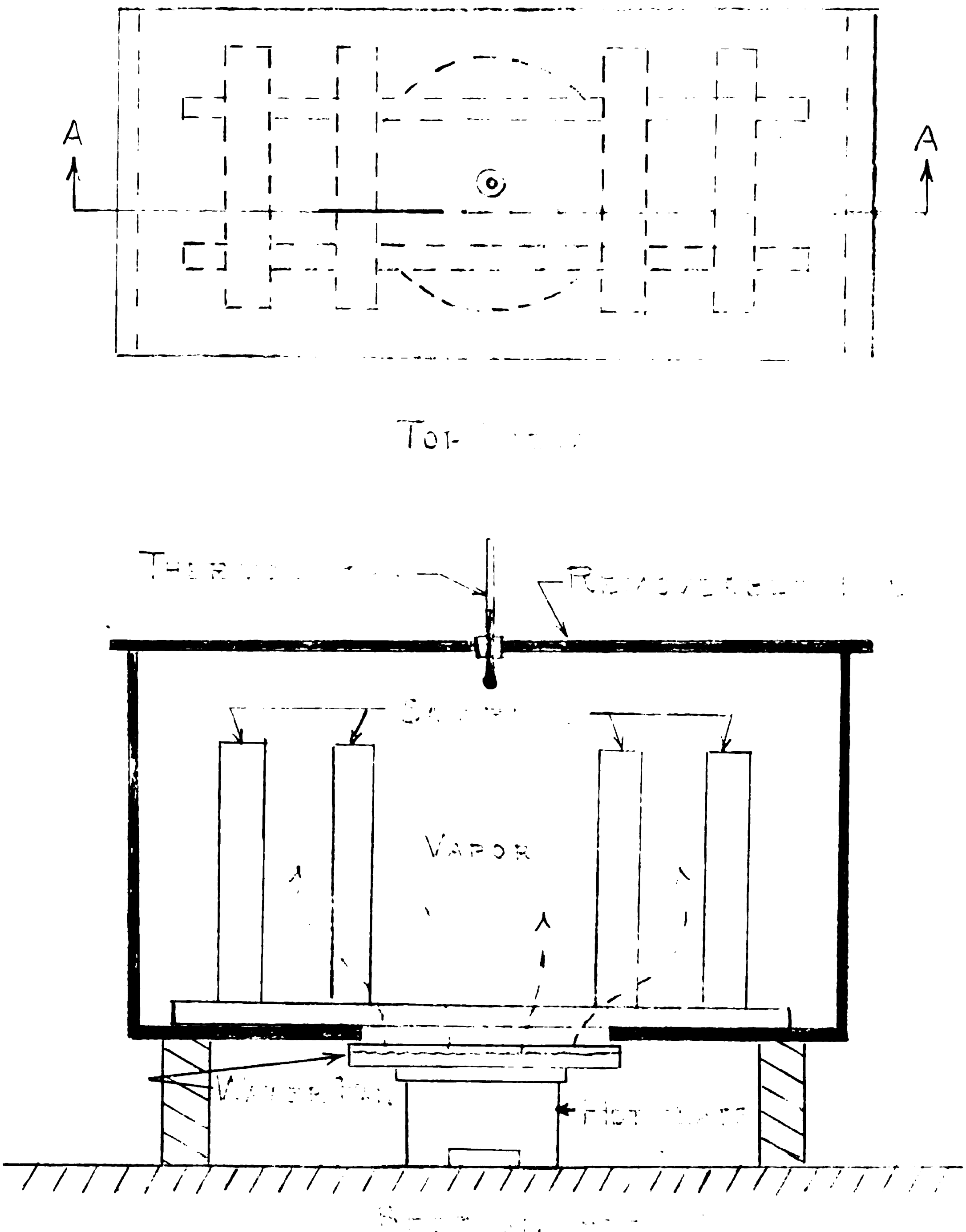

FIG. 2 HIGH HUMIDITY CHAMBER

standard Tinius Olsen, screw-type, manually-loaded testing machine.

Compression samples measured $3\frac{1}{2}$" x $3\frac{1}{2}$" x 2", except those of Fiberglas, which were $3\frac{1}{2}$" x $3\frac{1}{2}$" x $2\frac{1}{8}$". Since it was found that these materials had no definite yield point, merely becoming more compact and firm as compressive load was applied, compressive strength comparisons were based on the amount of load each material would support when compressed to 90% of its original thickness. The tests were then carried out on this basis, using a dial indicator to measure the amount of compacting.

For flexural strength determination, samples measuring 8" x 2" x 2" (8" x 2" x $2\frac{1}{8}$" for Fiberglas) were placed on V-blocks seven inches apart, and a wedge-type head was utilized on the Tinius Olsen screw-type testing machine as shown in Figure 3. Deflection was measured with a dial indicator.

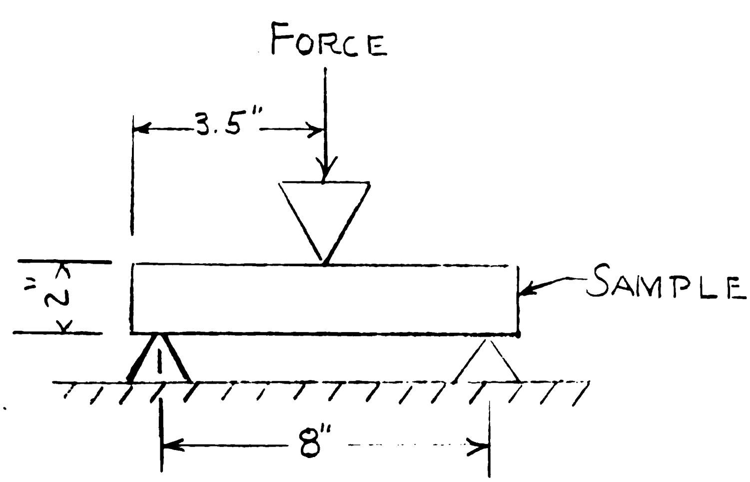

FIGURE 3.

For impact strength measurements, a steel ball one inch in diameter and weighing 0.135 pounds was dropped from a height of six feet upon the wet and dry samples. The Fiberglas samples were tested on the edge as well as on the face because of their nonhomogeneous laminar structure.

Three samples of each material were tested under normal and saturated conditions, and three drops were made on each sample, a total of eighteen per material.

DETERMINATION of HEAT-TRANSMISSION PROPERTIES

Since heat transmission properties of the selected insulating materials were to be determined under both wet and dry conditions, a departure from the conventional testing procedure was necessary. With the standard methods of determining thermal conductivity, accurate results from a moisture-laden sample are problematical, because a temperature difference is maintained between the two faces of the sample and any moisture contained therein migrates to the colder side.*

If a method were to be used in which the opposite faces of the sample were alternately the colder, then it would be reasonable to assume that the absorbed moisture would not migrate to one particular face. In all probability, most of it would remain in the interior of the sample.

In addition, any apparatus devised to produce this reversal of temperature gradient should be of such a nature that the temperature variations would conform to proven principles for heat flow in the unsteady state. Test results then could be applied in existing equations for computation of

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*Wilkes, G. B. Heat Insulation. New York: John Wiley and Sons, 1950, p. 152.

heat transfer coefficients. Therefore, it was decided to assemble an infinitely thick body subjected to a periodically varying temperature at one surface. Two equations applying to this case are the following:

(1) $$r = \frac{x}{2}\sqrt{\frac{1}{\alpha n \pi}}$$

Where: r = time for temperature of a given point within the body to be influenced by a change in surface temperature

n = number of complete cycles per hour

x = distance from the surface to the interior plane

α = thermal diffusivity = $\frac{\text{Coefficient of Thermal Conductivity}}{\text{Specific Heat x Density}}$

(2) $$\theta_p = \theta_s \epsilon^{-x\sqrt{\frac{\pi n}{\alpha}}}$$

Where: θ_p = maximum temperature variation at an interior plane

θ_s = magnitude of temperature variation at the surface

x = distance from the surface to the interior plane

n = number of complete cycles per hour

α = thermal diffusivity of the material*

Equation (2) was considered to be better adapted to the requirements of this investigation because of the possibility of measuring differences in temperature variation with greater accuracy than differences in time lag.

The test apparatus, as finally assembled, is pictured schematically in Figure 4. Construction of the main section of the equipment and the

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*Jakob, Max, and G. A. Hawkins. Elements of Heat Transfer and Insulation. New York, John Wiley and Sons, 1942. pp. 50-53.

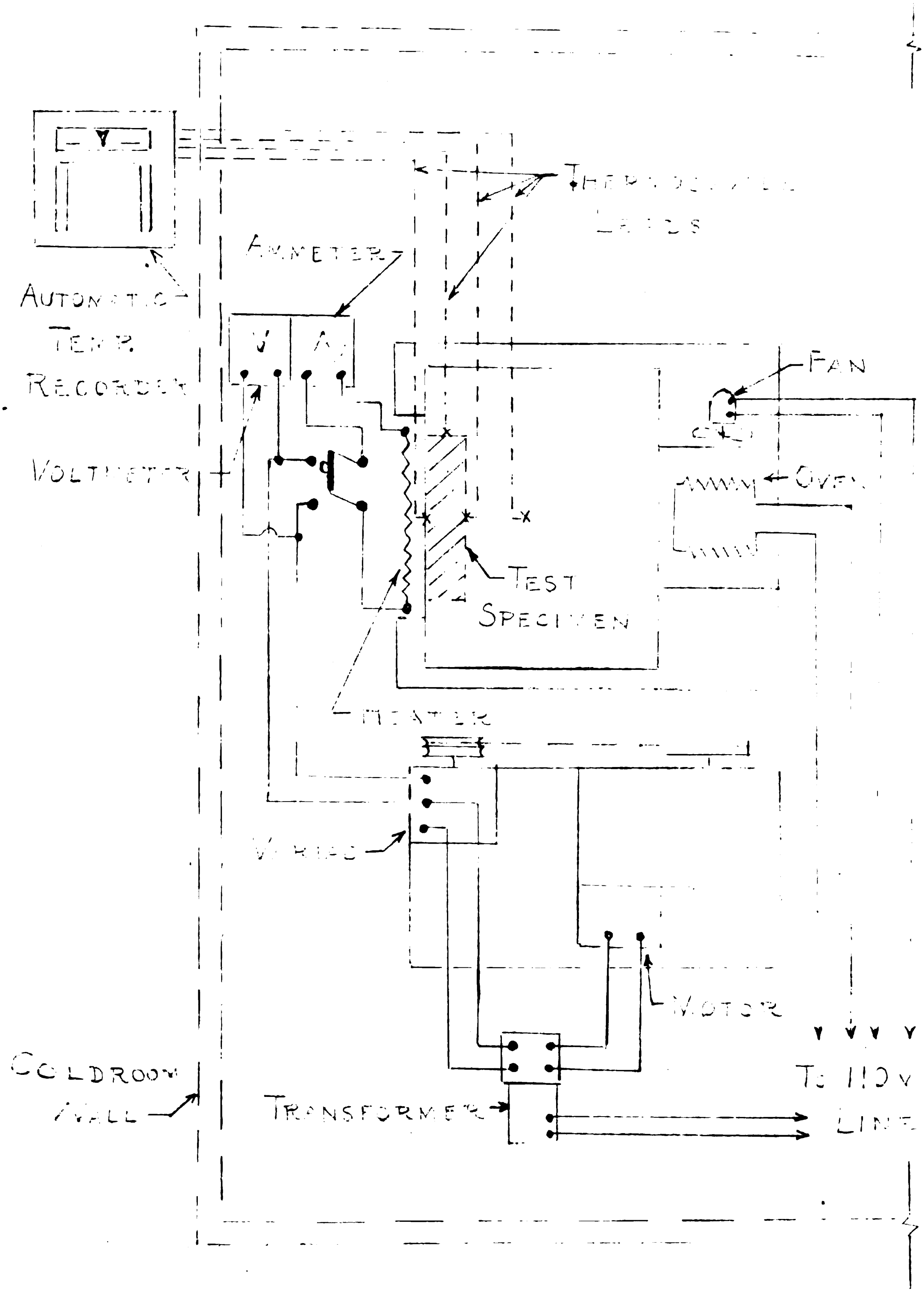

Fig. 4 Layout of Test Equipment

manner in which the test specimen is mounted are shown in greater detail on Figure 5.

The electric grid, indicated on Figures 4 and 5, provided heat source for one surface of the test specimen. A sine-wave variation in the voltage applied to this heater was produced by the arrangement pictured in Figure 6. The opposite surface and sides of the specimen were imbedded in a 24" x 24" x 15" mass of Fiberglas insulation enclosed by a plywood box. Surrounding the plywood box was a sheath of $\frac{7}{8}$" Celotex, and air at 120° Fahrenheit was circulated in the 2-inch space between the two enclosures. Heat was supplied to this enclosure by a partially dismantled electric oven with fan attached as shown in Figures 4 and 5.

All of the aforementioned equipment was installed in an insulated room with the temperature maintained at 40° Fahrenheit.

Thermocouples were placed at the center of both faces of the 12" x 12" x 2" test specimen, at the lower edge of the specimen, and at a point on the upper surface of the plywood inner box approximately five inches from the front face. Temperatures were recorded automatically by means of a Brown Electronik Potentiometer mounted on the outside of the insulated room.

An additional check on the temperature of the air circulating in the space between the two shells of the specimen mounting was provided by a mercury thermometer inserted at the rear near the oven.

The temperature of the air circulating around the equipment in the insulated room was indicated and recorded by a Brown Recording Thermometer with a temperature-sensitive bulb in the air exhaust duct. A mercury thermometer suspended in the room provided a check on these readings.

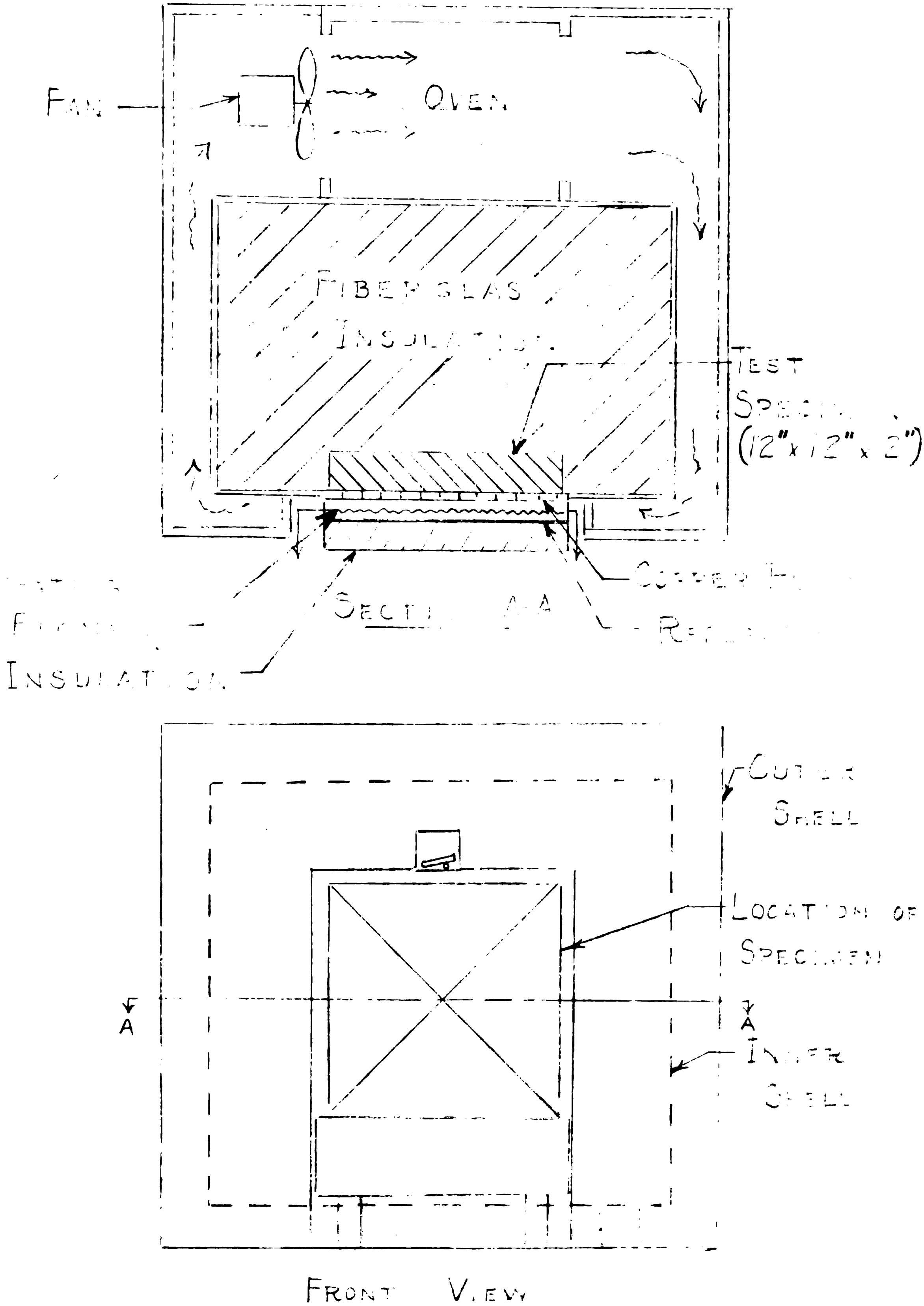

FIG. 5 DETAIL OF TEST SPECIMEN MOUNTING

The length of the complete temperature variation cycle was twelve hours. The equipment was adjusted to produce a temperature variation at the exposed face of the test specimen from 80° to 160° Fahrenheit with a mean of 120° Fahrenheit. Test periods for each specimen were twenty-four hours, or two complete cycles.

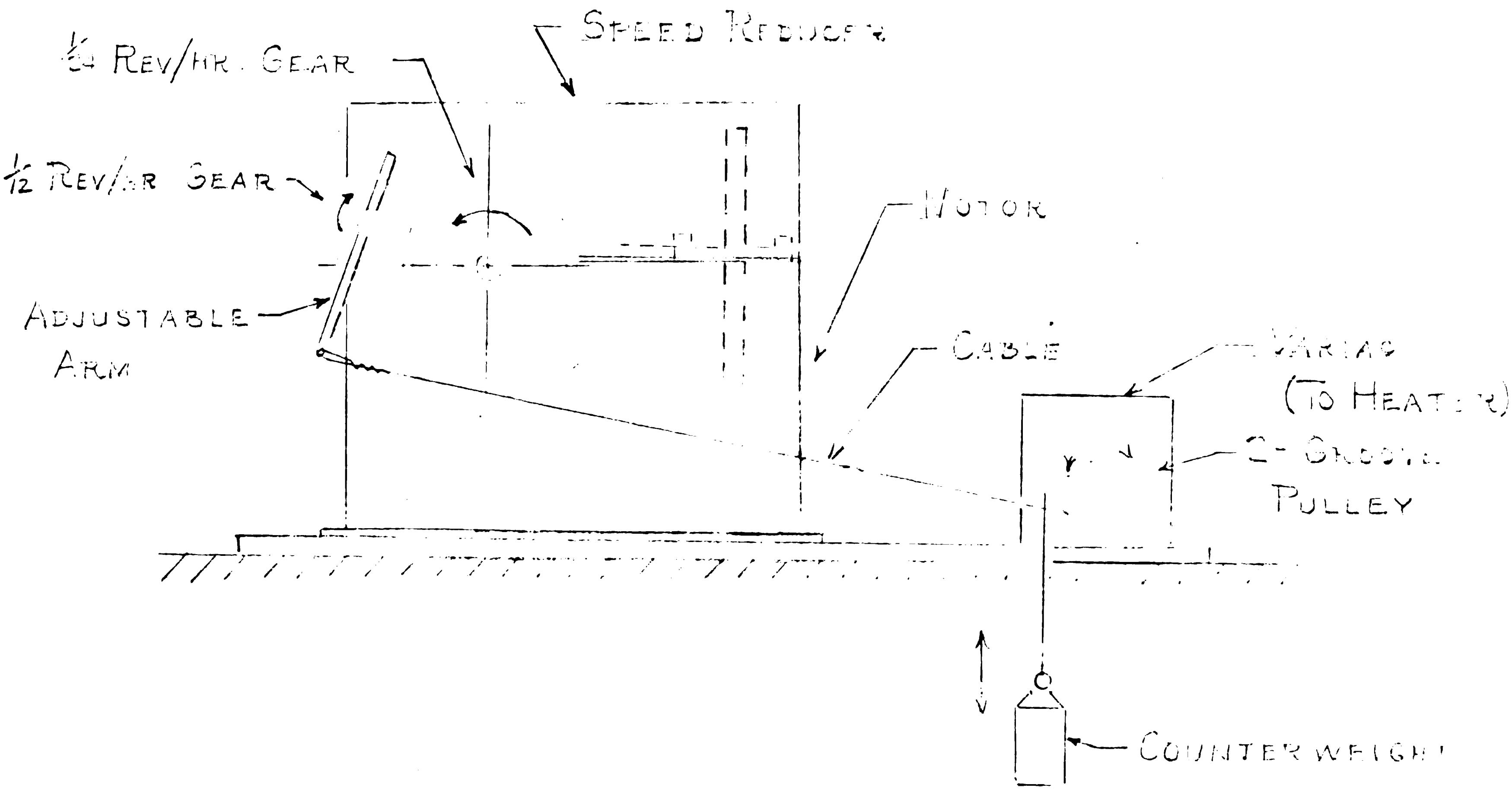

Fig. 6 Apparatus to Produce Sine-Wave Current Variation in Heater Coil.

DISCUSSION OF RESULTS

MOISTURE ABSORPTION

The results of the moisture absorption tests are shown in Figures 7 and 8. It should be noted that the amount of moisture present in each sample is expressed as a percentage by volume while usually the moisture content of insulating materials is stated as a percentage by weight. A percentage by weight comparison can be extremely misleading when materials of rather great differences in density are compared.*

On a percentage by weight basis, for example, final moisture content of the Styrofoam sample after four-hundred hours immersion would be 41% and the moisture content of the corkboard sample would be 35%. Actually, the corkboard sample had absorbed over twice as much moisture, and by indicating results on a percent-by-volume basis, the true relationship is shown. The moisture content by volume was 2% for Styrofoam and 5% for corkboard.

STRUCTURAL PROPERTIES

The results of the compression and flexural tests for the materials under investigation are as shown on Figures 9 and 10. The values indicated are the average of the results obtained on three samples of every material for each condition. Flexural strengths were compared on the

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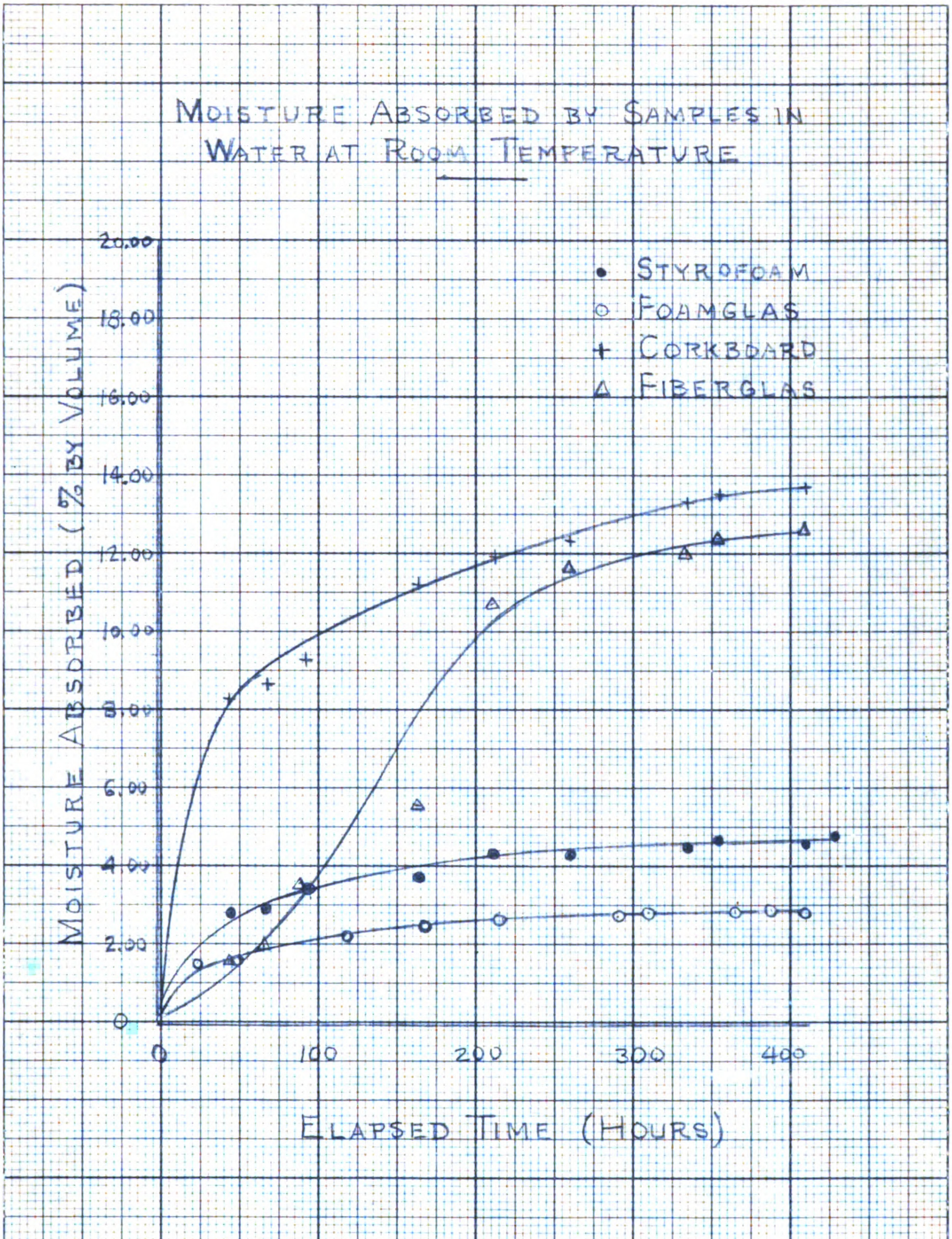
*Wilkes, G. B. Heat Insulation. New York: John Wiley and Sons, 1950, pp. 89-90.



MOISTURE ABSORBED BY SAMPLES IN WATER AT ROOM TEMPERATURE
• STYROFOAM
○ FOAMGLAS
+ CORKBOARD
Δ FIBERGLAS
MOISTURE ABSORBED (% BY VOLUME)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0
0
100
200
300
400
ELAPSED TIME (HOURS)

FIG. 7

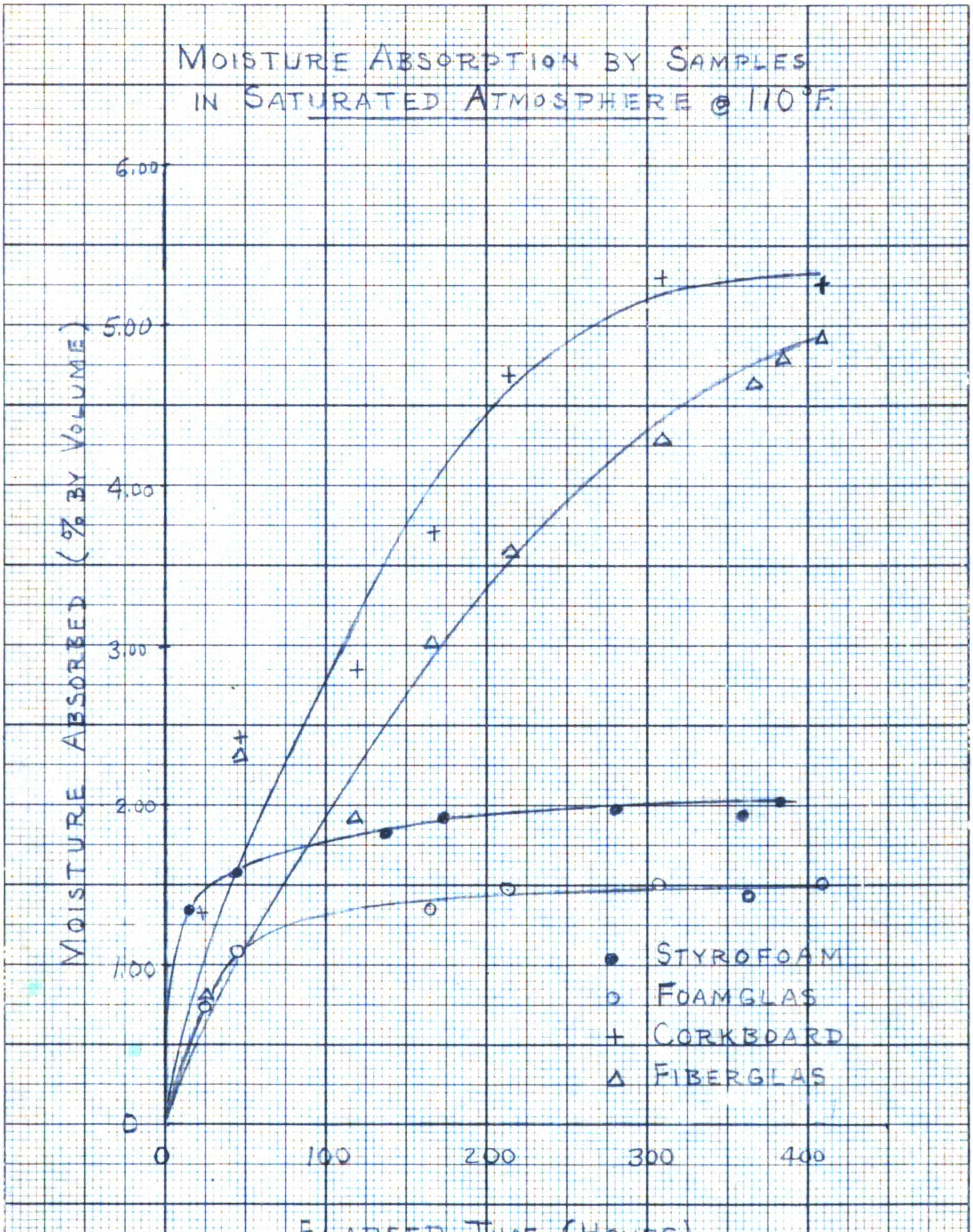

Moisture Absorption by Samples
in Saturated Atmosphere @ 110°F.
Moisture Absorbed (% by Volume)
6.00
5.00
4.00
3.00
2.00
1.00
0
0
100
200
300
400
Elapsed Time (Hours)
Styrofoam
Foamglas
Corkboard
Fiberglas

Fig. 8

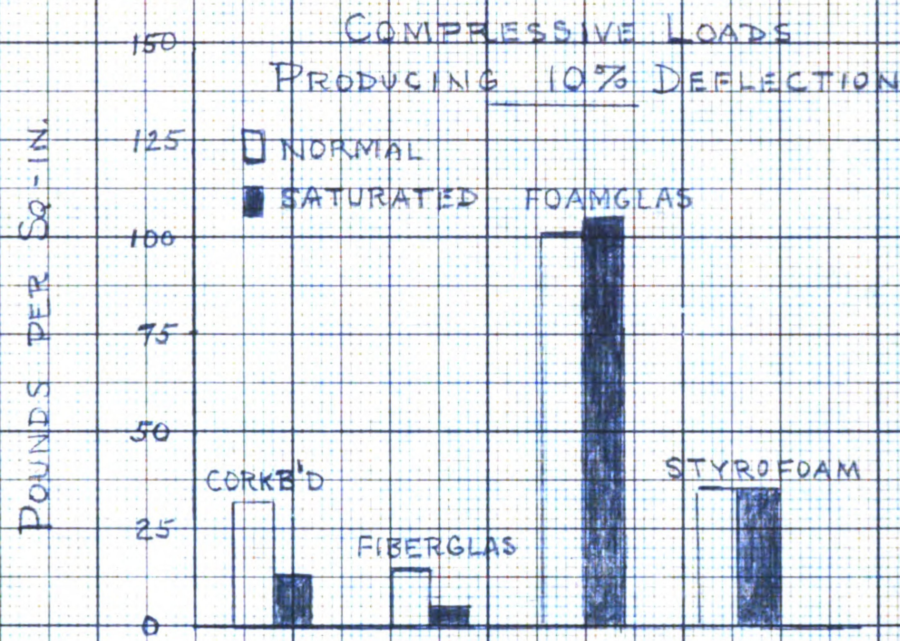

COMPRESSIVE LOADS
PRODUCING 10% DEFLECTION
POUNDS PER SQ-IN.
150
125
100
75
50
25
0
NORMAL
SATURATED
FOAMGLAS
CORKB'D
FIBERGLAS
STYROFOAM

FIG. 9

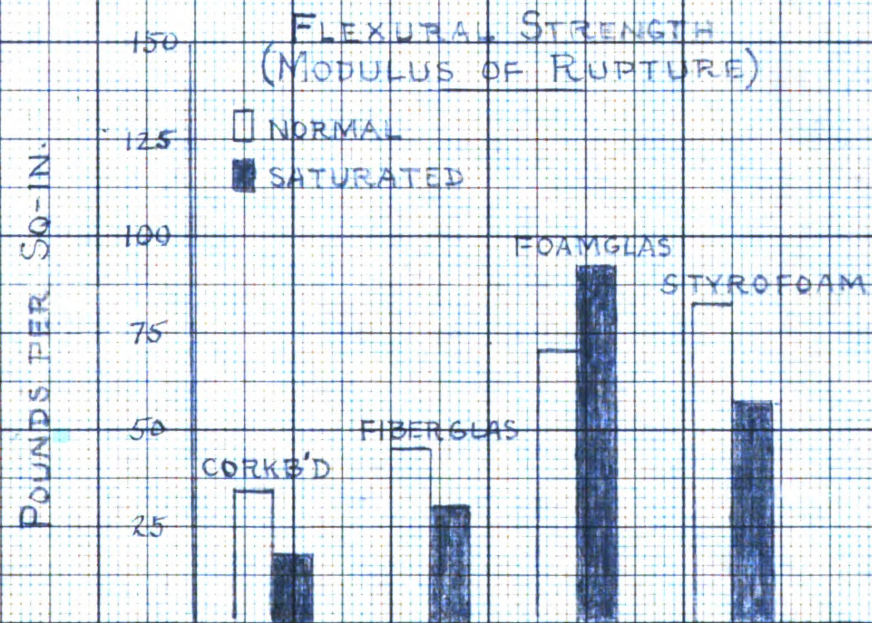
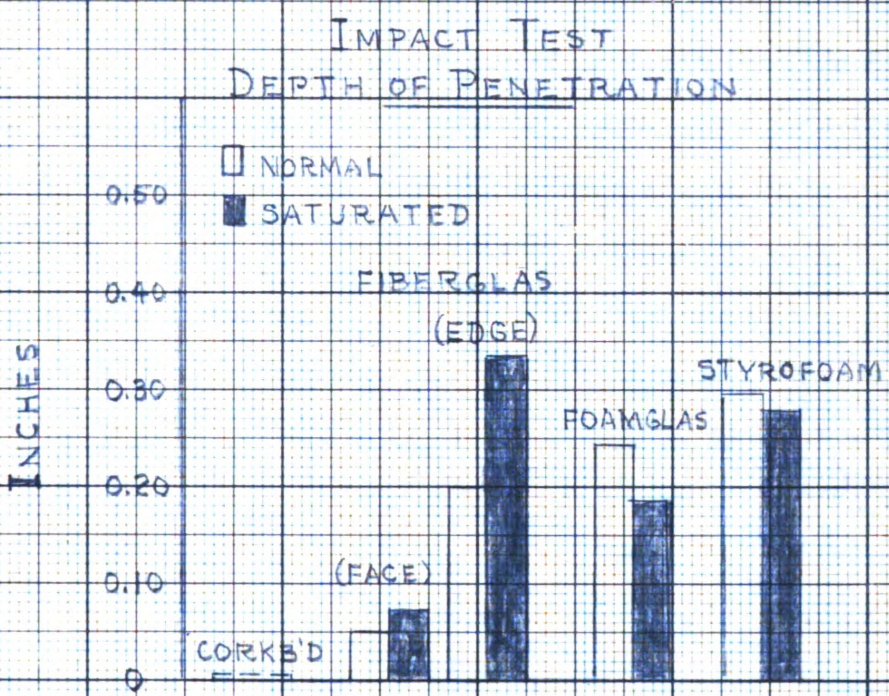

FLEXURAL STRENGTH
(MODULUS OF RUPTURE)
POUNDS PER SQ-IN.
150
125
100
75
50
25
NORMAL
SATURATED
FOAMGLAS
STYROFOAM
FIBERGLAS
CORKB'D

FIG. 10



IMPACT TEST
DEPTH OF PENETRATION
NORMAL
SATURATED
INCHES
0.50
0.40
0.30
0.20
0.10
0
FIBERGLAS
(EDGE)
(FACE)
CORKB'D
FOAMGLAS
STYROFOAM

FIG. 11

basis of Modulus of Rupture expressed in pounds per square inch.

$$\text{Modulus of Rupture} = \frac{\text{Bending Moment x Distance, Neutral Axis to Outer Fiber}}{\text{Moment of Inertia for Section}}$$

The results of the impact test are pictured in Figure 11. Impact resistance, of course, varies **inversely** as depth of penetration. This test was roughly comparable to dropping one leg of a twenty-pound-chair on the insulation from a height of three inches.

It should be noted that while the compressive and flexural strength of three of the materials tested remained the same or decreased after saturation, the flexural and compressive strength of Foamglas increased. Also, both Styrofoam and Foamglas showed an apparent increase in impact resistance after saturation. It is thought that this was due primarily to an increase in resilience of the exposed surfaces. According to the manufacturer, moisture does not penetrate beyond the surface layer of cells to any great extent.

RESULTS of HEAT TRANSMISSION TEST

The results of the heat transmission tests are shown in Figures 12 and 13. Figure 12 shows the variation in thermal diffusivity for the various samples with moisture content by weight. A comparison is made with a thermal diffusivity curve for wood fiberboard computed from the results of an investigation by Hechler, McLaughlin, and Queer* to determine heat and vapor transfer characteristics of the material. We may

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*Hechler, F. G., E. R. McLaughlin, and E. R. Queer. Simultaneous Heat and Vapor Transfer Characteristics of an Insulating Material. American Society of Heating and Ventilating Engineers Transactions, Vol. 48, 1942, p. 512.

also compare results with those of an investigation of foundry sand by Tanasawa (1935) described in Jakob*, where it was found that the thermal diffusivity of the sand first increased and then decreased with increasing humidity with a maximum at a humidity of 10% by volume. The reason being that starting with dry material the k first rose fast and then slowly to about five times its original value, whereas c_p increased at a linear rate. Tanasawa employed a periodic heat flow with very high frequency and a temperature difference of less than one-half degree Fahrenheit.

It must be noted here that although the approach to the problem of determining the heat flow characteristics of the selected insulating materials was based on the long-established principles of temperature variation in an infinitely thick homogeneous body subjected to periodically varying temperature on one surface, the actual experimental conditions departed somewhat from the theoretical ideal. Due to the impracticability of utilizing a large mass of each individual type of insulation at the identical saturation conditions of the 12" x 12" x 2" samples, a single enclosing mass of 2.18 pound per cubic foot Fiberglas was employed for all samples. The value of thermal diffusivity computed directly from test data then is actually a composite of that of the sample and the Fiberglas.

However, the test value should fall between the actual thermal diffusivity of the sample and that of the Fiberglas. In fact, for the conditions of this investigation it appeared that the relationship between the test diffusivity, actual diffusivity, and the diffusivity of the Fiberglas could be expressed with sufficient accuracy as a direct proportion--Fiberglas (α): Test (α) = Test (α): Actual (α). Test values were corrected

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*Jakob, Max. Heat Transfer. New York: John Wiley and Sons, Vol. I, 1949, pp. 320-321.

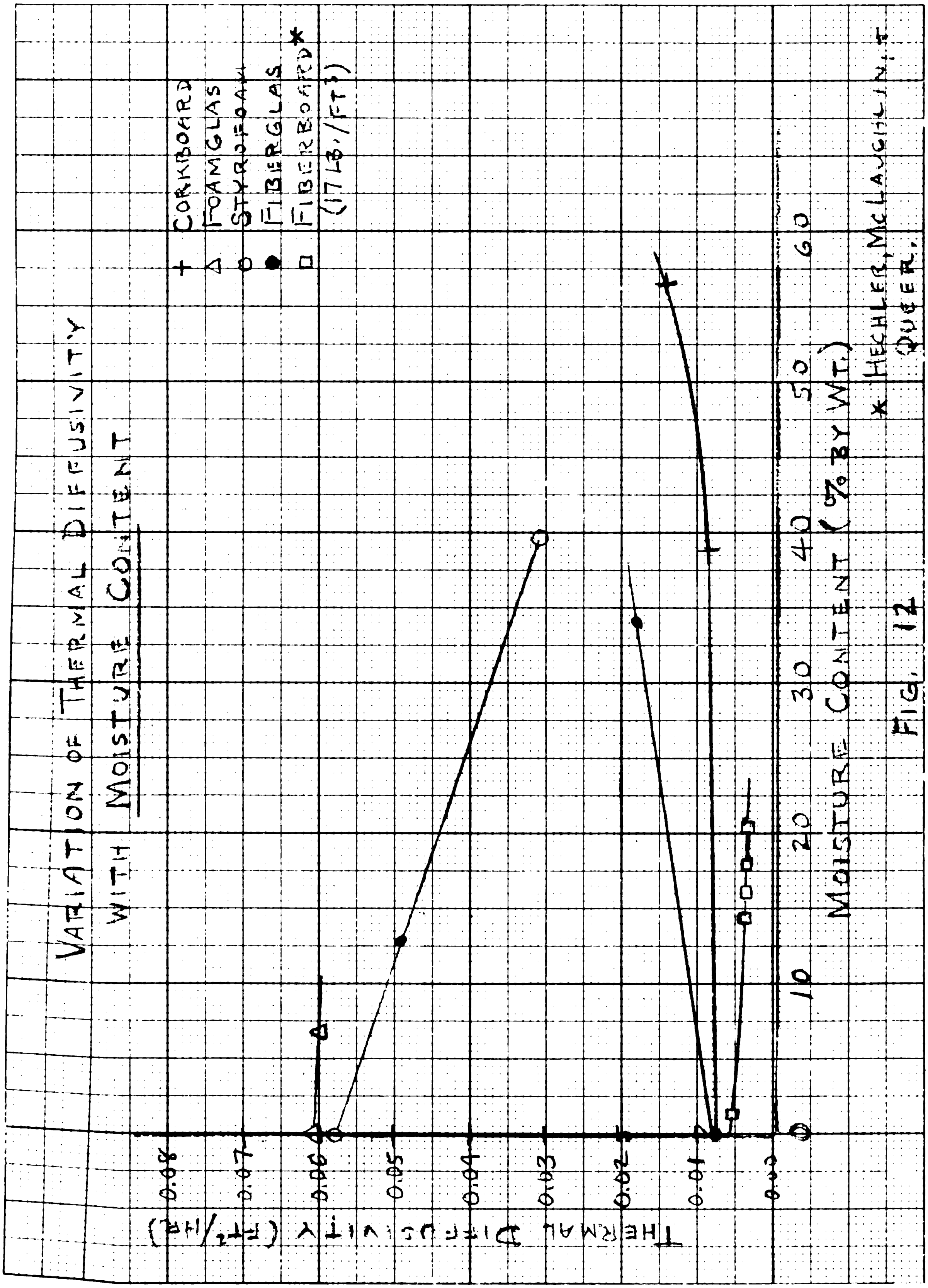
VARIATION OF THERMAL DIFFUSIVITY
WITH MOISTURE CONTENT
+ CORKBOARD
Δ FOAMGLAS
○ STYROFOAM
● FIBERGLAS
□ FIBERBOARD*
(17 LB./FT³)
THERMAL DIFFUSIVITY (FT²/HR)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
10
20
30
40
50
60
MOISTURE CONTENT (% BY WT.)
* HECHLER, McLAUGHLIN, QUEER.

FIG. 12

on this basis after a test of a sample of Fiberglas identical to that used in the backing provided a value for the thermal diffusivity. The determined value varied less than three percent from the computed value obtained using actual apparent density and the manufacturer's values for specific heat and thermal conductivity.

From the curves of Figure 12, it is seen that the thermal diffusivity of corkboard changes little until moisture content exceeds forty percent by weight, the rise in thermal conductivity apparently being balanced by the specific heat and density. The fiberboard, over the range covered, shows a slight increase in diffusivity. The other materials show varying trends. The obvious conclusion is that no set rule for a change in thermal diffusivity with change in moisture content is readily formulated, because the quantity depends upon the thermal conductivity, density, and specific heat, all of which are undergoing simultaneous changes at different rates as the moisture changes. The point at thirteen percent by weight for Fiberglas should be disregarded due to the fact that the sample had expanded to practically 150 percent of its original thickness during exposure in the high-humidity chamber and it was necessary to remove a portion of the material in order to fit it into the test apparatus. The high values of thermal diffusivity which are exhibited by Foamglas are rather difficult to account for. Calculation, using actual density and values of specific heat and thermal conductivity as given by the manufacturer, results in a value of approximately 0.020 and the test result should fall between this figure and that of the Fiberglas backing, which was 0.0519. Possible reasons for the discrepancy could be that the samples were not truly representative of the average product, that some unknown, experimental variable was present, or that the specific heat and/or the thermal conductivity undergo great changes in value between the manufacturer's figures for 75° Fahrenheit and the test mean temperature of 120° Fahrenheit. Wilkes* gives figures for a temperature of 112° Fahrenheit which do not differ appreciably from those at 75° so the third possibility does not seem very likely. It would also seem somewhat odd that an experimental error should occur only for the two samples of the one material, especially since the two tests were not consecutive. Probably the first reason given must be accepted as the most logical until further investigation is undertaken to prove otherwise.

In the calculation of thermal conductivity from the test results, values of specific heat and density are needed as well as thermal diffusivity.

No values of specific heat for moisture-laden materials were found in the literature, although there have been attempts to correct k values for moisture content. Jakob** suggests the following factors to correct thermal conductivities of building materials for various percentages of moisture content by volume:

Moisture Content	Correction Factor
1.0	1.30
2.5	1.55
5.0	1.75
10.0	2.10
15.0	2.35

MacLean (1941)***, from tests on various woods, developed empirical formulas to adjust k for moisture content, but they were of no help in

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*Wilkes, G. B. Heat Insulation. New York: John Wiley and Sons, 1950, pp. 171-180.

**Jakob, Max. Heat Transfer. New York: John Wiley and Sons, Vol. I, 1949, p. 94.

***MacLean, J. D. Thermal Conductivity of Wood. Heating Piping and Air Conditioning, 13, 380, 1941. p. 390.

this case. Therefore, to provide values of specific heat for the purpose of this investigation, the specific heats as given for the dry insulating materials were combined with that of water on a percent-by-weight basis as indicated in the sample computations. This provided a linear increase in specific heat values with increasing moisture content. The resulting calculated value was used with the apparent density and thermal diffusivity to determine thermal conductivities for the moisture-laden samples.

The variation in thermal conductivities with moisture content is shown on Figure 13. As expected, apparent <u>k</u> increases with moisture content, although at different rates for the various materials. An interesting correlation is obtained, in the case of corkboard, with data graphically portrayed in Wilkes*. This investigation extended only to a moisture content of approximately seventeen percent by weight. Nevertheless, this agreement seems to indicate that the method of correcting specific heat for moisture content is a valid one.

The values of conductivity indicated for Foamglas must be viewed with skepticism for the reasons outlined in the discussion of Figure 12. Also, the point for Fiberglas at thirteen percent by weight is assumed to be in error.

Slight decreases were noted in apparent densities of moisture-laden samples during the test, apparently due to evaporation of a portion of the included moisture. In order to hold this loss to a minimum, the edges and most of the inner surface of the sample had been covered with aluminum foil. The outer surface abutting the copper plate was not covered. Upon completion of a run, the foil was removed and the sample reweighed. The

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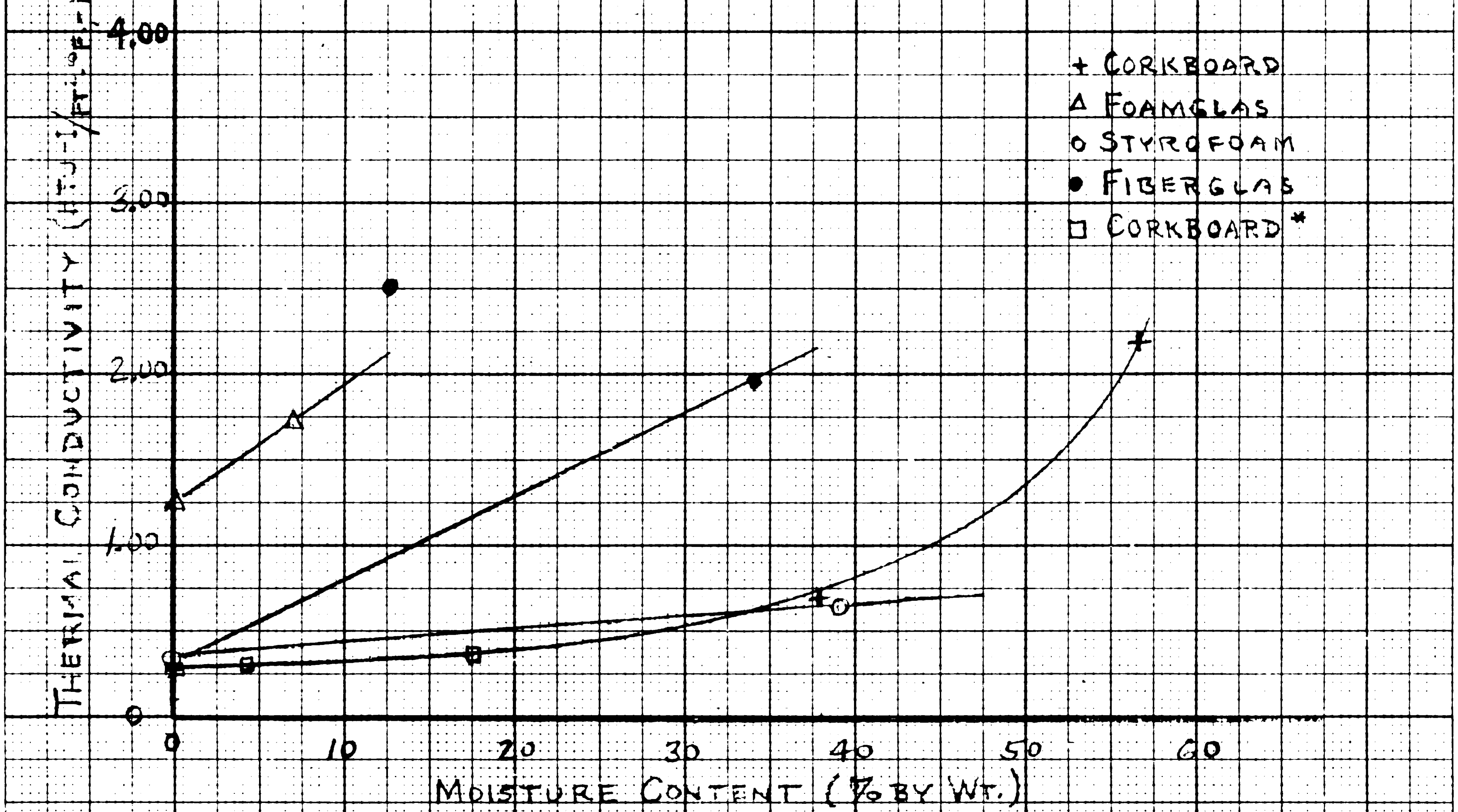
*Wilkes, G. B. <u>Heat Insulation</u>. New York: John Wiley and Sons, 1950 p. 21.

VARIATION OF THERMAL CONDUCTIVITY WITH MOISTURE CONTENT



* WILKES, P. 91

FIG. 13

weight used in determining percentage moisture content and apparent density was the numerical average of the weights at start and finish.

Only traces of moisture were noted on the foil and copper plate upon removal, indicating the apparent soundness of the premise concerning prevention of moisture migration to one surface by applying a periodically alternating temperature to the sample.

The complete results of the investigation are summarized on Table II. For comparison Table I lists the properties of the materials as obtained from texts or manufacturers' bulletins.

TABLE I

VARIOUS PROPERTIES OF INSULATING MATERIALS INVESTIGATED FROM MANUFACTURERS' DATA UNLESS OTHERWISE INDICATED

Property	Units	Corkboard	Fiberglas	Foamglas	Styrofoam
Density	Lbs./Ft.^{3}	6.9*	11.0*	9.0	1.6
Thermal diffusivity	Ft.^{2}/Hr.	0.0083*	0.0097*	0.0175	0.0598
Specific heat	Btu/Lb./$^\circ$F.	0.39*	0.24*	0.20	0.27
Thermal conductivity	$\frac{\text{Btu-In.}}{\text{Ft.}^2\text{-Hr.}^2\text{-}^\circ\text{F.}}$	0.26*	0.27*	0.40 ~~40.0~~	0.31
Compressive strength	Lbs./In.^{2}	N. A.	N. A.	125.0	25
Moisture absorption	% of Vol.	N. A.	1%	0.2%	6%

*Wilkes, G. B. Heat Insulation. New York: John Wiley and Sons, 1950, Appendix.

TABLE II

PROPERTIES OF THE INSULATING MATERIALS INVESTIGATED* AS DETERMINED FROM TESTS

Property	Units	Corkboard	Fiberglas	Foamglas	Styrofoam
Density	Lbs./Ft.^{3}	a. 7.81 b. 17.10	13.5	8.67 9.52	1.71 2.98
Thermal diffusivity	Ft.^{2}/Hr.	a. 0.0075 b. 0.014	0.0075 0.019	0.061 0.060	0.058 0.051
Specific heat	Btu/Lb./^{o}F.	a. 0.40 b. 0.74	0.24 0.50	0.20 0.25	0.27 0.56
Thermal conductivity	$\frac{\text{Btu-In.}}{\text{Ft.}^2\text{-Hr.-}^o\text{F.}}$	a. 0.27 b. 2.18	0.28 1.93	1.25 1.74	0.32 0.65
Compressive strength	Lbs./In.^{2}	a. 33 b. 14	15 5	102 105	35 35
Modulus of Rupture	Lbs./In.^{2}	a. 34 b. 17	44 30	71 92	82 37
Moisture (Liq.) absorption	% of Vol.	13.7	12.6	2.83	4.79
Moisture (Vap.) absorption	% of Vol.	5.30	4.92	1.51	2.02

*The "a" values are for the dry state; "b" were determined after immersion.

CONCLUSIONS AND RECOMMENDATIONS

From the results obtained from this investigation, it would appear that Styrofoam best meets the qualifications set forth for an ideal perimeter insulation. The apparent high values of thermal conductivity obtained for Foamglas, although not believed representative, cast some doubt upon its effectiveness as insulation, especially where radiant floor heating is employed. Fiberglas and corkboard should be made moisture and vapor proof if they are to be suitable for perimeter insulation.

It was evident, as a result of the research undertaken for this investigation, that there is a distinct lack of published information concerning the properties of the various insulations. Values of thermal conductivities and specific heats over a greater range of temperatures and for various moisture contents are particularly needed.

It is felt that the test procedures employed can be of great value in extending the knowledge of the properties of insulating materials under varying conditions of moisture content. Further refinements in the procedures and equipment used are necessary, however.

The entire mass of insulation comprising the pseudo-infinite body should be of the same material as the sample being tested, and have the same moisture content. This will necessitate the use of a much larger capacity heat source if the same temperature limits of oscillation are to be maintained.

In addition, a metal, rather than a plywood box, would be more suitable for enclosing the mass of insulation. The double-wall feature, with air circulating between the walls, could be retained, and the apparatus utilized to produce a sine-wave voltage input to the heater grid is satisfactory.

Consideration should also be given to reducing the period of the cycle and magnitude of temperature oscillation in future investigations, with the possibility of then utilizing a smaller mass of insulation to approximate the thick body.

Finally, a simple method of determining the specific heat of the moisture-laden material should be developed, so that experimental values can be combined with the thermal diffusivity test results to determine values of thermal conductivity with greater accuracy.

SAMPLE COMPUTATIONS

I. The Determination of Thermal Diffusivity (α) for corkboard (6.05% moist.):

Maximum Variation in Temperature at Interior Plane = 22.75 °F.

Magnitude of Temperature Variation at the Surface = 40.25 °F.

Number of Complete Cycles per Hour = 0.0834

Distance from Surface to Interior Plane = 0.1615 Ft.

Thermal Diffusivity of Backing Insulation = 0.0519 Ft.²/Hr.

$$\Delta\theta_p = \Delta\theta_s \, \epsilon^{-x\sqrt{\frac{\pi n}{\alpha}}}$$

$$\epsilon^{x\sqrt{\frac{\pi n}{\alpha}}} = \frac{\Delta\theta_s}{\Delta\theta_p}$$

$$0.1615\sqrt{\frac{0.0834\pi}{\alpha}} = \frac{40.25}{22.75} = 1.77$$

$$0.1615\sqrt{\frac{0.0834\pi}{\alpha}} = 0.571$$

$$\frac{0.0834\pi}{\alpha} = \left(\frac{0.571}{0.1615}\right)^2 = 12.5$$

$$\text{Thermal Diffusivity} = \alpha = \frac{0.0834\pi}{12.5}$$

$$\alpha = 0.0209 \text{ Ft.}^2/\text{Hr.}$$

Corrected Value: $\frac{0.0209}{0.0519} \times 0.0209 = 0.00842$ Ft.²/Hr.

II. Determination of Thermal Conductivity (k) for Corkboard (6.35% Moist.):

Thermal Diffusivity = 0.00842 Sq. Ft./Hr.

Density = Lbs./Cu. Ft.

Specific Heat = 0.632 Btu/Lb./°F.

Coefficient of
Thermal Conductivity, $k = c_p \, \alpha \, \rho$

$= 0.00842 \times 11.00 \times 0.632 \times 12$

$= 0.702$ Btu-In., Hr.^{-1}, Ft.^{-2}, $^{\circ}\text{F.}^{-1}$

III. Specific Heat of Moisture-Laden Sample (Corkboard):

Specific Heat of Corkboard in Dry State = 0.40 Btu/Lb./°F.

Specific Heat of Water at 120° F. = 0.0997 Btu/Lb./°F.

Percent of Water in Sample--by Weight = 38.9%

Composite Specific Heat $= 0.389 \, c_{pw} + 0.611 \, c_{pcb}$

$= (0.389 \times 0.997) + (0.611 \times 0.40)$

$c_{pc} = 0.632$ Btu/Lb./°F.

IV. Modulus of Rupture from Flexure Test Data for Styrofoam (Saturated):

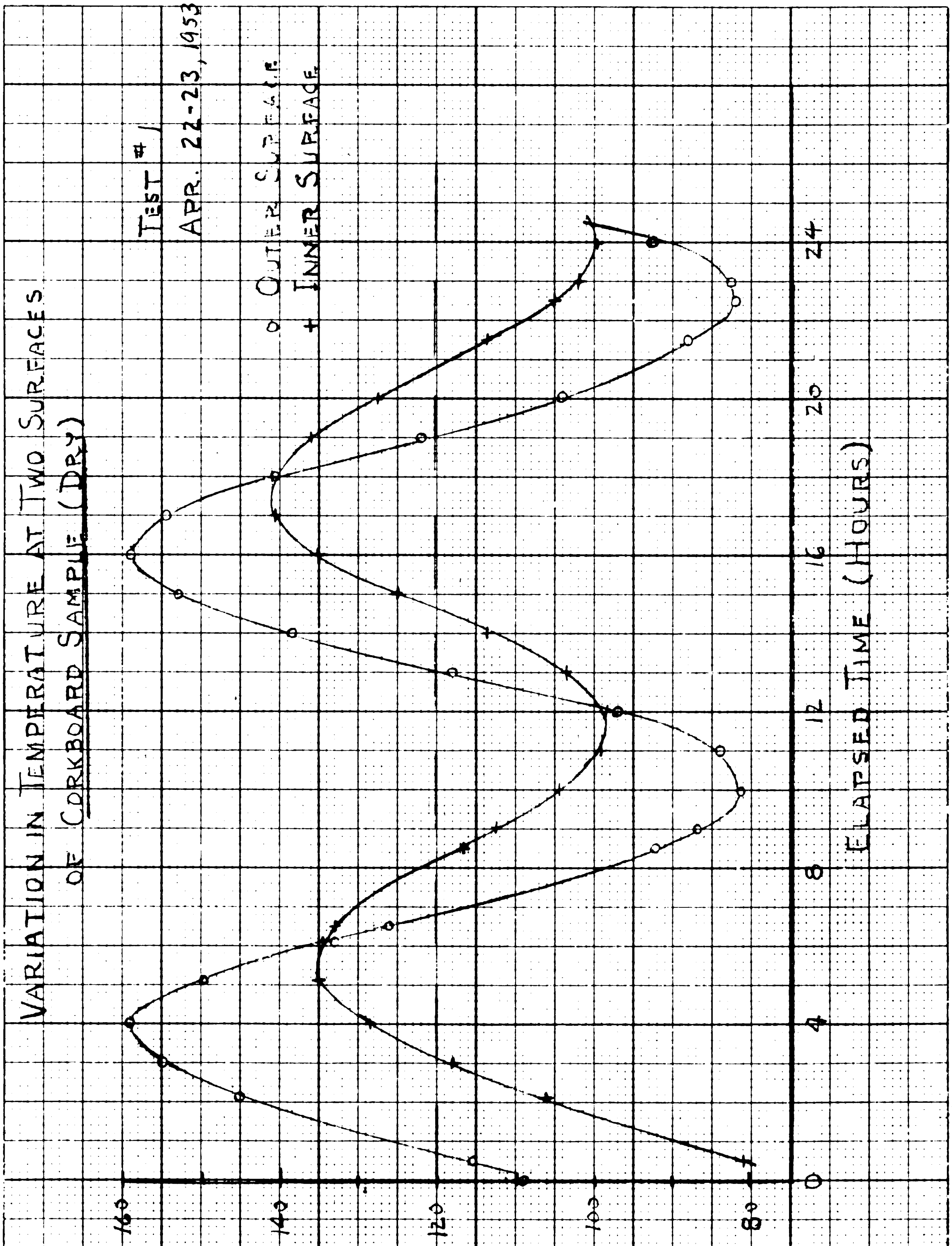
Bending Moment = 75.20 In./Lbs.

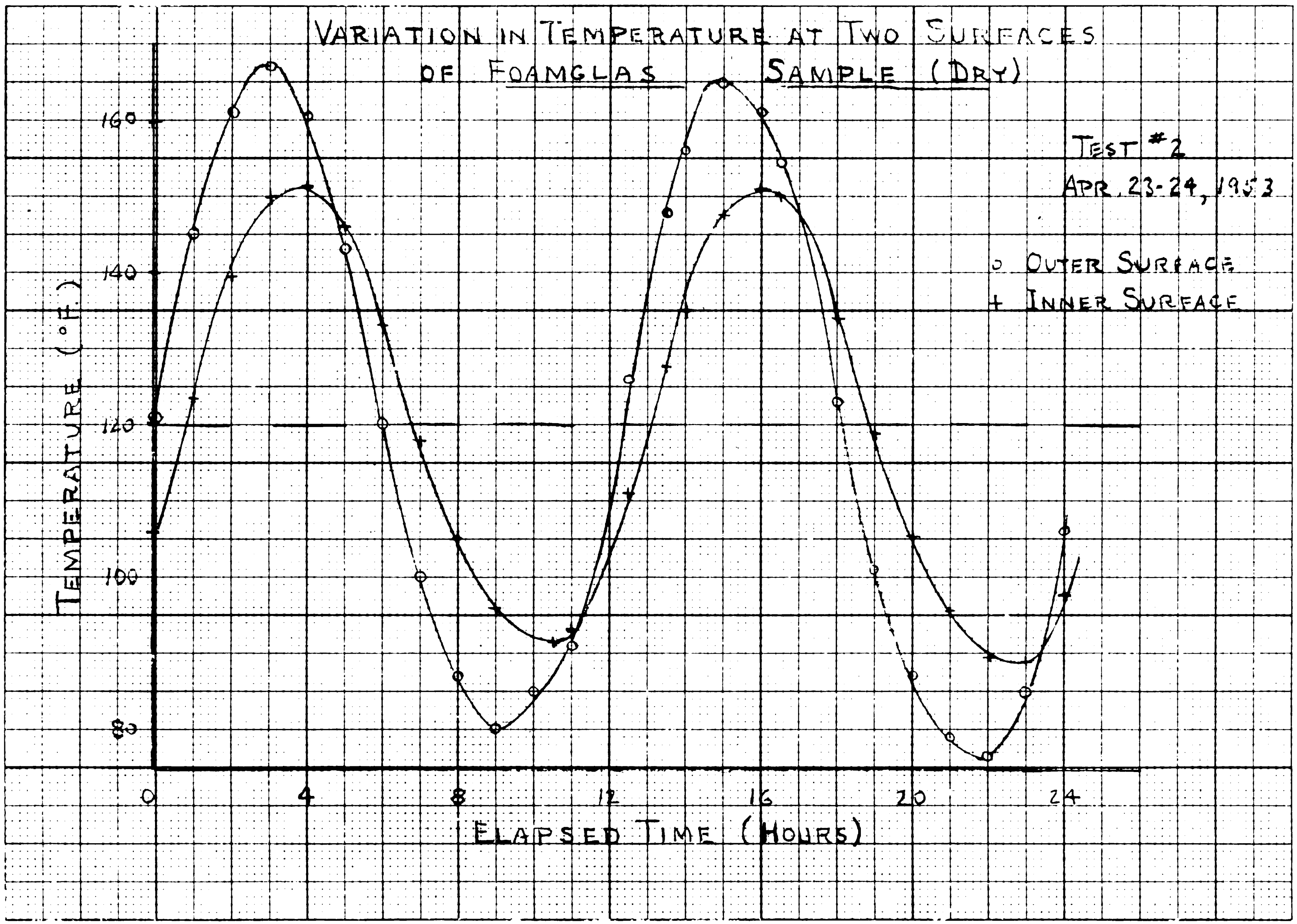
Distance from Neutral Axis to Outer Fiber = 1.00 In.

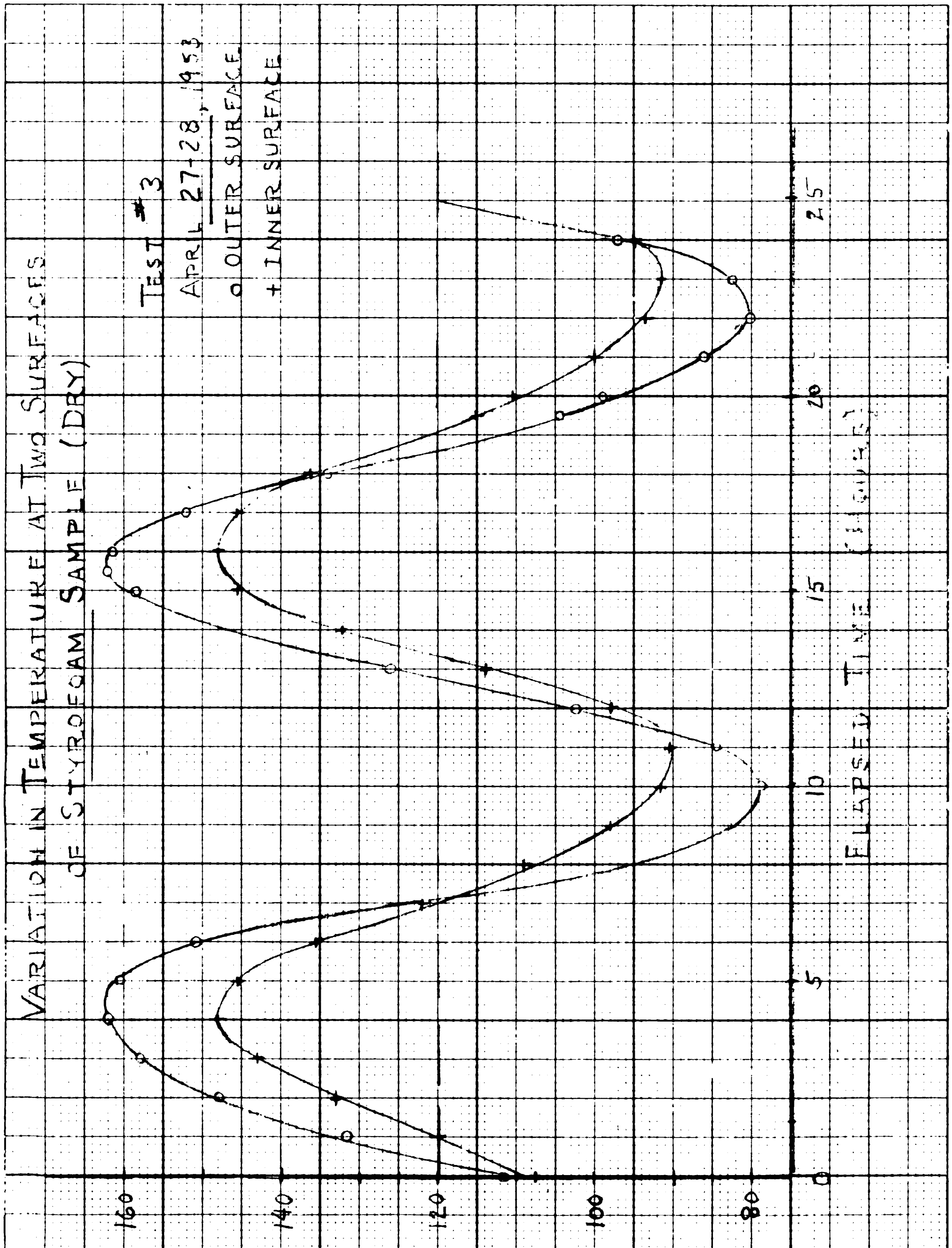
Moment of Inertia for Section = 1.33 In.^4

$$\text{Modulus of Rupture} = \frac{\text{Bending Moment x Dist., Neutral Axis to Outer Fiber}}{\text{Moment of Inertia}}$$

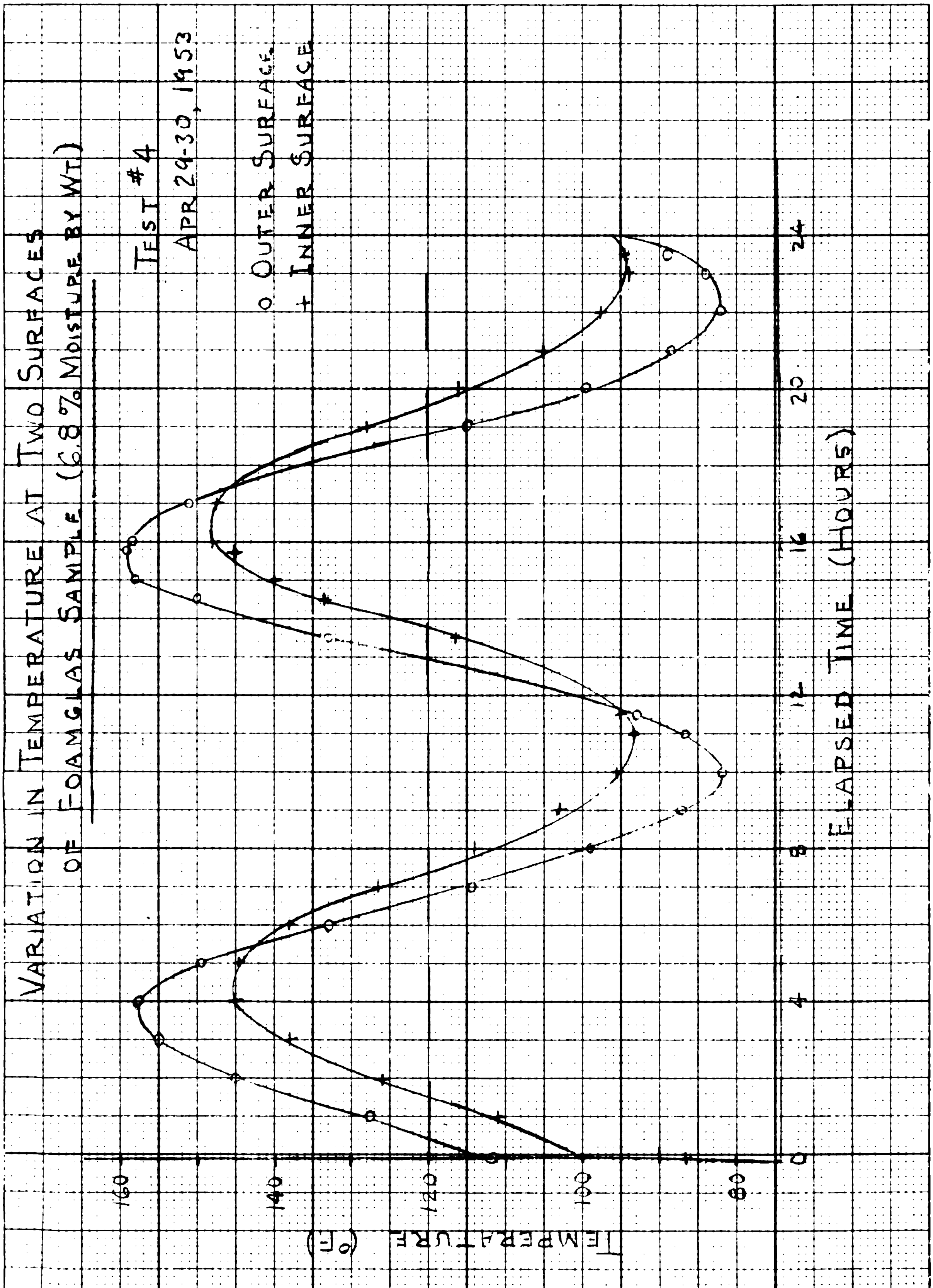
$$S = \frac{75.20 \times 1.00}{1.33} = 56.7 \ \text{Lbs./In.}^2$$

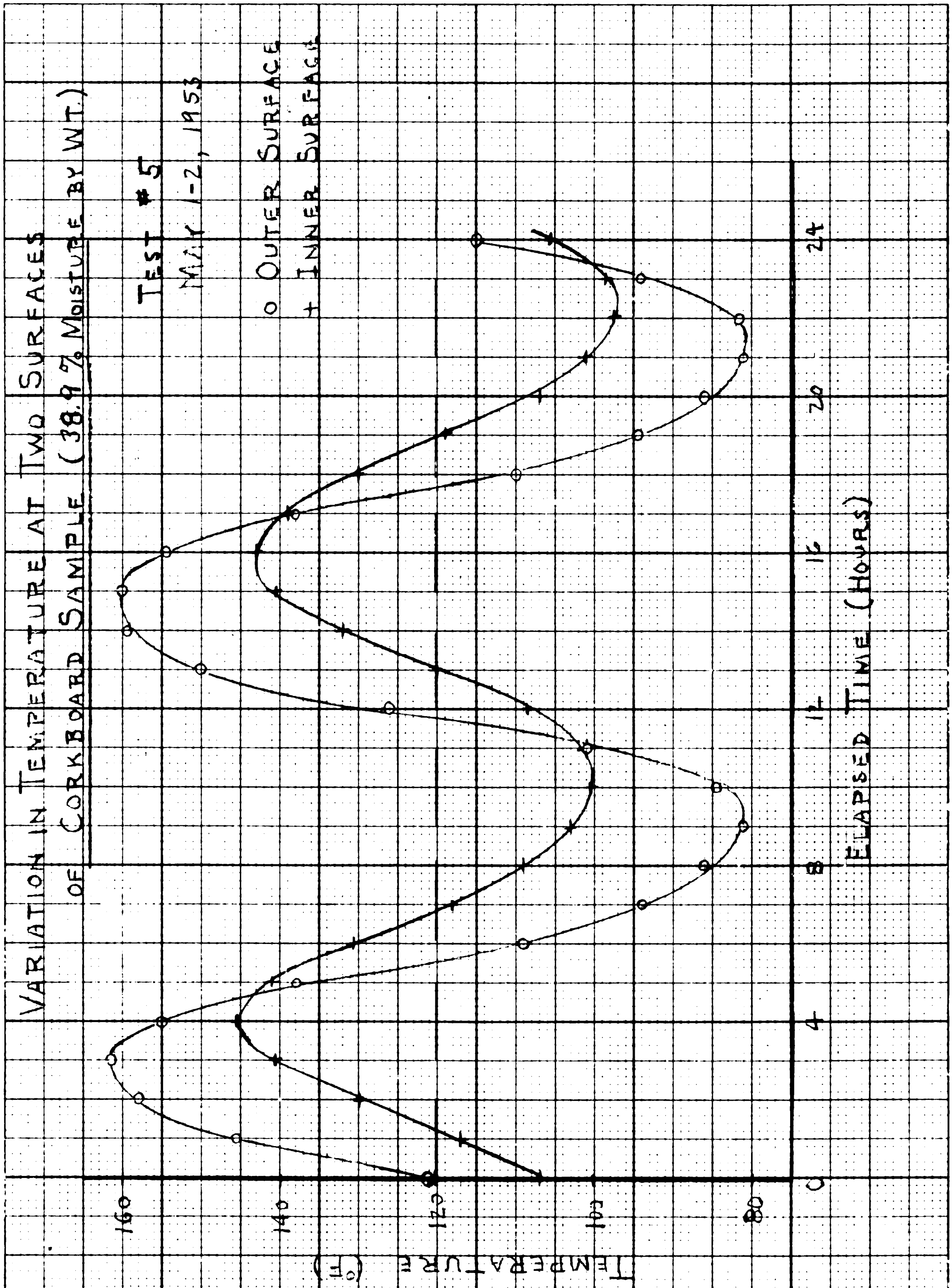

VARIATION IN TEMPERATURE AT TWO SURFACES
OF CORKBOARD SAMPLE (DRY)
TEST #1
APR. 22-23, 1953
o OUTER SURFACE
+ INNER SURFACE
ELAPSED TIME (HOURS)
TEMPERATURE (°F)
0
4
8
12
16
20
24
80
100
120
140
160


VARIATION IN TEMPERATURE AT TWO SURFACES
OF FOAMGLAS SAMPLE (DRY)
TEST #2
APR. 23-24, 1953
o OUTER SURFACE
+ INNER SURFACE
TEMPERATURE (°F.)
160
140
120
100
80
0
4
8
12
16
20
24
ELAPSED TIME (HOURS)

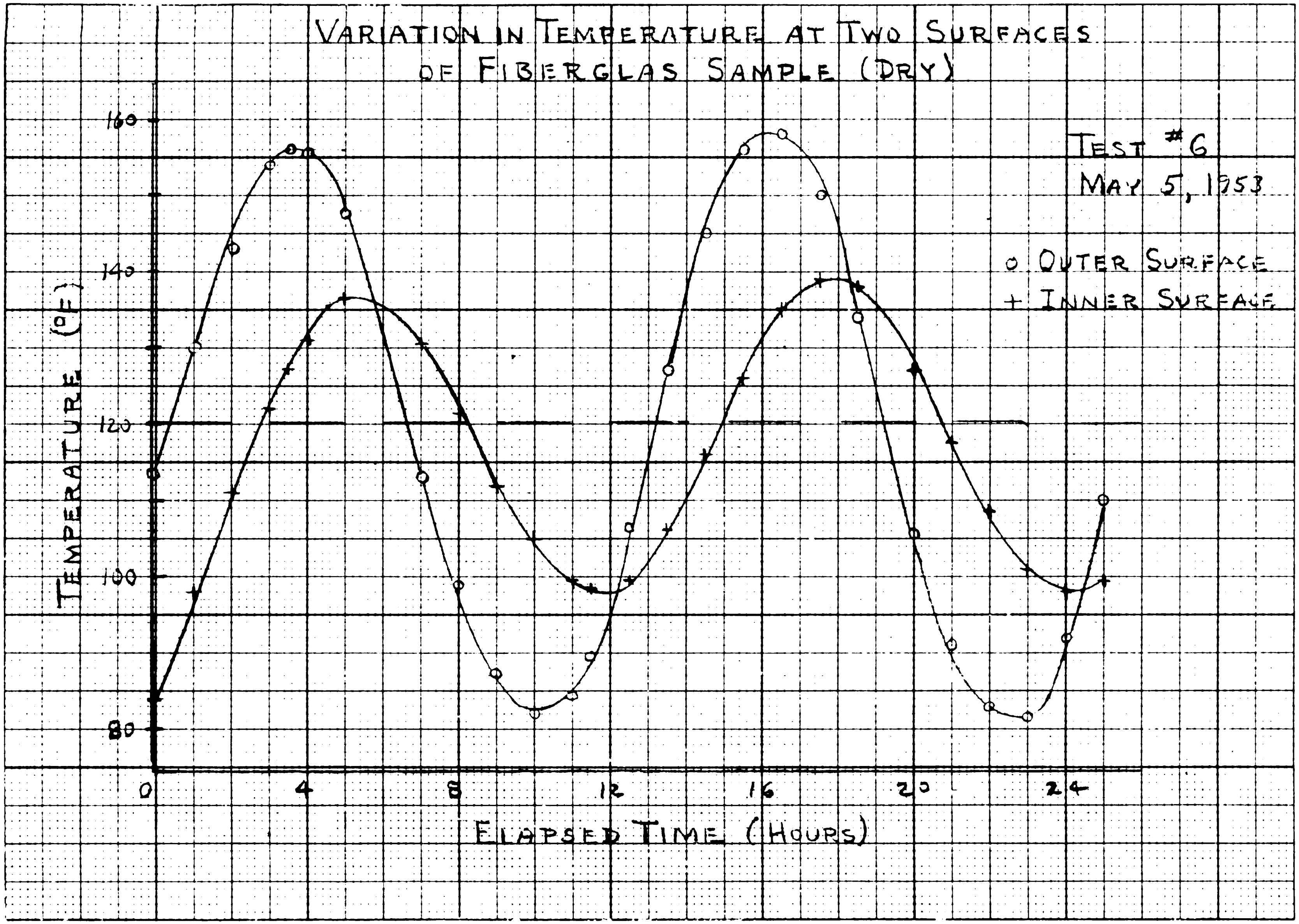


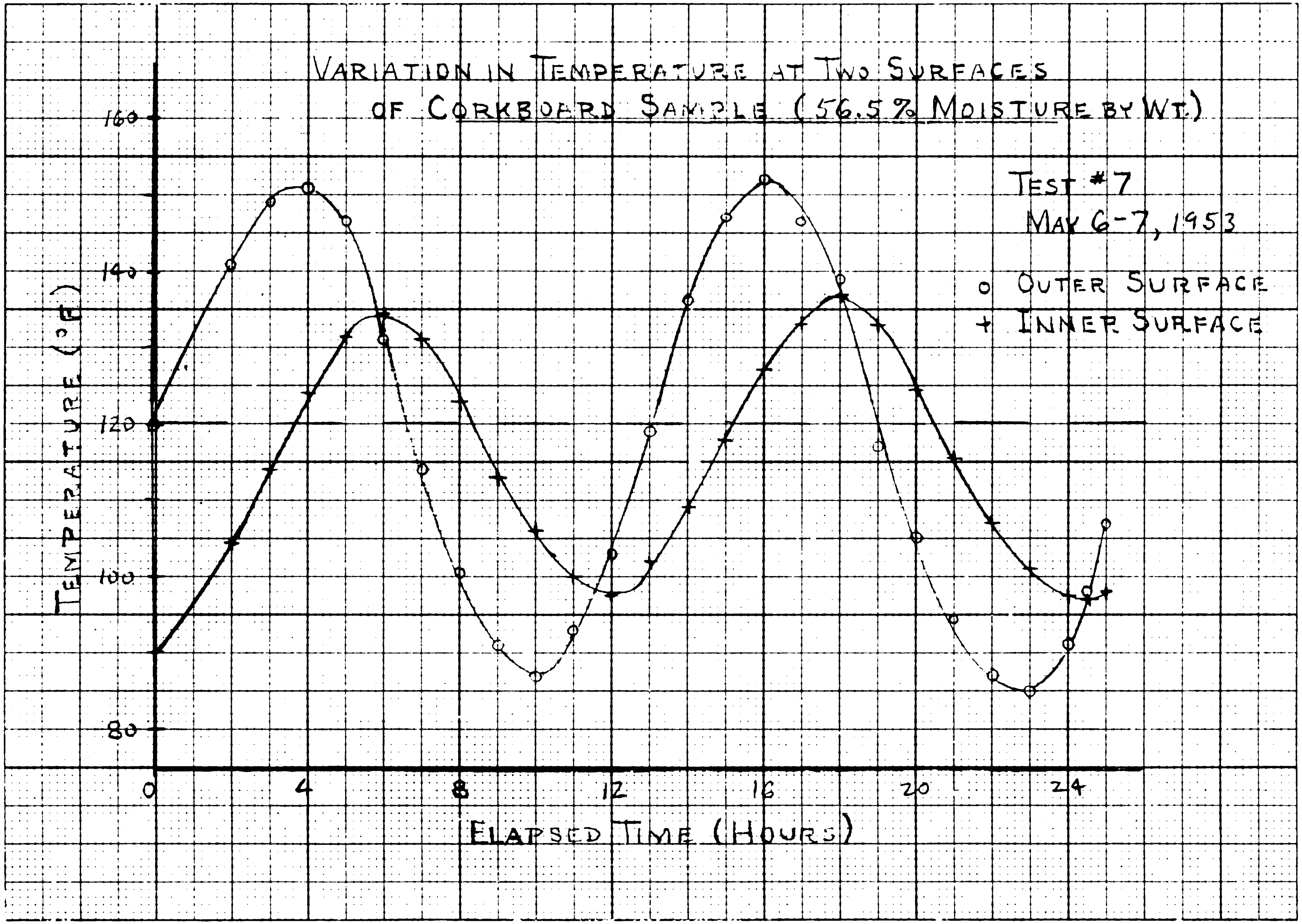
VARIATION IN TEMPERATURE AT TWO SURFACES
OF STYROFOAM SAMPLE (DRY)
TEST #3
APRIL 27-28, 1953
o OUTER SURFACE
+ INNER SURFACE
160
140
120
100
80
TEMPERATURE (°F)
0
5
10
15
20
25
ELAPSED TIME (HOURS)

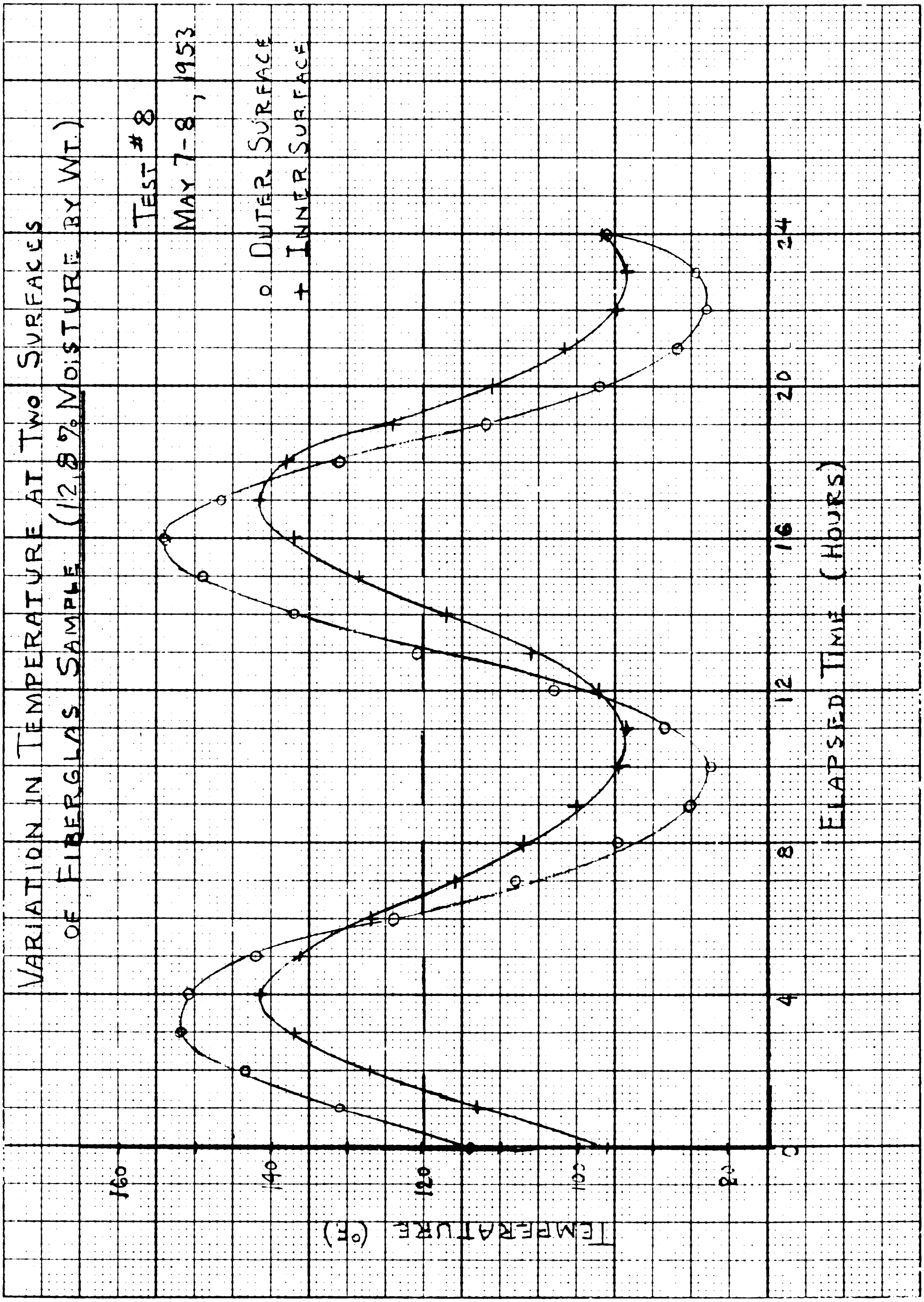

Variation in Temperature at Two Surfaces
of Foamglas Sample (6.8% Moisture by Wt.)
Test #4
Apr 29-30, 1953
o Outer Surface
+ Inner Surface
Elapsed Time (Hours)
Temperature (°F)
0
4
8
12
16
20
24
80
100
120
140
160

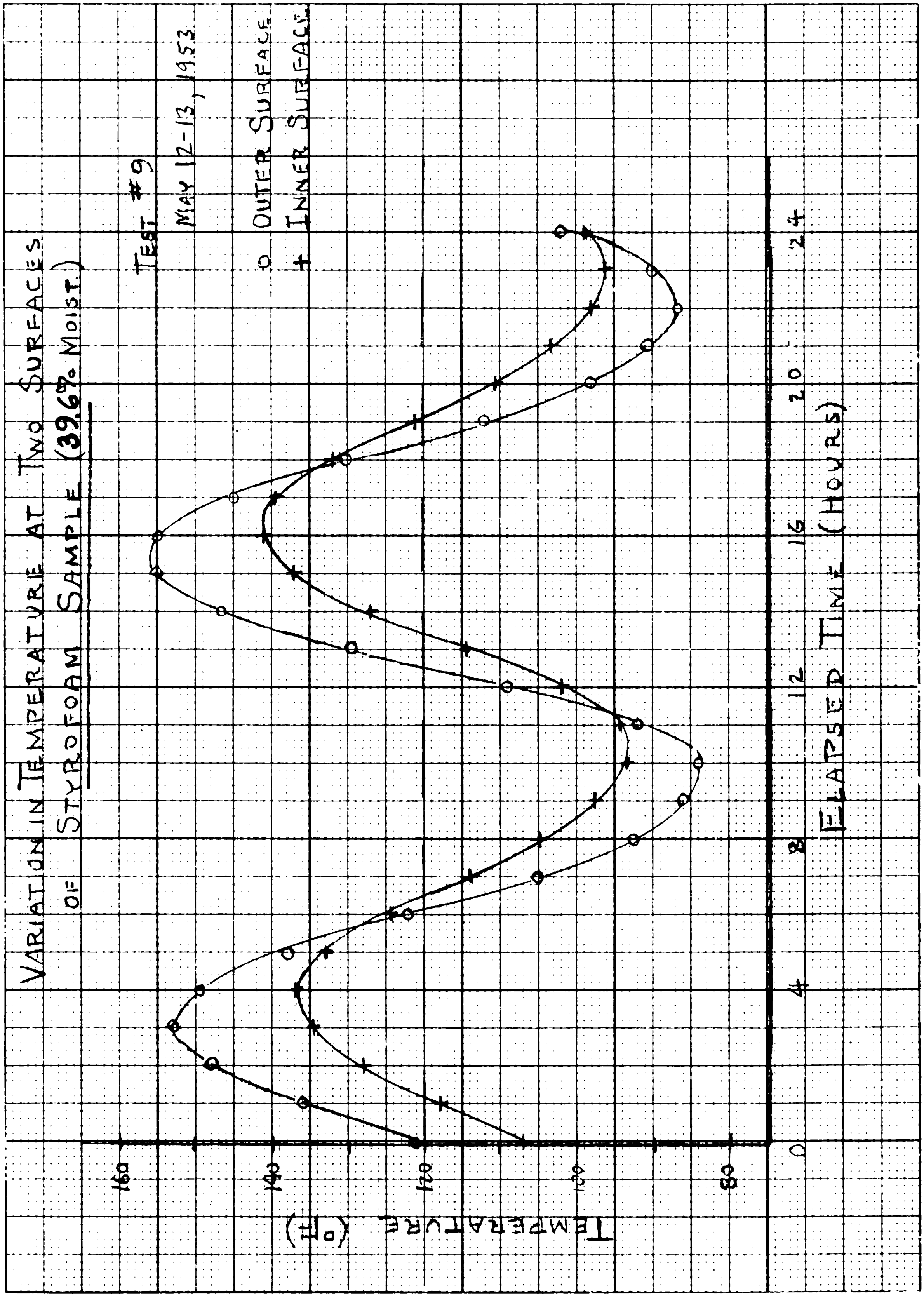


VARIATION IN TEMPERATURE AT TWO SURFACES
OF CORKBOARD SAMPLE (38.9 % MOISTURE BY WT.)
TEST # 5
MAY 1-2, 1953
o OUTER SURFACE
+ INNER SURFACE
TEMPERATURE (°F)
160
140
120
100
80
ELAPSED TIME (HOURS)
0
4
8
12
16
20
24

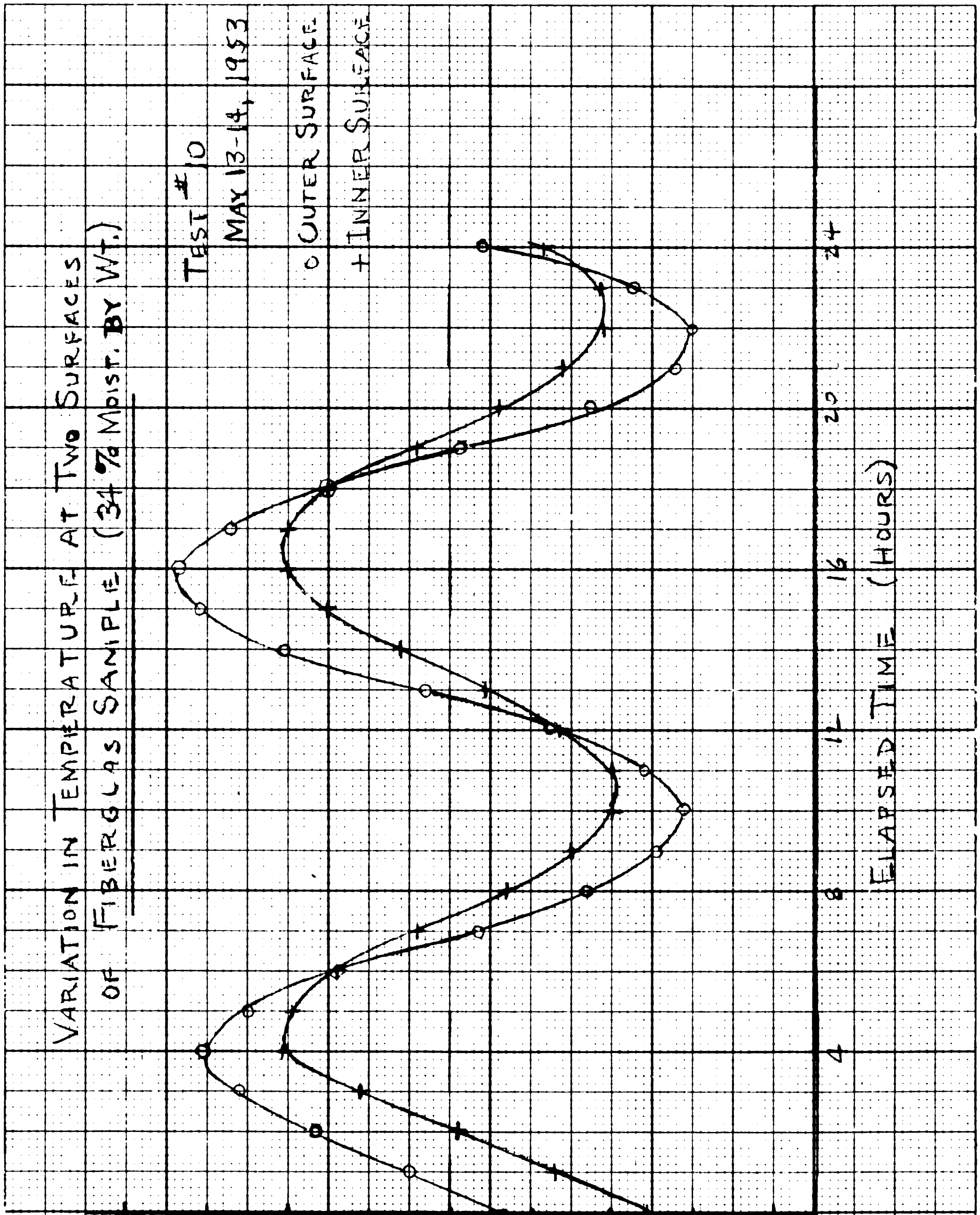

VARIATION IN TEMPERATURE AT TWO SURFACES
OF FIBERGLAS SAMPLE (DRY)
TEST #6
MAY 5, 1953
o OUTER SURFACE
+ INNER SURFACE
TEMPERATURE (°F)
160
140
120
100
80
0
4
8
12
16
20
24
ELAPSED TIME (HOURS)

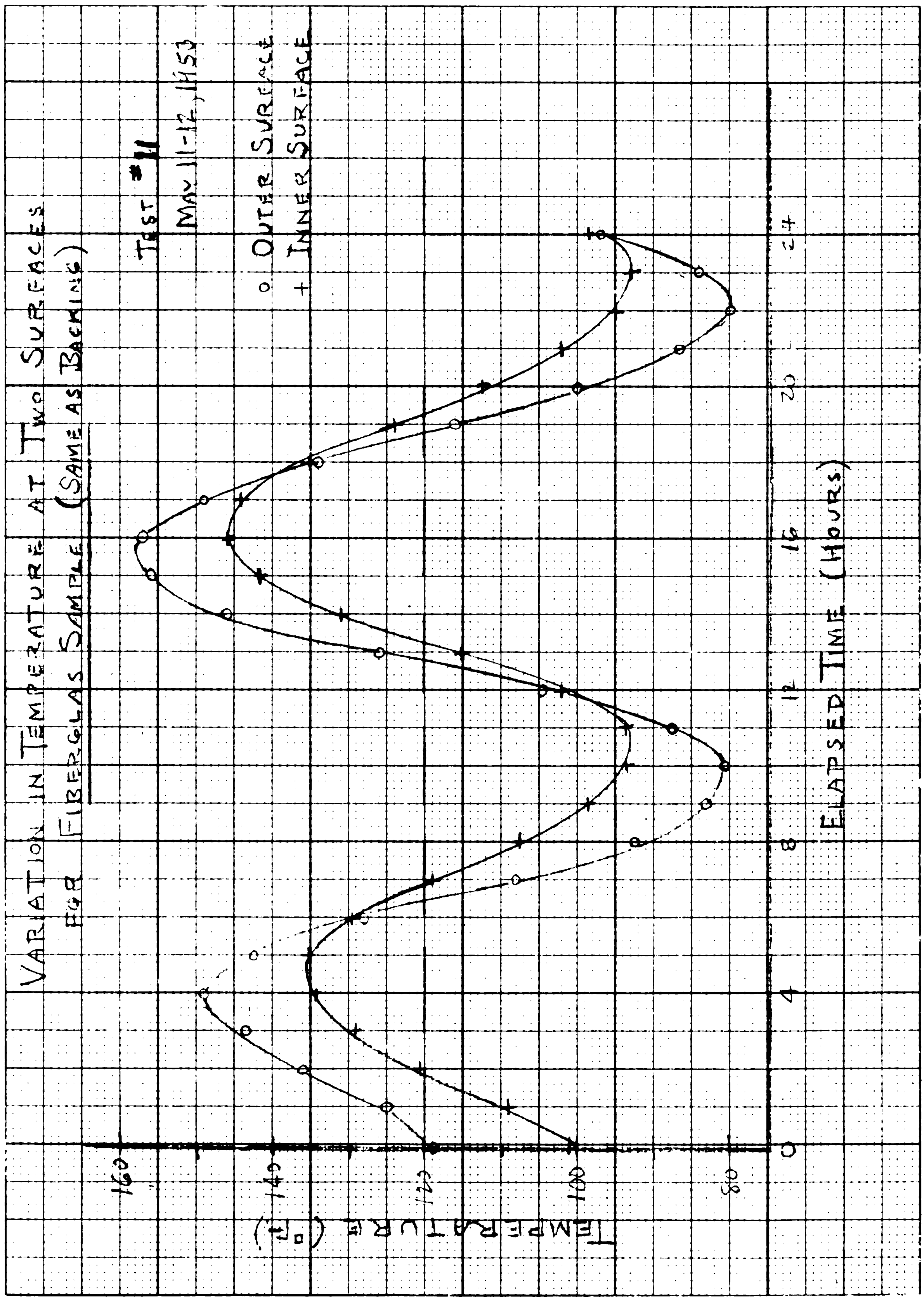

VARIATION IN TEMPERATURE AT TWO SURFACES
OF CORKBOARD SAMPLE (56.5% MOISTURE BY WT.)
TEST #7
MAY 6-7, 1953
o OUTER SURFACE
+ INNER SURFACE
TEMPERATURE (°F)
160
140
120
100
80
0
4
8
12
16
20
24
ELAPSED TIME (HOURS)


VARIATION IN TEMPERATURE AT TWO SURFACES
OF FIBERGLAS SAMPLE (12.8% MOISTURE BY WT.)
TEST # 8
MAY 7-8, 1953
o OUTER SURFACE
+ INNER SURFACE
ELAPSED TIME (HOURS)
TEMPERATURE (°F)
160
140
120
100
80
0
4
8
12
16
20
24



Variation in Temperature at Two Surfaces
of Styrofoam Sample (39.6% Moist.)
Test #9
May 12-13, 1953
o Outer Surface
+ Inner Surface
160
140
120
100
80
Temperature (°F)
0
4
8
12
16
20
24
Elapsed Time (Hours)


VARIATION IN TEMPERATURE AT TWO SURFACES
OF FIBERGLAS SAMPLE (34 % MOIST. BY WT.)
TEST # 10
MAY 13-14, 1953
o OUTER SURFACE
+ INNER SURFACE
ELAPSED TIME (HOURS)
TEMPERATURE (°F)
0
4
8
12
16
20
24
160
140
120
100
80


VARIATION IN TEMPERATURE AT TWO SURFACES
FOR FIBERGLAS SAMPLE (SAME AS BACKING)
TEST #11
MAY 11-12, 1953
o OUTER SURFACE
+ INNER SURFACE
TEMPERATURE (°F)
160
140
120
100
80
0
4
8
12
16
20
24
ELAPSED TIME (HOURS)

MLIT-232 **Sheet No.** 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

~~Running Log of~~ COMPUTATION LOG – PERIMETER · INSULATION INVESTIGATION
HEAT TRANSMISSION PROPERTIES

Observers { ______ ______ } Date MAY 12, 1953

No.	MAT'L	TEMPERATURE VARIATION OUTER SURFACE (°F)	TEMPERATURE VARIATION INNER SURFACE (°F)	RATIO θ_s / θ_p —	TEST THERMAL DIFFUS. [α] (FT^2/HR)	CORRECT'D THERMAL DIFFUS. [α] (FT^2/HR)	% MOIST. BY VOL. (%)	% MOIST. BY WT. (%)	APPARENT DENSITY (SAMPLE) (LB/FT^3)	SPEC. HEAT (DRY) (BTU/LB.)	COMPUT'D SPEC. HEAT (BTU/LB.)	THERMAL COND'T'V'TY [K] (APPARENT) ($BTU\text{-}IN / FT^2\text{-}°F\text{-}HR$)
1	C'KBOARD	38.50	21.25	1.812	0.0194	0.0075	—	—	7.81	0.40	—	0.27
2	FOAMGL'S	44.25	31.25	1.415	0.0560	0.061	—	—	8.67	0.20	—	1.25
3	STYROF'M	41.00	28.25	1.452	0.0550	0.058	—	—	1.71	0.27	—	0.32
4	FOAMGL'S	39.00	27.50	1.418	0.0559	0.060	1.04	6.82	9.52	0.20	0.25	1.74
5	C'KBOARD	40.25	22.75	1.770	0.0209	0.0084	6.85	38.9	11.00	0.40	0.63	0.70
6	FIBERGL'S	39.25	20.25	1.939	0.0194	0.0075	—	—	13.50	0.24	—	0.28
7	C'KBOARD	33.50	20.00	1.673	0.0273	0.014	15.5	56.5	17.10	0.40	0.74	2.18
8	FIBERGL'S	35.75	24.00	1.490	0.0504	0.049	2.61	12.8	12.73	0.24	0.34	2.51
9	STYROF'M	34.75	22.75	1.528	0.0404	0.031	1.90	39.7	2.98	0.27	0.56	0.63
10	FIBERGL'S	32.50	20.00	1.625	0.0305	0.018	9.89	34.0	18.12	0.24	0.50	1.96
*11	FIBERGL'S	39.00	26.50	1.471	0.0519	—	—	—	2.16	0.24	—	0.32
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

Remarks: * CONTROL (α VARIES < 3% FROM COMPUTED VALUE)

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Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of SAMPLES TO BE TESTED FOR HEAT TRANSMISSION — DRY PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date MAR-APR, 1953

Sample	Date	Time	Weight (LBS.)	Gain or (Loss) (LBS.)	Density (LBS/FT³)	Moisture Content (% BY WT)	Moisture Content (% BY VOL.)	
CORKB'D SAMPLE #1	3-14-53	11:05	1.321	—	7.94	2.12	0.27	AS REC'D
	4-7-53	9:45	1.288	(0.033)	7.74	0.00	0.00	BONE DRY
STYROFOAM SAMPLE #3	3-23-53	10:00	0.287	—	1.72	0.70	0.19	AS REC'D
	4-8-53	9:50	0.285	(0.002)	1.71	0.00	0.00	BONE DRY
FOAMGLAS SAMPLE #1	3-30-53	10:00	1.445	—	8.68	0.14	0.02	AS REC'D
	4-8-53	11:15	1.443	(0.002)	8.66	0.00	0.00	BONE DRY
FIBERGLAS SAMPLE #1	3-23-53	10:20	2.248	—	13.50	0.13	0.03	AS REC'D.
	4-16-53	11:00	2.245	(0.003)	13.48	0.00	0.00	BONE DRY

Remarks:

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MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of CORKBOARD SAMPLES — MOISTURE ABSORPTION TEST
PERIMETER INSULATION INVESTIGATION

Observers { W. W. TREICHLER JR. { Date MAR-APR., 19 53

No.		DATE	TIME	TIME ELAPSED (HRS.)	WEIGHT (LBS.)	GAIN OR (LOSS) (LBS.)	MOISTURE CONTENT (% BY WT.)	MOISTURE CONTENT (% BY VOL.)	
1	SAMPLE # 2	3-14-53	11:10	—	1.267	—	1.90	0.23	AS REC'D.
2		3-23-53	14:20	—	1.243	(0.024)	0.00	0.00	← BONE DRY
3		3-25-53	10:30	44:10	2.089	0.846	40.5	8.12	(IMMERSED)
4		3-26-53	10:50	68:30	2.145	0.902	42.0	8.65	
5		3-27-53	10:15	91:55	2.205	0.962	43.6	9.25	
6		3-30-53	10:25	164:05	2.407	1.164	48.3	11.2	
7		4-1-53	11:15	212:55	2.477	1.234	49.9	11.9	
8		4-3-53	10:20	260:00	2.521	1.278	50.7	12.3	
9		4-6-53	13:30	335:10	2.625	1.382	52.7	13.3	
10		4-7-53	9:40	355:20	2.650	1.407	53.0	13.5	
11		4-9-53	16:40	410:20	2.670	1.427	53.4	13.7	
12									
13	SAMPLE # 3	3-14-53	11:10	—	1.138	—	1.76	0.20	AS REC'D
14		3-25-53	9:55	—	1.118	(0.020)	0.00	0.00	← BONE DRY
15		3-26-53	9:55	24:00	1.255	0.137	10.92	1.32	(PLACED
16		3-27-53	10:35	48:40	1.370	0.252	18.40	2.42	IN HUMID
17		3-30-53	10:00	120:05	1.415	0.297	21.00	2.85	CHAMBER)
18		4-1-53	11:15	169:20	1.508	0.390	25.90	3.74	
19		4-3-53	10:35	216:40	1.610	0.492	30.5	4.72	
20		4-7-53	10:00	312:05	1.670	0.552	33.1	5.30	
21		4-9-53	20:20	370:25	1.666	0.548	33.0	5.27	
22		4-11-53	11:15	408:55	1.668	0.550	33.1	5.30	
23									
24									
25									

Remarks:

	DRY DENSITY	SATURATED DENSITY
SAMPLE # 2	7.47 #/FT³	16.00 #/FT³

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MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of FIBERGLAS SAMPLES – MOISTURE ABSORPTION TEST
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR. Date MAR-APR, 1953

No.		Date	Time	Time Elapsed (Hrs.)	Weight (Lbs)	Gain or (Loss) (Lbs)	Moisture Content (% by Wt)	Moisture Content (% by Vol)	
1	Sample #2	3-14-53	11:20	—	1.995	—	0.15	0.03	As Rec'd
2		3-20-53	13:30	—	1.992	(0.003)	0.00	0.00	← Bone Dry
3		3-25-53	10:20	41:50	2.150	0.158	7.35	1.52	(Immersed)
4		3-26-53	10:00	65:30	2.189	0.207	9.46	1.99	
5		3-27-53	10:15	89:45	2.357	0.365	15.50	3.51	
6		3-30-53	10:40	162:10	2.570	0.578	22.5	5.55	
7		4-1-53	11:20	210:50	3.108	1.116	35.9	10.7	
8		4-3-53	10:35	258:05	3.207	1.215	37.8	11.6	
9		4-6-53	13:40	333:10	3.235	1.243	38.5	12.0	
10		4-7-53	10:00	354:30	3.287	1.245	39.4	12.4	
11		4-9-53	16:45	409:15	3.313	1.321	39.7	12.6	
12									
13	Sample #3	3-14-53	11:25	—	2.250	—	0.13	0.03	As Rec'd
14		3-25-53	10:05	—	2.247	(0.003)	0.00	0.00	← Bone Dry
15		3-26-53	9:55	23:50	2.327	0.080	3.44	0.77	(Placed in
16		3-27-53	10:35	48:30	2.488	0.241	9.70	2.32	Humid-
17		3-30-53	10:05	120:00	2.448	0.201	8.22	1.93	Chamber)
18		4-1-53	11:20	169:15	2.562	0.315	12.30	3.03	
19		4-3-53	10:35	216:15	2.625	0.378	14.40	3.63	
20		4-7-53	10:00	311:40	2.695	0.448	16.65	4.31	
21		4-9-53	20:20	370:00	2.735	0.488	17.85	4.68	
22		4-10-53	13:50	387:30	2.750	0.503	18.30	4.83	
23		4-11-53	11:15	408:55	2.760	0.513	18.55	4.92	
24									
25									

Remarks:

	Dry Density	Saturated Density
Sample #2	11.96 #/ft³	19.90 #/ft³
Sample #3	13.50	16.60

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MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of FOAMGLAS SAMPLES — MOISTURE ABSORPTION TEST
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR

Date MAR-APR., 1953

No.		Date	Time	Time Elapsed (Hrs)	Weight (Lbs.)	Gain or (Loss) (Lbs.)	Moisture Content (% by Wt.)	Moisture Content (% by Vol.)	
1	Sample #2	3-23-53	14:20	—	1.458	—	0.21	0.03	As Rec'd
2		3-25-53	10:45	—	1.455	(0.003)	0.00	0.00	← Bone Dry
3		3-26-53	9:40	22:55	1.612	0.157	9.73	1.50	(Immersed)
4		3-27-53	10:10	47:25	1.630	0.175	10.73	1.68	
5		3-30-53	10:20	119:35	1.680	0.225	13.40	2.16	
6		4-1-53	11:00	168:15	1.709	0.254	14.90	2.44	
7		4-3-53	10:10	215:25	1.725	0.270	15.70	2.60	
8		4-6-53	13:20	290:35	1.735	0.280	16.15	2.69	
9		4-7-53	9:40	310:45	1.748	0.293	16.76	2.81	
10		4-9-53	16:30	365:35	1.749	0.294	16.81	2.82	
11		4-10-53	14:10	387:15	1.750	0.295	16.82	2.83	
12		4-11-53	10:10	407:15	1.750	0.295	16.82	2.83	
13									
14	Sample #3	3-23-53	14:45	—	1.478	—	0.20	0.03	As. Rec'd.
15		3-25-53	10:45	—	1.475	(0.003)	0.00	0.00	← Bone Dry
16		3-26-53	9:55	23:10	1.553	0.078	5.02	0.75	(Placed in
17		3-27-53	10:40	47:55	1.589	0.114	7.18	1.10	Humid –
18		4-1-53	11:15	168:30	1.614	0.139	8.62	1.34	Chamber)
19		4-3-53	10:35	215:50	1.628	0.153	9.40	1.47	
20		4-7-53	10:00	311:15	1.631	0.156	9.55	1.50	
21		4-10-53	13:50	387:05	1.625	0.150	9.25	1.44	
22		4-11-53	11:10	408:25	1.632	0.157	9.62	1.51	
23									
24									
25									

Remarks:

	Dry Density	Saturated Density
Sample #2	8.73 #/Ft³	10.51 #/Ft³
Sample #3	8.83	9.80

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Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of STYROFOAM SAMPLES - MOISTURE ABSORPTION TEST

PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date MAR-APR., 1953

No.		DATE	TIME	TIME ELAPSED (HRS)	WEIGHT (LBS.)	GAIN OR (LOSS) (LBS.)	MOISTURE CONTENT (% BY WT.)	MOISTURE CONTENT (% BY VOL.)	
1	SAMPLE #1	3-19-53	11:25	—	0.302	—	0.66	0.02	AS REC'D.
2		3-25-53	15:10	—	0.300	(0.002)	0.00	0.00	← BONE DRY
3		3-26-53	9:50	18:40	0.433	0.133	30.75	1.35	(PLACED IN
4		3-27-53	10:40	43:30	0.465	0.165	35.50	1.58	HUMID-
5		3-30-53	10:05	90:55	0.445	0.145	33.60	1.50	CHAMBER.)
6		4-1-53	11:20	140:10	0.489	0.189	38.70	1.82	
7		4-3-53	10:35	188:55	0.500	0.200	40.00	1.92	
8		4-7-53	10:00	284:20	0.505	0.205	40.60	1.97	
9		4-11-53	11:15	383:35	0.510	0.210	41.20	2.02	
10		4-12-53	11:20	407:40	0.509	0.209	41.18	2.02	
11									
12	SAMPLE #2	3-14-53	11:17	—	0.298	—	0.00	0.00	AS REC'D
13		3-23-53	14:10	—	0.298	—	0.00	0.00	← BONE DRY
14		3-25-53	10:10	44:00	0.590	0.292	49.5	2.80	(IMMERSED)
15		3-26-53	9:40	67:30	0.603	0.305	50.6	2.93	
16		3-27-53	10:10	92:00	0.654	0.356	54.5	3.41	
17		3-30-53	10:20	164:10	0.690	0.392	56.8	3.77	
18		4-1-53	11:00	212:50	0.730	0.432	59.2	4.15	
19		4-3-53	10:15	260:05	0.738	0.440	59.6	4.23	
20		4-6-53	13:20	335:10	0.760	0.462	60.8	4.44	
21		4-7-53	9:40	355:30	0.777	0.479	61.7	4.61	
22		4-9-53	16:30	410:20	0.770	0.472	61.3	4.54	
23		4-10-53	14:00	429:00	0.797	0.499	62.5	4.79	
24									
25									

Remarks:

	DRY DENSITY	SATURATED DENSITY
SAMPLE #1	1.80 #/FT³	3.06 #/FT³
SAMPLE #2	[illegible]	

MLIT-232 Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of COMPRESSION TEST ON 3.5" x 3.5" x 2" SAMPLE*
PERIMETER INSULATION INVESTIGATION

Observers W. W. TREICHLER JR. Date APRIL 14, 19 53

SAMPLE No.		NORMAL: LOAD AT 10% DEFLECTION (LBS.)	NORMAL: AVERAGE LOAD (LBS.)	NORMAL: COMPRESSIVE STRESS (LBS./IN.²)		SATURATED: LOAD AT 10% DEFLECTION (LBS.)	SATURATED: AVERAGE LOAD (LBS.)	SATURATED: COMPRESSIVE STRESS (LBS./IN.²)
1	CORKBOARD	440			1s	170		
2	CORKBOARD	375			2s	175		
3	CORKBOARD	390	402	33	3s	160	168	14
4	FIBERGLAS	190			4s	60		
5	FIBERGLAS	185			5s	55		
6	FIBERGLAS	165	180	15	6s	80	65	5
7	FOAMGLAS	1175			7s	875		
8	FOAMGLAS	1035			8s	1375		
9	FOAMGLAS	1520	1243	102	9s	1600	1283	105
10	STYROFOAM	430			10s	430		
11	STYROFOAM	420			11s	420		
12	STYROFOAM	435	428	35	12s	420	423	35
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

Remarks: * FIBERGLAS SAMPLE 3.5" x 3.5" x 2.125".

MLIT-232

Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of FLEXURE TEST ON 8" x 2" x 2" SAMPLES*

PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date APRIL 14, 1953

Sample No.		NORMAL: Load at Failure (LBS)	Bending Moment (Ave.) (IN-LBS)	I/C + (IN.³)	Deflection at Failure (IN.)	Modulus of Rupture (LBS/IN.²)		SATURATED: Load at Failure (LBS)	Bending Moment (Ave.) (IN-LBS)	I/C (IN.³)	Deflection at Failure (IN.)	Modulus of Rupture (LBS/IN.²)
1	CORKBOARD	27			0.360		1a	15			0.210	
2		25			0.250		2a	13			0.283	
3		25	45.5	1.33	0.335	34	3a	12	21.0	1.33	0.275	17
4	FIBERGLAS	40			>0.800		4a	27			>0.650	
5		37			>0.800		5a	25			>0.650	
6		38	66.5	1.51	>0.800	44	6a	25	45.5	1.51	>0.650	30
7	FOAMGLAS	100			0.175		7a	68			0.158	
8		40			0.156		8a	78			0.140	
9		35	101.5	1.33	0.160	71	9a	65	122.5	1.33	0.156	92
10	STYROFOAM	65			0.426		10a	45			0.405	
11		62			0.410		11a	45			0.420	
12		60	108.5	1.33	0.502	82	12a	40	75.3	1.33	0.412	57
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

Remarks: * FIBERGLAS SAMPLE 8" x 2" x 2 1/8".

+ $\frac{I}{C} = \frac{\text{MOMENT OF INERTIA OF SECTION}}{\text{DISTANCE, NEUTRAL AXIS TO OUTER FIBER}}$

MODULUS OF RUPTURE = $\frac{\text{BEND. MOMENT}}{\frac{I}{C}}$

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of IMPACT TEST

PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date APRIL 17, 1953

Sample No.	Material	Normal Penetration (Inches) A.	B.	C.	Ave.	Final Ave.	Sample No.	Saturated Penetration (Inches) A.	B.	C.	Ave.	Final Ave.
1	Corkboard	No Measureable Penetration					1a	No Measureable Penetration				
2	Corkboard						2a					
3	Corkboard						3a					
4	Fiberglas	0.037	0.040	0.034	0.037		4a	0.059	0.092	0.090	0.080	
5	Fiberglas	0.060	0.072	0.058	0.063		5a	0.066	0.095	0.078	0.080	
6	Fiberglas	0.059	0.060	0.074	0.064	0.055	6a	0.097	0.060	0.065	0.074	0.078
7	Fiberglas (Edge)	0.149	0.176	0.153	0.159		7a	0.310	0.330	0.360	0.333	
8	Fiberglas (Edge)	0.290	0.177	0.200	0.222		8a	0.352	0.325	0.285	0.354	
9	Fiberglas (Edge)	0.282	0.198	0.274	0.231	0.204	9a	0.305	0.361	0.335	0.334	0.340
10	Foamglas	0.237	0.238	0.260	0.245		10a	0.212	0.204	0.194	0.203	
11	Foamglas	0.244	0.257	0.250	0.250		11a	0.209	0.187	0.170	0.189	
12	Foamglas	0.233	0.236	0.262	0.244	0.246	12a	0.142	0.207	0.150	0.166	0.186
13	Styrofoam	0.306	0.300	0.325	0.310		13a	0.260	0.257	0.265	0.261	
14	Styrofoam	0.300	0.330	0.321	0.317		14a	0.280	0.287	0.290	0.286	
15	Styrofoam	0.262	0.300	0.258	0.273	0.300	15a	0.327	0.287	0.285	0.300	0.282
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

Remarks: STEEL BALL, 1-INCH DIA. (0.185 LBS).
DROPPED 6 FT.

MLIT-232

Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of Test #1 – Heat Transmission Properties – Corkboard (Dry)
Perimeter Insulation Investigation

Observers: W. W. Treichler Jr.

Date Apr. 22-23, 1953

No.	Time	Elapsed Time (Hrs)	Outer Surface Temp. (Sample) (°F.)	Inner Surface Temp. (Sample) (°F.)	Room Wall Temp. (°F.)	Surface of Inner Box (°F.)	Edge Temp. (Sample) (°F.)	Heater Input (Volts)	Heater Input (Amps)	Room Air Temp. (°F.)	
1	11:00	-0-	109.0	73.5	44.0	119.0	87.0	80	0.50	39.0	
2	11:30	0.50	115.5	81.0	43.5	118.0	92.5	90	0.50	38.0	
3	13:05	2.10	145.0	106.0	42.5	121.0	111.5	113	0.55	38.5	
4	14:00	3.00	155.0	118.0	42.5	120.5	120.0	116	0.60	39.0	
5	15:00	4.00	158.0	128.5	42.5	120.5	126.0	105	0.55	39.5	
6	16:05	5.10	149.0	135.0	42.0	120.5	126.5	82	0.45	38.0	
7	17:05	6.10	133.0	134.5	42.0	120.5	122.5	58	0.25	39.0	
8	17:30	6.50	126.0	133.0	42.0	120.5	119.5	50	0.25	39.0	
9	19:30	8.50	92.0	116.5	41.0	120.5	102.0	17	—	37.0	
10	20:00	9.00	87.0	112.5	41.0	120.5	99.0	17	—	38.0	
11	21:00	10.00	81.5	104.5	40.5	120.0	94.0	30	—	37.5	
12	22:00	11.00	84.0	99.0	40.5	120.0	92.5	45	0.25	37.0	
13	23:00	12.00	97.0	98.5	40.0	120.5	96.0	70	0.40	37.0	
14	24:00	13.00	118.0	103.5	40.0	122.0	104.0	N.R.	N.R.	N.R.	
15	01:00	14.00	138.5	113.5	40.0	122.0	114.0				
16	02:00	15.00	153.0	125.0	40.0	123.0	123.0				
17	03:00	16.00	159.0	135.0	40.0	122.5	128.5				
18	04:00	17.00	154.5	140.5	40.0	122.0	130.0				
19	05:00	18.00	140.5	141.0	40.0	122.0	127.0				
20	06:00	19.00	122.0	136.0	40.0	122.0	120.0				
21	07:00	20.00	104.0	127.5	40.0	122.0	111.0				
22	08:30	21.50	88.0	113.5	40.0	121.0	99.0	18	—	37.5	
23	09:30	22.50	82.0	105.0	39.5	119.5	93.5	33	0.20	37.5	
24	10:00	23.00	82.5	102.0	39.5	119.5	93.0	40	0.25	37.5	
25	11:00	24.00	92.5	99.5	40.0	119.5	94.5	62	0.30	38.0	

Remarks: Wt. at Start — 1.302#

Wt. at Finish — 1.302#

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #2 - HEAT TRANSMISSION PROPERTIES - FOAMGLAS (DRY) PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date APR. 23, 1953

No.	TIME	ELAPSED TIME (HRS)	OUTSIDE SURFACE TEMP. (SAMPLE) $\bar{T}_1$ (°F.)	INNER SURFACE TEMP. (SAMPLE) $\bar{T}_2$ (°F.)	SURFACE TEMP. (INNER BOX) $\bar{T}_4$ (°F)	LOWER EDGE TEMP. (SAMPLE) $\bar{T}_5$ (°F)	ROOM TEMP. (THERM.) (°F.)	AIR TEMPERATURE D.B. (°F.)	AIR TEMPERATURE W.B. (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)
1	2200	-0-	121.0	106.0	119.0	104.0	40.5	39.5	34.0	97	0.50
2	2300	1.00	145.0	123.5	120.0	118.5	40.0	38.5	34.0	115	0.60
3	2400	2.00	161.0	139.5	121.5	130.5	N.R.	39.5	36.0	N.R.	N.R.
4	0100	3.00	167.0	150.0	120.5	137.0					
5	0200	4.00	160.5	152.5	121.0	136.0					
6	0300	5.00	143.0	146.0	121.0	128.5					
7	0400	6.00	120.0	133.0	121.0	116.0					
8	0500	7.00	100.0	118.0	121.0	104.0					
9	0600	8.00	87.0	105.0	124.0	93.5					
10	0700	9.00	80.0	96.0	123.5	87.0					
11	0800	10.00	80.5	92.0	123.5	85.0	40.0	39.0	34.5	39	0.20
12	0830	10.50	85.0	91.5	122.0	86.0	41.5	39.0	35.0	50	0.25
13	1030	12.50	126.0	111.0	119.5	107.0	42.5	40.0	35.0	102	0.50
14	1130	13.50	148.0	127.5	120.0	120.5	41.0	41.0	36.0	118	0.60
15	1200	14.00	156.0	135.0	120.0	126.0	40.0	38.5	34.0	120	0.65
16	1300	15.00	165.0	147.5	121.0	135.0	40.0	39.0	35.0	117	0.60
17	1400	16.00	161.0	151.0	121.0	135.0	40.0	38.5	34.0	102	0.50
18	1430	16.50	154.5	150.0	121.0	133.0	40.5	39.0	35.0	89	0.50
19	1600	18.00	123.0	134.0	121.0	116.5	41.5	40.0	35.0	47	0.25
20	1700	19.00	101.0	119.0	121.0	103.5	40.0	38.5	34.0	30	—
21	1800	2000	87.0	105.5	121.0	93.0	N.R			N.R.	N.R.
22	1900	2100	79.0	95.5	121.0	86.0					
23	2000	2200	76.5	89.5	121.0	82.5					
24	2100	2300	85.0	89.0	121.0	85.0	41.5	39.0	34.5	55	0.30
25	2200	2400	106.0	97.5	120.5	92.5	40.5	38.5	35.0	80	0.45

Remarks:

WT. AT START — 1.443 #

WT. AT FINISH — 1.443 #

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of Test #3 - Heat Transmission Properties — Styrofoam (Dry) Perimeter Insulation Investigation

Observers W. W. Treichler Jr.

Date Apr. 27-28, 1953

No.	Time	Elapsed Time (Hrs)	Outer Surface (Sample) T_1 (°F.)	Inner Surface (Sample) T_2 (°F.)	Surface Temp. (Inner Box) T_4 (°F.)	Lower Edge Temp. (Sample) T_5 (°F.)	Room Temp. (Therm.) (°F.)	Air Temperature D. B. (°F.)	Air Temperature W. B. (°F.)	Heater Input (Volts)	Heater Input (Amps)
1	22:30	-0-	111.5	107.5	119.5	101.5	40.0	38.5	35.0	86	0.40
2	23:30	1.00	131.5	120.0	119.0	113.0	40.5	39.0	35.5	108	0.50
3	24:30	2.00	148.0	133.0	120.0	124.0	N. R.	↓	↓	N. R.	N. R.
4	01:30	3.00	158.0	143.0	120.5	130.0	↓	↓	↓	↓	↓
5	02:30	4.00	162.0	148.0	120.5	133.5	↓	↓	↓	↓	↓
6	03:30	5.00	160.5	145.5	121.0	129.0	↓	↓	↓	↓	↓
7	04:30	6.00	151.0	135.5	121.0	117.0	↓	↓	↓	↓	↓
8	05:30	7.00	112.5	122.0	121.0	104.0	↓	↓	↓	↓	↓
9	06:30	8.00	95.0	109.0	120.5	93.0	↓	↓	↓	↓	↓
10	07:30	9.00	83.0	98.0	121.0	84.5					
11	08:30	10.00	78.0	91.5	120.5	79.0	40.0	39.0	36.0	35	0.20
12	09:30	11.00	84.5	90.5	120.5	81.5	40.5	39.0	36.5	53	0.25
13	10:30	12.00	102.5	98.0	120.0	92.0	40.0	38.5	35.0	75	0.35
14	11:30	13.00	126.0	114.0	120.0	108.5	41.5	39.0	36.5	102	0.50
15	13:30	15.00	158.5	134.0	119.5	129.0	41.0	39.0	36.5	120	0.60
16	14:00	15.50	162.0	145.5	120.0	132.5	40.0	38.0	35.0	114	0.55
17	14:30	16.00	161.5	148.0	119.0	134.0	41.0	39.0	35.5	108	0.50
18	15:30	17.00	152.0	145.5	119.5	131.0	40.5	40.0	37.0	89	0.40
19	16:30	18.00	134.0	136.0	120.0	121.5	41.5	40.0	37.0	65	0.30
20	18:00	19.50	104.5	115.0	120.5	103.0	41.0	39.5	36.5	35	0.20
21	18:30	20.00	99.0	110.5	120.5	99.0	40.5	39.0	36.0	30	—
22	19:30	21.00	86.0	100.0	120.5	90.5	39.5	38.0	35.0	17	—
23	20:30	22.00	80.0	93.5	120.5	85.0	39.0	38.0	34.5	30	—
24	21:30	23.00	82.5	91.5	120.5	85.0	39.5	39.0	35.5	42	0.20
25	22:30	24.00	97.5	95.0	121.0	91.5	40.0	39.0	36.5	68	0.30

Remarks: Wt. at Start — 0.285 #

Wt. at Finish — 0.285 #

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #4 - HEAT TRANSMISSION PROPERTIES - FOAMGLAS (6.8 % MOIST.)
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date APR 29-30, 1953

No.	TIME	ELAPSED TIME (HRS.)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	LOWER EDGE TEMP. (SAMPLE) T_5 (°F.)	ROOM AIR (°F.)	ROOM TEMP. (THERM.) (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)
1	2400	-0-	112.0	86.5	119.5	92.0	39.5	38.0	80	0.45
2	0100	1.00	127.5	111.0	119.5	107.5	N.R.	N.R.	N.R.	N.R.
3	0200	2.00	145.0	126.0	120.0	121.0	↓	↓	↓	↓
4	0300	3.00	155.5	138.0	120.5	131.5				
5	0400	4.00	157.5	145.0	121.0	137.0				
6	0500	5.00	149.0	144.5	121.0	134.5				
7	0600	6.00	133.0	138.0	121.0	126.5				
8	0700	7.00	114.5	126.5	120.5	115.0				
9	0800	8.00	99.0	114.0	119.5	104.5				
10	0900	9.00	87.0	103.0	119.0	94.5	41.0	39.0	20	—
11	1000	10.00	82.0	95.5	119.0	89.0	40.5	39.0	30	—
12	1100	11.00	86.5	93.5	118.0	90.5	40.5	39.0	50	0.30
13	1130	11.50	93.0	95.0	118.5	94.0	41.0	39.5	62	0.35
14	1330	13.50	133.0	116.5	119.5	121.0	39.0	38.0	104	0.50
15	1430	14.50	150.0	133.5	120.0	135.5	39.0	38.0	112	0.55
16	1500	15.00	156.0	140.0	120.5	140.5	40.0	38.5	112	0.55
17	1540	15.67	159.0	145.0	120.5	144.0	40.0	38.5	110	0.55
18	1600	16.00	158.5	148.0	120.5	145.0	40.5	39.0	108	0.50
19	1700	17.00	151.0	147.5	121.0	142.0	40.5	39.0	83	0.40
20	1900	19.00	115.0	128.0	120.5	118.0	39.0	38.0	37	0.20
21	2000	20.00	99.5	116.0	120.0	106.0	40.0	38.5	20	—
22	2100	21.00	88.5	105.0	120.0	96.5	39.5	39.0	16	—
23	2200	22.00	82.0	97.5	120.0	91.5	40.0	38.0	28	—
24	2300	23.00	84.0	94.0	120.5	90.0	39.5	38.0	42	0.30
25	2330	23.50	89.0	94.5	120.5	92.5	40.5	38.0	55	0.35

Remarks: WT. AT START — 1.608#

WT. AT FINISH — 1.563# AVE. 1.583#

MLIT-232

Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #5 – HEAT TRANSMISSION PROPERTIES – CORKBOARD (38.9% MOIST.)
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date MAY 1-2, 1953

No.	TIME	ELAPSED TIME (HRS.)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	EDGE TEMP. (SAMPLE) T_5 (°F.)	ROOM TEMP. (THERM.) (°F.)	ROOM AIR (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)
1	1800	-0-	121.0	107.0	121.0	110.0	40.5	39.0	85	0.50
2	1900	1.00	145.5	117.0	121.5	121.0	40.0	39.0	112	0.55
3	2000	2.00	158.0	130.0	120.5	130.0	39.5	38.0	120	0.60
4	2100	3.00	161.5	140.5	119.5	134.5	41.5	39.0	125	0.60
5	2200	4.00	155.5	145.5	119.0	132.0	41.5	40.0	117	0.55
6	2300	5.00	138.0	141.0	119.0	123.0	N.R.	N.R.	N.R.	N.R.
7	2400	6.00	109.0	130.5	119.0	113.0	↓	↓	↓	↓
8	0100	7.00	94.0	118.0	120.0	103.5				
9	0200	8.00	86.0	109.0	121.0	96.5				
10	0300	9.00	81.0	103.0	121.0	92.5				
11	0400	10.00	84.5	100.5	120.5	95.0				
12	0500	11.00	101.0	101.0	120.5	100.0				
13	0600	12.00	126.0	108.5	121.0	113.0				
14	0700	13.00	150.0	120.0	121.0	123.5				
15	0800	14.00	159.5	132.0	121.0	130.0				
16	0900	15.00	160.0	140.5	121.0	133.5	41.0	40.0	126	0.60
17	1000	16.00	154.5	143.0	120.5	134.0	40.0	39.0	122	0.60
18	1100	17.00	138.0	139.0	120.5	131.5	41.5	39.5	115	0.55
19	1200	18.00	110.0	130.0	119.5	121.5	40.0	38.5	98	0.50
20	1300	19.00	94.5	119.0	119.5	111.0	40.5	39.0	67	0.40
21	1400	20.00	86.0	107.0	119.0	101.0	40.0	38.5	35	0.20
22	1500	21.00	81.0	101.0	119.5	93.0	41.0	39.0	27	—
23	1600	22.00	81.5	97.5	120.0	90.0	41.0	39.5	20	—
24	1700	23.00	94.0	98.5	120.0	93.5	40.5	38.5	40	0.20
25	1800	24.00	115.0	105.5	120.5	98.0	41.0	39.0	91	0.50

Remarks: WT. AT START – 2.009#
WT. AT FINISH – 1.652#

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #6 — HEAT TRANSMISSION PROPERTIES — FIBERGLAS (DRY) PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date MAY 5, 1953

No.	TIME	ELAPSED TIME (HRS.)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	ROOM WALL TEMP. T_3 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	EDGE TEMP. (SAMPLE) T_5 (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)
1	1230	0	113.5	84.0	40.5	119.5	97.0	80	0.45
2	1330	1.00	130.0	98.0	40.0	120.0	107.0	98	0.50
3	1430	2.00	143.0	111.0	40.0	120.5	115.0	111	0.55
4	1530	3.00	154.0	122.0	39.5	121.0	122.5	113	0.55
5	1600	3.50	156.0	127.0	40.0	122.0	125.0	109	0.55
6	1630	4.00	155.5	131.0	39.5	122.0	127.0	103	0.50
7	1730	5.00	147.5	136.5	40.0	122.0	127.0	82	0.45
8	1930	7.00	113.0	130.5	39.5	122.0	116.0	36	0.20
9	2030	8.00	98.0	121.5	40.5	121.5	109.0	17	—
10	2130	9.00	87.5	112.0	40.0	121.0	102.0	17	—
11	2230	10.00	82.0	105.0	40.0	121.5	98.0	20	—
12	2330	11.00	84.5	99.5	40.5	122.0	97.0	41	0.25
13	2400	11.50	89.5	98.5	40.5	122.0	102.5	N.R.	N.R.
14	0100	12.50	106.5	99.5	40.0	122.0	110.0	↓	↓
15	0200	13.50	127.0	106.0	40.5	122.0	119.0	↓	↓
16	0300	14.50	145.0	116.0	40.0	122.0	125.5	↓	↓
17	0400	15.50	156.0	126.0	40.0	122.5	129.5	↓	↓
18	0500	16.50	158.0	135.0	40.0	122.5	129.5	↓	↓
19	0600	17.50	150.0	139.0	39.5	122.5	125.5	↓	↓
20	0700	18.50	134.0	138.0	40.0	122.5	113.0	↓	↓
21	0830	20.00	105.5	127.0	40.5	120.5	109.0	17	—
22	0930	21.00	91.0	117.5	40.5	120.5	99.0	17	—
23	1030	22.00	83.0	108.5	40.5	121.0	95.0	31	—
24	1130	23.00	81.5	101.0	40.0	120.5	97.0	40	0.25
25	1230	24.00	92.0	98.0	40.5	120.5	99.5	N.R.	N.R.
		25.00	110.0	99.5					

Remarks:

WT. AT START — 2.250#

MLIT-232

Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of Test #7 – Heat Transmission Properties – Corkboard (56.5% Moist.) Perimeter Insulation Investigation

Observers: W. W. Treichler Jr. Date May 6-7, 1953

No.	Time	Elapsed Time (Hrs.)	Outer Surface Temp. (Sample) T_1 (°F.)	Inner Surface Temp. (Sample) T_2 (°F.)	Room Wall Temp. T_3 (°F.)	Surface Temp. (Inner Box) T_4 (°F.)	Edge Temp. (Sample) T_5 (°F.)	Heater Input (Volts)	Heater Input (Amps)		
1	1730	-0-	120.0	90.0	41.0	121.0	104.0	84.0	0.45		
2	1930	2.00	141.0	104.5	40.5	121.0	123.0	120.0	0.60		
3	2030	3.00	149.0	114.0	40.5	121.5	129.0	128.0	0.65		
4	2130	4.00	150.5	124.0	41.0	120.0	130.5	116.0	0.55		
5	2230	5.00	146.5	131.5	41.0	120.5	130.0	93.0	0.48		
6	2330	6.00	131.0	134.5	41.0	120.5	124.0	N.R.	N.R.		
7	2430	7.00	114.0	131.0	41.0	119.5	104.0	↓	↓		
8	0130	8.00	100.5	123.0	41.0	119.0	100.0				
9	0230	9.00	91.0	113.0	40.5	119.0	100.0				
10	0330	10.00	87.0	106.0	40.5	119.0	99.0				
11	0430	11.00	93.0	100.0	40.5	119.0	98.0				
12	0530	12.00	103.0	97.5	41.0	119.0	104.0				
13	0630	13.00	119.0	102.0	40.5	119.0	109.0				
14	0730	14.00	136.0	109.0	40.5	119.5	117.5				
15	0830	15.00	147.0	118.0	41.0	120.0	125.0				
16	0930	16.00	152.0	127.0	40.5	118.5	131.0				
17	1030	17.00	146.5	133.0	41.0	119.5	130.0	120.0	0.60		
18	1130	18.00	134.0	137.0	40.5	120.5	123.0	N.R.	N.R.		
19	1230	19.00	117.0	133.0	41.0	121.0	112.5	↓	↓		
20	1330	20.00	105.0	124.5	41.0	121.0	104.5				
21	1430	21.00	94.5	115.5	40.5	121.0	96.5				
22	1530	22.00	87.0	107.0	40.5	121.0	95.0	32	—		
23	1630	23.00	85.0	101.0	40.5	121.0	95.0	27	—		
24	1730	24.00	91.0	97.5	41.0	121.0	96.0	68	0.30		
25	1800	24.50	98.0	97.0	40.5	121.0	98.0	N.R.	N.R.		
		25.00	107.0	98.0							

Remarks:

Wt. at Start : 2.964#
Wt. at Finish : 2.750#
} Ave. – 2.857#

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #8 - HEAT TRANSMISSION PROPERTIES - FIBERGLAS (12.8% MOIST.)
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR.

Date MAY 7-8, 1953

No.	TIME.	ELAPSED TIME. (HRS)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	ROOM WALL TEMP. T_3 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	INNER SURFACE* (SAMPLE) T_5 (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)		
1	2200	-0-	114.0	96.0	41.0	121.0	96.5	84	0.45		
2	2300	1.00	131.0	113.0	41.0	120.5	113.5	N.R.	N.R.		
3	2400	2.00	143.5	127.0	41.0	120.5	127.0	↓	↓		
4	0100	3.00	151.5	137.0	41.0	120.5	137.0				
5	0200	4.00	151.0	141.5	41.0	120.5	141.0				
6	0300	5.00	142.0	136.5	41.0	120.0	136.0				
7	0400	6.00	124.0	127.0	41.0	120.0	127.0				
8	0500	7.00	108.0	116.0	41.0	119.5	116.0				
9	0600	8.00	94.5	107.0	40.5	119.0	107.0				
10	0700	9.00	85.0	100.0	40.5	118.5	100.0				
11	0800	10.00	82.5	94.5	40.5	118.0	94.5				
12	0900	11.00	88.5	93.5	41.0	118.0	93.5				
13	1000	12.00	103.0	97.0	40.5	117.0	97.0				
14	1100	13.00	121.5	106.0	41.0	116.0	105.0				
15	1200	14.00	137.0	117.0	41.0	116.0	116.0				
16	1300	15.00	149.0	128.5	40.5	118.0	127.5	↓	↓		
17	1400	16.00	154.0	137.0	41.0	119.0	136.5	113.0	0.60		
18	1500	17.00	146.5	141.5	41.0	119.0	140.5	92.0	0.50		
19	1600	18.00	131.0	138.0	41.0	119.5	137.0	N.R.	N.R.		
20	1700	19.00	112.0	124.0	41.0	119.5	123.0	↓	↓		
21	1800	20.00	97.0	111.0	40.5	120.0	111.0				
22	1900	21.00	87.0	101.5	41.0	120.0	101.5	30	—		
23	2000	22.00	83.0	95.0	40.5	120.0	95.0	30	—		
24	2100	23.00	86.0	93.5	40.5	120.0	94.0	48	0.20		
25	2200	24.00	96.0	96.5	41.0	120.0	96.0	72	0.35		

Remarks: * AT PT. APPROX. 1-INCH FROM T_2

WT. AT START — 2.315#
WT. AT FINISH — 2.20[illegible]#
} AVE. — 2.259#

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #9 – HEAT TRANSMISSION PROPERTIES – STYROFOAM (1.9% MOIST./VOL.) PERIMETER INSULATION INVESTIGATION

Observers: W.W. TREICHLER JR

Date MAY 12-13, 1953

No.	TIME	ELAPSED TIME (HRS)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	ROOM TEMP. T_3 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	EDGE TEMP. (SAMPLE) T_5 (°F.)	HEATER INPUT (VOLTS)	(AMPS)		
1	1200	-0-	121.0	107.0	40.5	121.0	111.5	94	0.50		
2	1300	1.00	136.0	118.0	40.5	121.0	123.0	N.R.	N.R.		
3	1400	2.00	148.0	128.0	40.5	120.0	132.5	↓	↓		
4	1500	3.00	153.0	134.5	40.5	120.0	137.0				
5	1600	4.00	149.5	136.5	40.5	120.0	136.0				
6	1700	5.00	138.0	133.0	40.5	120.5	128.5				
7	1800	6.00	122.0	124.5	40.5	119.5	117.0				
8	1900	7.00	105.0	114.0	41.0	120.0	104.5				
9	2000	8.00	92.5	105.0	41.0	120.0	95.0	17	—		
10	2100	9.00	86.0	97.5	40.5	120.0	89.0	30	—		
11	2200	10.00	84.0	93.5	41.0	120.5	87.0	40	0.25		
12	2300	11.00	92.0	94.5	41.0	121.0	92.5	N.R.	N.R.		
13	2400	12.00	109.0	102.0	41.0	119.5	104.5	↓	↓		
14	0100	13.00	129.5	114.5	40.5	121.5	119.5				
15	0200	14.00	146.5	127.0	41.0	123.0	132.5				
16	0300	15.00	155.0	137.0	41.0	124.0	140.0				
17	0400	16.00	155.0	141.0	41.0	124.0	141.5				
18	0500	17.00	145.0	139.5	41.0	124.0	136.0				
19	0600	18.00	130.0	132.0	40.5	124.0	125.0				
20	0700	19.00	112.0	121.0	40.5	124.0	111.5				
21	0800	20.00	98.0	110.5	40.5	123.5	100.0				
22	0900	21.00	90.5	103.0	40.5	122.5	93.5				
23	1000	22.00	86.5	98.0	40.5	121.5	90.0				
24	1100	23.00	90.0	96.0	41.0	119.0	91.5	55.0	0.30		
25	1200	24.00	102.0	98.5	40.5	119.0	97.5	66.0	0.35		

Remarks: WT. AT START — 0.518# AVE. — 0.497#

WT. AT FINISH — 0.476#

MLIT-232

Sheet No. 1 OF 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

Running Log of TEST #10 – HEAT TRANSMISSION PROPERTIES – FIBERGLAS (9.9% MOIST./VOL.)
PERIMETER INSULATION INVESTIGATION

Observers: W. W. TREICHLER JR

Date MAY 13-14, 1953

No.	TIME	ELAPSED TIME (HRS)	OUTER SURFACE TEMP. (SAMPLE) T_1 (°F.)	INNER SURFACE TEMP. (SAMPLE) T_2 (°F.)	ROOM TEMP. T_3 (°F.)	SURFACE TEMP. (INNER BOX) T_4 (°F.)	EDGE TEMP. (SAMPLE) T_5 (°F.)	HEATER INPUT (VOLTS)	HEATER INPUT (AMPS)
1	1330	– 0 –	113.5	95.5	41.0	121.0	101.0	89	0.50
2	1430	1.00	125.0	107.0	40.5	120.5	112.0	111	0.55
3	1530	2.00	136.5	119.0	41.0	120.5	122.0	123	0.60
4	1630	3.00	146.0	131.0	40.0	121.0	133.5	125	0.60
5	1730	4.00	150.5	140.0	41.0	122.0	140.0	N.R.	N.R.
6	1830	5.00	145.0	139.5	40.5	122.0	137.0	↓	↓
7	1930	6.00	134.0	134.0	40.5	122.0	129.0	63	0.40
8	2030	7.00	116.5	124.0	41.0	120.5	115.5	N.R.	N.R.
9	2130	8.00	103.0	113.0	41.0	119.5	103.0	↓	↓
10	2230	9.00	94.5	105.0	41.0	121.5	97.0		
11	2330	10.00	91.0	100.0	40.5	120.5	94.0		
12	2430	11.00	96.0	100.0	41.0	120.0	95.5		
13	0130	12.00	107.5	106.5	41.0	120.0	102.0		
14	0230	13.00	123.0	115.5	40.5	121.0	114.5		
15	0330	14.00	140.5	126.0	40.5	122.0	128.0		
16	0430	15.00	151.0	135.0	40.5	122.0	139.5		
17	0530	16.00	153.5	140.0	41.0	121.0	143.0		
18	0630	17.00	147.0	140.0	41.0	121.5	137.0		
19	0730	18.00	135.0	135.0	40.5	121.5	131.0		
20	0830	19.00	119.0	124.0	41.0	121.0	118.5		
21	0930	20.00	102.5	114.0	41.0	120.5	104.0		
22	1030	21.00	92.0	106.0	40.5	120.0	95.0		
23	1130	22.00	90.0	101.0	40.5	120.0	92.5		
24	1230	23.00	98.5	101.5	40.5	119.5	96.0	↓	↓
25	1330	24.00	117.0	108.5	41.0	119.5	108.0	88	0.50

Remarks: WT. AT START — 3.29# AVE. — 3.02#
WT. AT FINISH — 2.75#

MLIT-232

Sheet No. 1 of 1

MECHANICAL ENGINEERING LABORATORY
MICHIGAN STATE COLLEGE

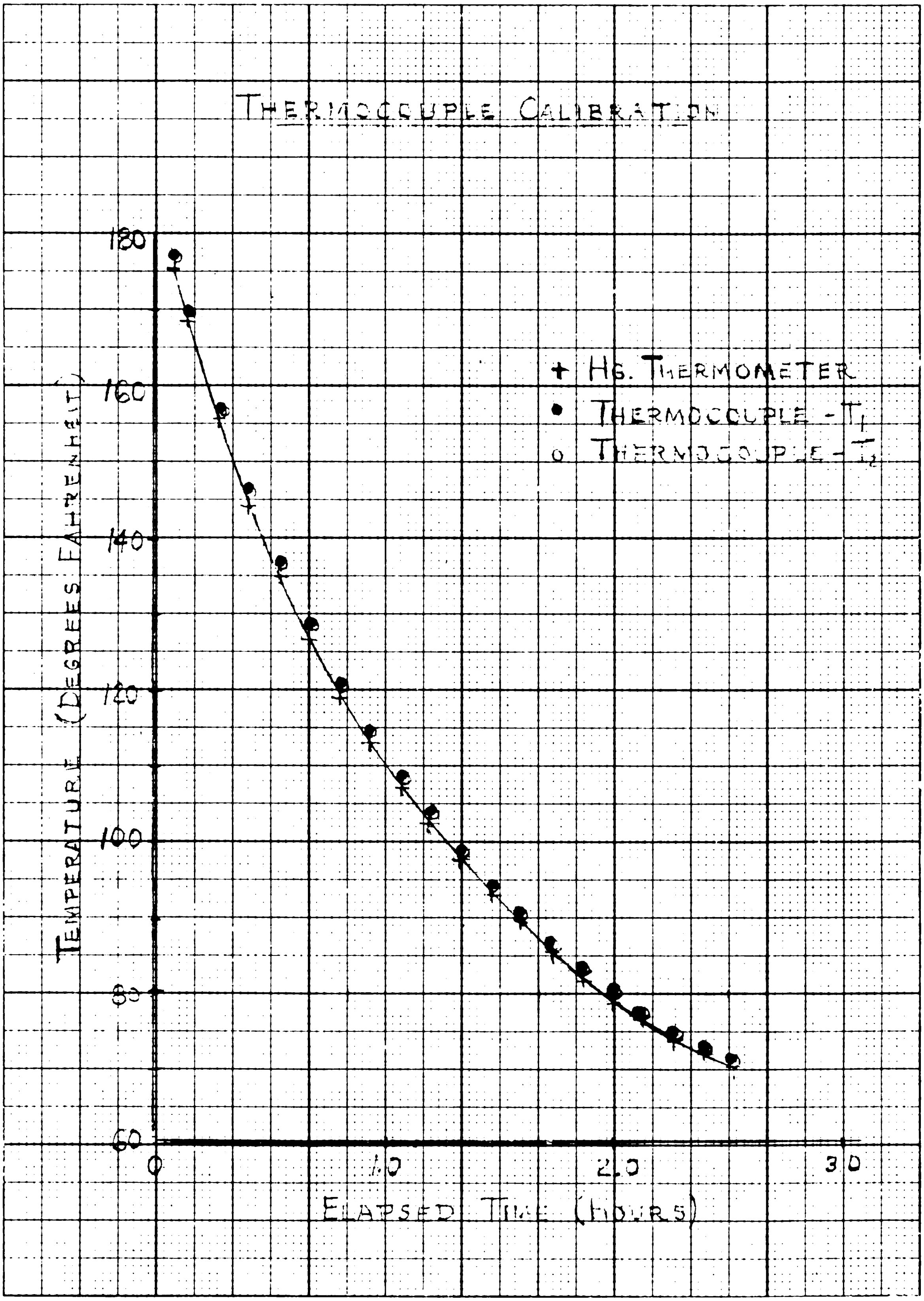
Running Log of Test #11 - Heat Transmission Properties - Fiberglas (2.16 #/ft³ - Dry) Perimeter Insulation Investigation

Observers: W. W. Treichler Jr.

Date May 11-12, 1953

No.	Time	Elapsed Time (Hrs)	Outer Surface Temp. (Sample) T_1 (°F.)	Inner Surface Temp. (Sample) T_2 (°F.)	Room Temp. T_3 (°F.)	Surface Temp. (Inner Box) T_4 (°F.)	Heater Input (Volts)	Heater Input (Amps)			
1	1000	-0-	119.0	101.0	45.0	118.0	81.0	0.45			
2	1100	1.00	125.0	109.0	42.0	118.0	N.R.	N.R.			
3	1200	2.00	136.0	120.5	41.5	119.0	↓	↓			
4	1300	3.00	143.5	129.0	42.0	119.0					
5	1400	4.00	148.0	134.5	41.0	119.5					
6	1500	5.00	142.5	135.0	41.5	120.0					
7	1600	6.00	128.0	129.5	41.5	120.5					
8	1700	7.00	108.0	119.0	41.0	121.0					
9	1800	8.00	92.5	107.5	41.0	120.5	17	—			
10	1900	9.00	83.0	98.5	40.5	119.0	17	—			
11	2000	10.00	80.5	93.5	41.0	119.0	32	—			
12	2100	11.00	87.5	93.5	40.0	119.5	55	0.30			
13	2200	12.00	104.5	100.0	40.5	119.5	N.R.	N.R.			
14	2300	13.00	126.0	115.0	40.5	120.0	105	0.50			
15	2400	14.00	146.0	131.0	40.5	120.0	N.R.	N.R.			
16	0100	15.00	156.0	141.5	40.5	120.5	↓	↓			
17	0200	16.00	157.0	146.0	40.0	120.0					
18	0300	17.00	149.0	144.0	40.0	120.0					
19	0400	18.00	134.0	135.0	40.5	119.5					
20	0500	19.00	116.0	124.0	40.5	119.5					
21	0600	20.00	99.5	112.5	40.5	119.5					
22	0700	21.00	86.5	102.0	40.5	120.0					
23	0800	22.00	80.0	95.0	40.5	120.0					
24	0900	23.00	84.0	93.0	40.5	120.0					
25	1000	24.00	97.0	98.5	40.5	120.5					

Remarks: Wt. at Start — 2.16 #
Wt. at Finish — 2.16 #



THERMOCOUPLE CALIBRATION
+ HG. THERMOMETER
• THERMOCOUPLE - T_1
o THERMOCOUPLE - T_2
TEMPERATURE (DEGREES FAHRENHEIT)
180
160
140
120
100
80
60
0
1.0
2.0
3.0
ELAPSED TIME (HOURS)

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