SC 1004-A (3-55)

[redacted]

UNCLASSIFIED

1537

[redacted]

THIS MEMORANDUM IS NOT TO BE RE-PRODUCED [redacted] WRITTEN PERMISSION OF SANDIA CORPORATION.

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

1st Review Date: 9-30-96
Authority: ☐ADC ☒ADD
Name: W. Layne
2nd Review Date: 10/2/96
Authority: ADD
Name: R.B. Crane

Classification Name (Number): U
Changes to: U
Classified Information
Contains UCAI?
Comments: OK to Release to Open Net

SCTM86-58(14)

[redacted]

Fred H. Darugh - 1461
Mina Lingenfelter - 1461

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

U
Emelda Selph 10-03-96
R.T. Duff 10/29/96
W.C. Layne
97SN009
DATED 9-30-96

A METHOD OF TESTING THE IGNITABILITY OF THERMAL BATTERY HEAT PAPER

ABSTRACT

In the development of thermal batteries, one of the many problems encountered was that of an ignitability test for the heat paper. In general the heat paper is one of the most critical factors involved in the construction of the thermal battery. This memorandum describes a method of testing, the test equipment, and the results obtained from a series of tests as developed and performed by Division 1461, Sandia Corporation

Work performed under AEC Contract AT-(29-1)-789.

[redacted]

Case No. 789.12

April 16, 1958

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

DISTRIBUTION:

Naval Ordnance Laboratories, Mr. R. Bianchi, Attn: A. S. Will,
White Oak, Silver Spring, Maryland
Diamond Ordnance Fuze Laboratories, Washington 25, D. C.
U. S. Army Signal Engineering Laboratory, Fort Monmouth, New Jersey,
Attn: Dr. Adolph Fischback, Chief, Power Sources Division
Eagle-Picher Company, Joplin, Missouri, Attn: M. F. Chubb
Catalyst Research Company, 6101 Falls Road, Baltimore 9, Maryland,
Attn: J. P. Woolley
Pass and Seymour, Inc., Solvay Station, Syracuse, New York,
Attn: M. N. Russell
Rudolph Wurlitzer Co., North Tonawanda, New York, Attn: J. W. Lally
E. I. Bruce, 1461
R. S. Summers, 2551
F. H. Darugh, 1461-1
M. Lingenfelter, 1461-2
J. McMinn, 8141
R. K. Smeltzer, Central Record File, 7221-3
L. F. Parman, 7223 (6)

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

TABLE OF CONTENTS

	Page
Introduction	5
Description of Tester	5
Operation of Tester	[illegible]
Technical Description of Test Equipment	[illegible]
Operational Sequence of Relays in Control Unit	[illegible]
Resetting the Tester	9
Calibration of Tester	9
Description of Tests Performed	10
Test Results	11
Conclusions	12

UNCLASSIFIED

[redacted]

LIST OF ILLUSTRATIONS

Page

Graph Number 1 -- Variac setting vs thermocouple temperature 13

Graph Number 2 -- Ignition time vs igniting temperature for MC-860 heat paper . . 14

Graph Number 3 -- Range of ignition times for 100 samples of MC-860 heat paper at 500°F 15

Graph Number 4 -- Range of ignition times for 100 samples of MC-860 heat paper at 750°F . . . . . [illegible]

Graph Number 5 -- Range of ignition times for 100 samples of [illegible] paper at 1000°F . . . . . [illegible]

Graph Number 6 -- Range of ignition times for 100 samples of MC-818 heat paper at 500°F 18

Graph Number 7 -- Range of ignition times for 100 samples of MC-818 heat paper at 750°F 19

Graph Number 8 -- Range of ignition times for 100 samples of MC-818 heat paper at 1000°F 20

Graph Number 9 -- Ignition time vs igniting temperature for MC-818 heat paper . . . 21

Graph Number 10 -- Ignition time vs igniting temperature for MC-583 heat paper . . 22

Graph Number 11 -- Ignition time vs igniting temperature for heat paper from an experimental battery 23

Table I -- Average ignition times for 300 samples of MC-860 heat paper at 500°, 750°, and 1000°F 24

Table II -- Average ignition times for 441 samples of MC-583 heat paper at 500- to 1000-degree temperatures 24

Table III -- Average ignition times for 400 samples of MC-818 heat paper at 450- to 1000-degree temperatures . . . . . [illegible]

Table IV -- Average ignition times for 269 samples of heat paper from an experimental battery at 500- to 1000-degree temperatures . . 25

Schematic 1 -- Heat-paper tester 26

Schematic 2 -- Layout of optical system (igniter) 27

UNCLASSIFIED

A METHOD OF TESTING THE IGNITABILITY OF THERMAL BATTERY HEAT PAPER

Introduction

The extremely desirable electrical and mechanical characteristics of the thermal battery make it attractive for use in powering electronic equipment in missiles and military weapons. This battery, being a relative newcomer to the field of electronic power devices, is in a state of constant change due to the demands of new applications.

One of the many development problems encountered was that of a precise ignitability test for the heat paper. It was acknowledged that prior methods of ignition testing by the electric spark method left much to be desired. The spark length was not [redacted] the actual heat output of the arc was not easily measured. In the search for a [redacted]est method, personnel in Division 1461 tried a concentrated beam of light in an attempt to ignite heat paper. This experiment proved so promising that further development was done along this line.

This memorandum describes a heat-paper ignition tester utilizing a concentrated beam of light as the ignition source and gives the results of a series of tests performed on heat paper by this method.

Description of Tester

The tester is composed of two units: the control panel and power supplies, and the optical system and paper holder.

The control panel (see Schematic 1,) contains two precision timers and a meter, plus various switches, calibration potentiometers, and a variac for controlling the brilliancy of a projection lamp which is incorporated in the optical system. Number 1 timer indicates the time it takes a heat-paper sample to ignite when a controlled temperature beam of light is applied to it. Number 2 timer indicates the length of time it takes to burn 7-3/4 inches of a heat-paper sample. The meter is calibrated in degrees Fahrenheit and measures the temperature induced by the beam of light at the point where it intercepts the heat paper. Potentiometer R1 controls the voltage bias on photocell No. 1. This voltage can be measured by connecting a vacuum-tube voltmeter between terminals J1 and J2 (90 volts bias appears to give a maximum sensitivity). Potentiometer R2 controls the voltage bias on photocell No. 2; this voltage can be measured between terminals J1 and J3. Potentiometer R3 controls the voltage bias on photocell No. 3; this voltage can be measured between terminals J1 and J4. Potentiometer R4 controls the voltage bias on the cathode of a 2D21 thyratron used in starting the ignition-timer. Potentiometer R5 controls the voltage bias of a thyratron used in starting the burn-rate timer. The calibration of these two units will be discussed under the section on calibration.

The optical system (see Schematic 2,) and paper holder are connected to the control panel by means of a 6-foot length of cable. In the optical system, the light from a projection lamp is focused on the heat paper sample by means of a lens system. In the instrumentation of the optical section, three photocells are used, one to monitor the intensity or temperature of the light beam, one to measure the ignition time of the paper, and one to measure the burning rate of the paper. An assembly of metal-lined asbestos strips is used to hold the heat paper in place in the beam of light and in front of the photocells. It also acts as a heat sink to

UNCLASSIFIED

UNCLASSIFIED

match the heat-sink effect of the materials in the thermal batteries. A solenoid-controlled shutter is used to control the time of application of the beam of light to the heat paper. This shutter was necessary in order to allow stabilization of the projection lamp temperature before application of the beam of light to the paper.

Other parts of the tester are a 28-volt DC supply used for relay operation, and AC-line voltage regulator, and a regulated 300-volt DC power supply for the various tubes. (These are separate units and are not shown in the schematics.)

Operation of Tester

The tester is turned on and allowed to warm up in the reset mode. [redacted]

The sample of heat paper is placed between the two as[redacted] test assembly; one strip is hinged for ease in doing this. The th[redacted] together. ~~The variac on the control panel is set at the temperatur~~[redacted] test. A curve of temperature versus variac dial setting is provided wit[redacted]ster (see section on tester calibration). When the fire switch is operated, the projection lamp lights, and 3 seconds later a time-delay relay (K6) in the tester operates. The relay K6 starts ignition-timer No. 1, and at the same instant operates the shutter, allowing the beam of light to strike the heat paper. The heat paper ignites after a period of time which is controlled by the characteristics of the paper and by the temperature induced by the light beam. The light from the ignited heat paper causes photocell No. 2 to conduct, which in turn triggers thyratron tube V4. The triggering of the thyratron tube operates a sensitive relay (K1), which stops the ignition-timer and starts burning-rate timer No. 2. The heat paper burns along its length until light from the burning paper strikes the surface of photocell No. 3, causing it to conduct and thus to trigger thyratron tube V5. The triggering of this thyratron tube operates a sensitive relay (K2), which stops the burning-rate timer.

The information supplied by the two timers is recorded along with the temperature and other pertinent information. The tester may be reset by means of the reset button.

Technical Description of Test Equipment

The optical system is composed mainly of the collimation assembly, projection lamp, socket and reflector from a standard slide projector, complete with lens-mounting clips (but the external focusing lens with tube assembly and the heat-filtering lens which come with a projector are not needed). Experimentation showed that a 750-watt projection lamp was necessary to obtain the proper temperature for heat-paper ignition.

The equipment (see Schematic 2) was mounted on a metal base in a metal box with a removable side. Slots were cut in the base so that the lens-mounting clips could be moved forward and backward in a line from the projection lamp. A small squirrel-cage type blower attached to the box cooled the projection bulb. Prior to complete assembly, power was applied to the projection lamp through the variac on the control panel; only about a third of the lamp's brilliancy was used for test purposes, chiefly to protect the eyesight and fingers of the person making the adjustments. The lamp, lenses, and reflector were adjusted until a point of light 1/8 inch in diameter and of maximum intensity was obtained at a point about 3 inches forward of the front lens. All pieces were then fastened firmly in place in the box.

UNCLASSIFIED

The optical assembly was then fastened to a radio chassis base. The heat-paper ignition-assembly asbestos strips were mounted so that the light beam coming through the hole at the beam's focal point would strike a piece of paper held between the strips.

Three coil-shield square cans were mounted on square fiber bases about 1/8 inch larger than the cans themselves so that the cans were made light-tight. Sockets for No. 927 photocells were mounted in the bases so that a photocell would stand upright inside each can. Opposite the center of the photocell's face, a vertical slot 1/16 inch wide by 1/4 inch long was cut in the side of each shield can.

Photocell No. 1 (see Schematic 2) was mounted on the end of the optical-assembly can at a right angle to the beam so that it could monitor the intensity of the beam [illegible] end lens had focused it. This photocell controls the light-intensity meter on the panel. [illegible] ocell No. 2 was mounted on the hinged section of the heat-paper asbestos-strip assembly [illegible] its slot was in line with a slit in the asbestos strip. This slit was in line with [illegible] t-beam hole drilled in the fixed-position asbestos strip. Photocell No. 3 was [illegible] was in line with a slit in the fixed-position asbestos strip. The slit in the [illegible] exactly 8 inches from the light-beam hole. A shutter, operated by a solenoid, was [illegible] line with the light-beam hole so that the beam could be cut off until needed. Photocell No. [illegible] used to measure paper-ignition time, while photocell No. 3 measures the burning rate of the paper.

The entire optical system was connected to the control panel through a 6-foot cable.

The control panel (Schematic 1) is composed of several electronic circuits. One is a 300-volt DC vacuum-tube-regulated power supply which is used as the B+ plate-voltage supply for the photocells and for the vacuum-tube sensing circuits. A 28-volt light-duty DC supply is incorporated in the control unit; its purpose is to bias the 2D21 thyratron-tube cathode circuits for correct voltage-triggering level.

Photocell circuit No. 1 is connected to the control grid of a 6C4 tube which is used as a cathode follower and is a buffer between the photocell and the temperature meter; in other words, it keeps the direct load of the meter off the photo tube. It also gives a lower minimum no-light voltage reading on the meter. The meter used is a zero-to-one milliammeter with a 50-K resistance multiplier, making it essentially a 0- to 50-volt voltmeter. It is calibrated in degrees Fahrenheit, and when a paper sample is ignited, the meter monitors the temperature of the light beam.

Photocell No. 2 controls a clock for indication of paper-ignition time. The output of the photocell is connected to grid No. 1 of a 6SN7 tube (V3) which is used as a cathode follower. The control grid of the 2D21 thyratron tube (V4) is connected to cathode No. 3 of tube V3. Light striking photocell No. 2 causes it to conduct, thus making the grid of cathode-follower tube V3 more positive. The increase in cathode-follower current results in a higher cathode voltage, which is applied to the grid of the 2D21 thyratron (V4). The grid voltage of the 2D21 (V4) was held constant by means of potentiometer R4 in the cathode circuit; the 2D21 (V4) then triggers, drawing a fairly large plate current, and thus operates the sensitive relay (K1) connected in series with the plate. Operation of the relay K1 in turn energizes a toggle-latch relay (K4), which in operating opens the timer clutch circuit, stopping the ignition-timer. At the same time, the energized K4 also connects 28 volts DC through the normally closed contact of sensitive relay K2 to the clutch which operates and starts the burning-rate timer.

Photocell No. 3 controls the burning-rate timer. When the light from a burning heat-paper sample strikes this photocell, it conducts. Its output is connected to grid No. 4 of 6SN7 cathode-follower tube V3. The voltage from the photocell causes the grid to become more positive, resulting in a higher cathode-follower current, which in turn causes a higher cathode voltage. This voltage rise is applied to the control grid of 2D21 thyratron tube (V5), and since the control-grid voltage of this tube was held constant by potentiometer R5, tube V5 triggers,

drawing a fairly large plate current through the winding of relay K2 and causing K2 to operate. The operation of K2 removes the 28 volts DC from the clutch of the burning-rate timer, stopping the timer.

The purpose of relay K3 is to remove the plate voltage from the thyratron tubes until the tester is fired. This relay prevents premature triggering of the tubes which might be caused by daylight striking the surface of the photocells during the period when heat-paper samples are being loaded or removed from the paper-holding assembly.

Relay K6 is a time-delay relay which allows the projection bulb to come up to full temperature before its output is applied to the paper sample.

Power for relay operation is supplied from a 28-volt Nobatron power supply.

A 115-volt AC power-source regulator is used to keep the light output of the projection lamp constant.

Operational Sequence of Relays in Control Unit

1. Fire button is operated, activating and latching relay K5.

2. Relay K5 operates and:

   a. Applies power to projection lamp, lighting it.
   b. Applies 28 volts DC to relays K3 and K6.

3. Relay K3 operates, connecting plate voltage to thyratrons.

4. Relay K6 (a time-delay relay, set to act 3 seconds after operation of fire button) operates and:

   a. Starts ignition-timer.
   b. Operates shutter solenoid.

5. Shutter solenoid operates, permitting light beam to act on paper sample.

6. Heat paper ignites, admitting light to photocell No. 2.

7. Photocell No. 2 conducts, triggering thyratron V4.

8. Thyratron V4 triggers, operating relay K1.

9. Relay K1 operates, activating relay K4.

10. Relay K4 latches operate and:

    a. Open the circuit to the timer clutch, stopping ignition-timer.
    b. Connect power through normally closed contacts of relay K2 to the clutch which starts the burning-rate timer.

11. Heat-paper burns its length. At end of burn, it provides light on face of photocell No. 3, causing photocell to conduct.

12. Photocell No. 3 conducts, triggering thyratron V5.

13. Thyratron V5 triggers, operating sensitive relay K2.

14. Relay K2 operates, opening power to the clutch which stops burning-rate timer.

15. Operator records data.

Resetting the Tester

1. Reset button is operated, which:

   a. Applies 28 volts DC to relay K4 reset coil, releasing K4.
   b. Applies 28 volts DC to relay K5 reset coil, releasing K5.

2. Relay K5 releases, and:

   a. Removes power from relay K3, releasing K3.
   b. Removes power from relay K6, releasing K6.
   c. Removes power from shutter solenoid, releasing solenoid.

3. Relay K3 releases, removing plate power from thyratron-tube plates and restoring them to normal.

Calibration of Tester

Potentiometers R1, R2, and R3 are adjusted with the tester in the reset position, with no light striking the surfaces of any of the photo tubes. Each potentiometer is adjusted until a vacuum-tube voltmeter indicates 90 volts when connected between J1 and J2, J1 and J3, and J1 and J4.

The most complicated calibration of this tester is that of the light-beam temperature. The calibration is performed as follows:

1. A thin piece of asbestos is placed in the heat-paper holder so as to prevent the light beam from striking the face of photocell No. 2 (the ignition-time photocell).

2. The paper holder is clamped shut.

3. A thermocouple is placed against the asbestos piece in the center of the light beam.

4. The fire button is operated.

5. The variac on the control panel is advanced from its minimum position in five-point increments of the dial, and recordings are taken of the meter readings and the temperature as indicated on a potentiometer connected to the thermocouple. Two graphs are made, one of temperature versus variac and the other of temperature versus meter readings. The meter's purpose is to monitor for any temperature changes caused by aging of the projection lamp or smoking of the lens assembly.

The setting of R4 is a cut-and-try method:

1. A thin sheet of asbestos (one used as a spacer in a battery is best) is placed so as to cover the light-beam hole in the paper-holding assembly.

2. Assembly is clamped shut.

3. Fire button is operated.

4. Lamp is adjusted to full brilliance.

5. R4 is set so that light leaking through the asbestos will not trigger the ignition-time thyratron. (It will be necessary to fire and reset the tester several times in order to find this setting.) The R4 should be set at the maximum level that will not allow the thyratron to trigger under the above condition.

6. When clamped strips are opened, the light from a flashlight directed on photocell No. 2 should trigger the thyratron. The triggering can be monitored by the [illegible]ing of the ignition-timer, which is proof of the triggering. [illegible]

The calibration of R5 is less complex. The light from a [illegible] orifice of photocell No. 3 should trigger the thyratron, stopping [illegible] control R5 should be set just above the point where the dark output [illegible] No. 3 [illegible]ot prematurely trigger the thyratron associated with the burn-rate timer. [illegible]

The temperature range at the point of the beam can be varied from ambient to 1000°F in the prototype tester.

Description of Tests Performed

(Note: In this section, the optical system will be called the igniter.)

Most heat-paper samples were ignited with both the igniter and the sample holders stabilized at -65°F. A few samples were ignited with the sample holders and igniter at ambient room temperature. Still others were ignited at -65°F but with the igniter at ambient room temperature.

Heat-paper samples were taken from Lot 208 MC-583 batteries, Lot 303 MC-818 batteries, Lot 101 MC-860 batteries, and from an experimental battery in which the heat paper ignited but failed to burn where it was in contact with metal. The battery lots were from different manufacturers.

Samples to be tested were cut and placed in the metal sample holders so as completely to cover the light-beam entrance holes. The sample assemblies were clamped together and the groups of samples to be ignited at -65°F were placed in a plastic bag [illegible] cold box to stabilize. (The plastic bags were used to help control test conditions by [illegible]ting the [illegible]mation of frost on the samples.) Samples to be ignited at ambient room temperature were [illegible]t in another plastic bag until removed for testing.

The sample holders containing the heat paper were removed one at a time from the plastic bags and placed in the light-beam path of the igniter. The fire button on the tester was operated, causing activation of the igniter. The heat-paper ignition times and, where applicable, the burning rates of the samples were recorded. The ignition temperature recorded was the temperature induced by the light-beam in a thermocouple mounted at the hottest point in the light-beam. A very small iron-constantan thermocouple was used for the calibrations. It was noted that the backing materials behind the thermocouple greatly affected the temperature recorded because of their various reflecting qualities. A graph was made which compares temperatures obtained with a dull black backing, an asbestos backing, and no backing. The calibration used was obtained with the asbestos backing, as it came closest to matching the [illegible]flecting qualities of the heat paper. The temperature of the beam at the light-beam entrance [illegible]

hole in the sample holders was checked at regular intervals. This was necessary to compensate for test equipment drift, aging of the projection lamp, and smoking of the lens assembly due to the proximity of the burning heat paper.

Test Results

Graph Number 1 contains temperatures obtained using a dull black backing, an asbestos backing, and no backing.

Graph Number 2 shows the relationship of ignition times versus [illegible] temperature for heat paper taken from an MC-860 battery. The [illegible] heat-paper samples were stabilized at -65°F.

Graph Number 3 gives the range of ignition times for 100 samples [illegible] MC-860 battery when exposed to the light beam [illegible] igniter and samples were stabilized at -65°F.

Graph Number 4 gives the range of ignition times for 100 samples of heat paper from an MC-860 battery when exposed to the light beam at 750°F. The igniter and samples were stabilized at -65°F.

Graph Number 5 gives the range of ignition times for 100 samples of heat paper from an MC-860 battery when exposed to the light beam at 1000°F. The igniter and samples were stabilized at -65°F.

Graph Number 6 gives the range of ignition times for 100 samples of heat paper from MC-818 batteries when exposed to the light beam at 500°F. Igniter and samples were stabilized at -65°F.

Graph Number 7 gives the range of ignition times for 100 samples of heat paper from MC-818 batteries when exposed to the light beam at 750°F. Igniter and samples were stabilized at -65°F.

Graph Number 8 gives the range of ignition times for 100 samples of heat paper from MC-818 batteries when exposed to the light [illegible] 1000°F. Igniter [illegible] samples were stabilized at -65°F.

Graph Number 9 gives the relationship of ignition time versus [illegible] temperature for [illegible] samples of heat paper from MC-818 batteries. [illegible] and samples were stabilized at -65°F.

Graph Number 10 gives the relationships of ignition time versus igniting temperatures for heat-paper samples from MC-583 batteries. The solid line indicates [illegible] -65°F environment. The dashed line indicates ambient room-temperature environment.

Graph Number 11 gives the relationships of ignition time versus igniting temperatures for heat paper from an experimental battery. The paper ignited but failed to burn where it was in contact with metal. The solid line indicates -65°F environment; the dashed line indicates ambient room-temperature environment.

Table I shows average ignition times in seconds for 300 samples of heat paper from an MC-860 battery when exposed to light-beam temperatures of 500°, 750°, and 1000°F.

Table II shows average ignition times in seconds for 441 heat-paper samples from MC-583 batteries. Quantities of 25 or more samples were exposed to light-beam temperatures ranging from 500° to 1000°F.

Table III shows average ignition times in seconds for 400 heat-paper samples from MC-818 batteries. Quantities of ten or more samples were exposed to light-beam temperatures of 450° up to 1000°F.

Table IV shows average ignition times in seconds for 269 heat-paper samples from an experimental battery. Quantities of ten or more samples were exposed to light-beam temperatures of 500° up to 1000°F.

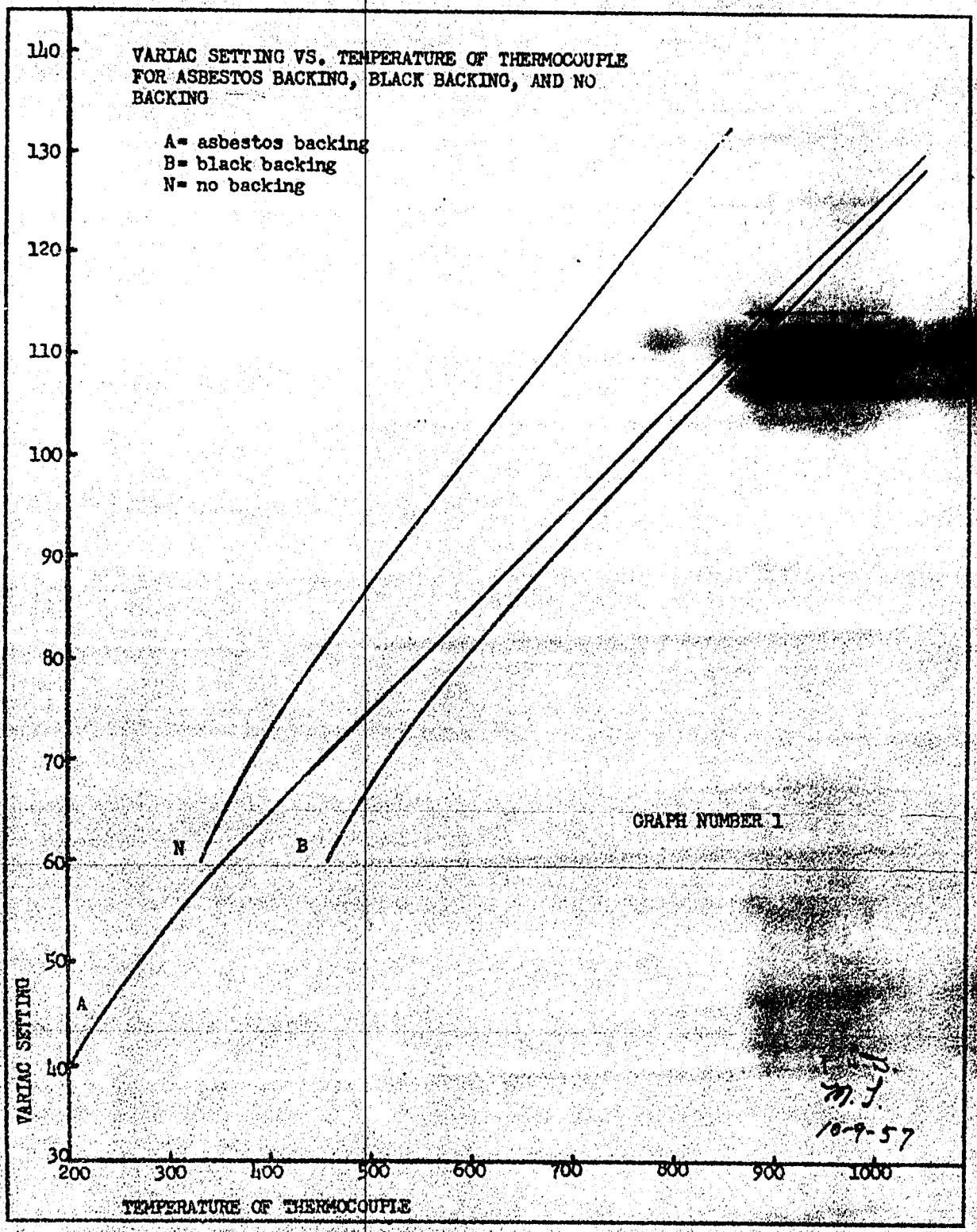
Conclusions

Over 2000 tests were run on the ignitability of small samples of heat paper removed from four models of thermal batteries. The graphs and tables of the test results indicate that the light-beam method of igniting heat paper is feasible and that the patterns of ignition times fall within limits which could be established as controls.

The principal source of trouble in the prototype tester was found to be the shutter solenoid. When operated in the cold box, this solenoid would gradually collect a coating of frost, and would freeze in either the operated or the normal position. Various silicone oils and so-called moisture repellants were tried but to no avail. It is suggested that a very heavy-duty solenoid be used in future testers.

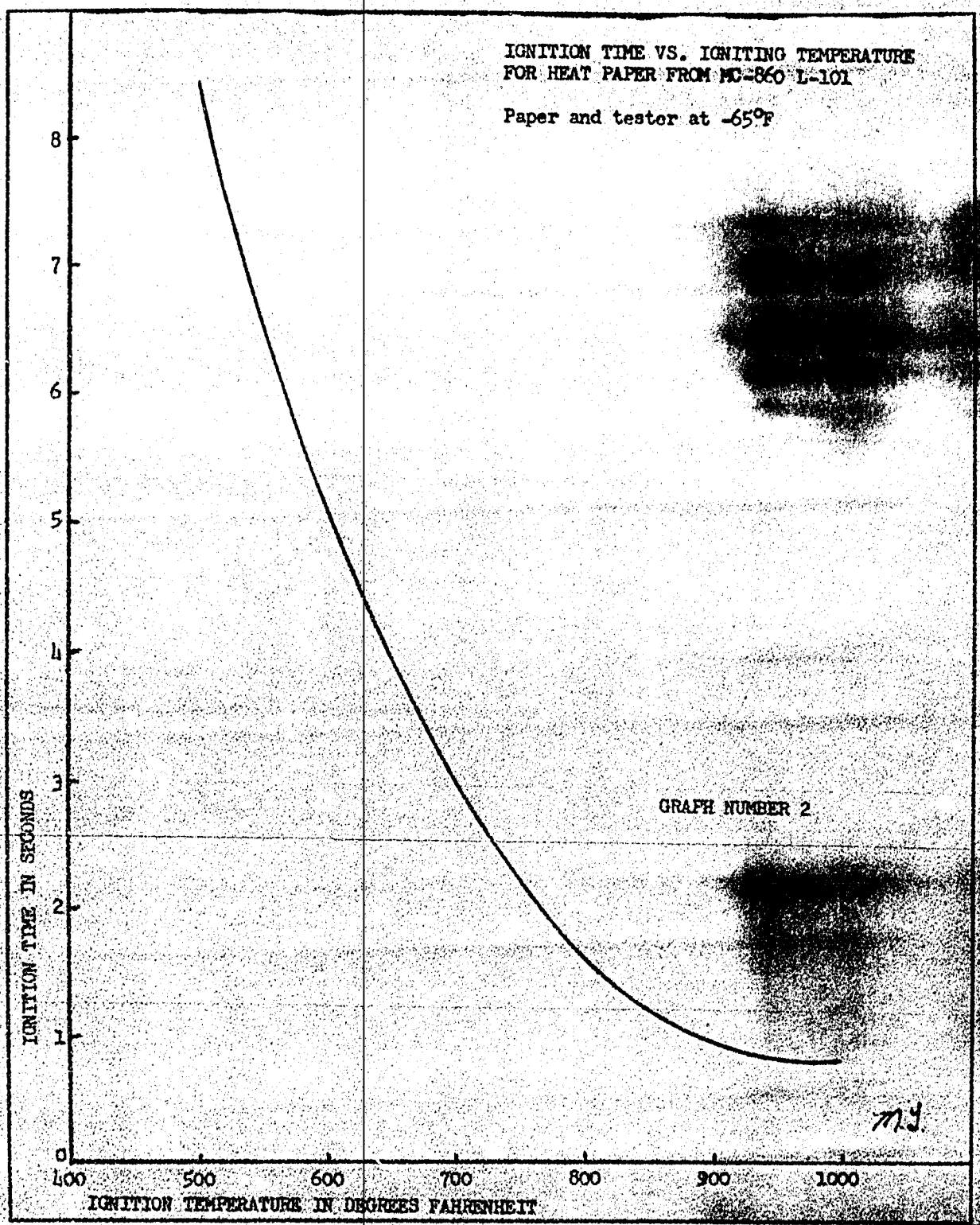
Also desirable is a method for holding the two steel-lined asbestos protection strips together under a uniform pressure. A simple spring clamp was used for this series of tests, but some means of calibrating the pressure should be used. While it appears to be an improvement to measure burning rate in contact with metal rather than in the open air, it is likely that the burning rate is also determined by the degree of compression of the heat paper.

It will be noted that the defective heat paper (Graph 11) might have been found acceptable either on the basis of an ignitability test or a burning-rate test in open air, but would have been rejected by a burning-rate test made with the tester described here.


VARIAC SETTING VS. TEMPERATURE OF THERMOCOUPLE FOR ASBESTOS BACKING, BLACK BACKING, AND NO BACKING
A= asbestos backing
B= black backing
N= no backing
GRAPH NUMBER 1
VARIAC SETTING
TEMPERATURE OF THERMOCOUPLE
140
130
120
110
100
90
80
70
60
50
40
30
200
300
400
500
600
700
800
900
1000
A
B
N
10-9-57

UNCLASSIFIED

[redacted]



UNCLASSIFIED

[redacted]

UNCLASSIFIED

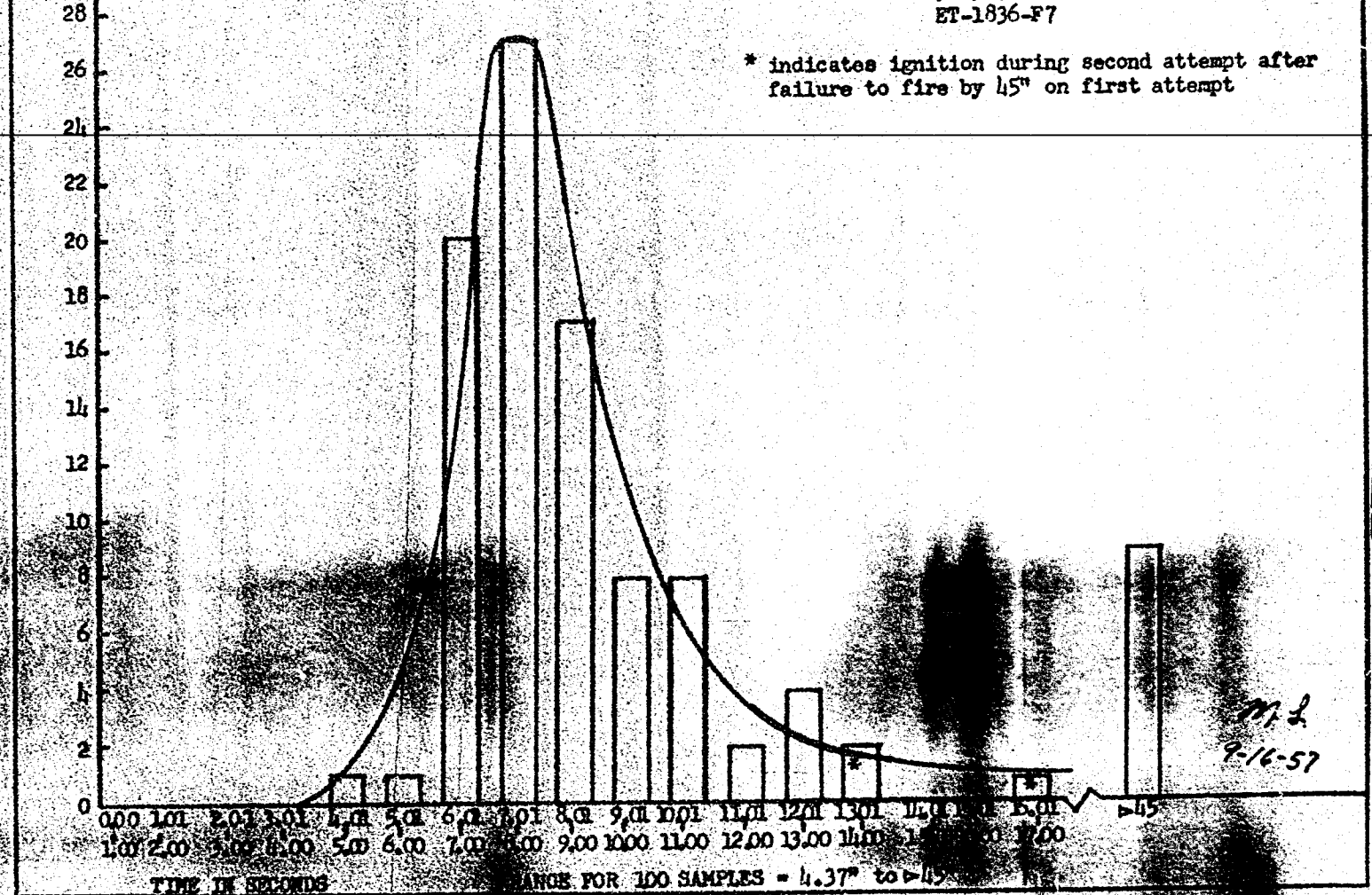
[redacted]

GRAPH NUMBER 3

TIME OF EXPOSURE OF HEAT PAPER AT -65°F to 500°F
LIGHT BEAM BEFORE IGNITION

Heat paper from MC-860
Lot 101
310527-00
ET-1836-F7

* indicates ignition during second attempt after failure to fire by 45" on first attempt



M.L.
9-16-57

UNCLASSIFIED

[redacted]

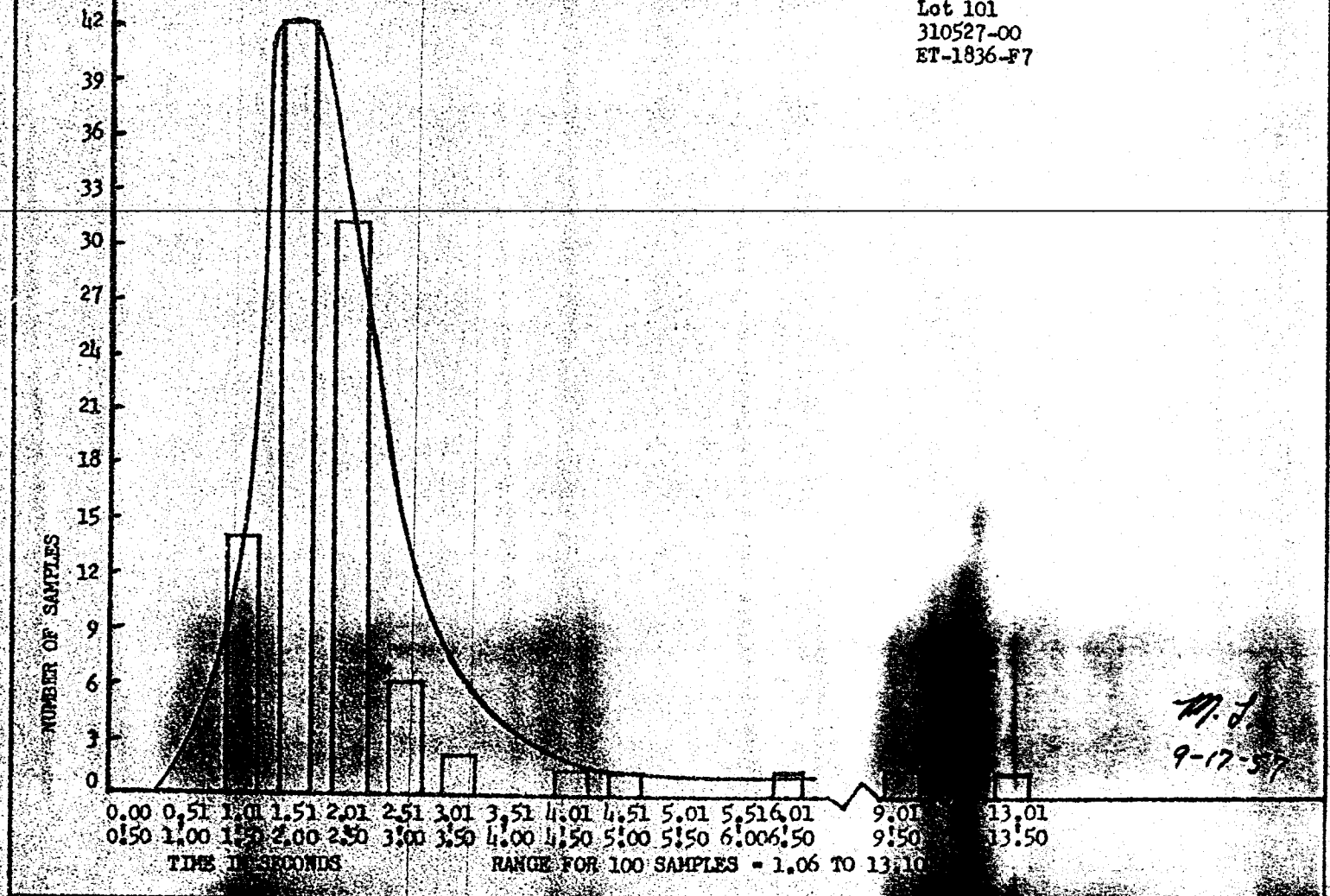
UNCLASSIFIED

[redacted]

GRAPH NUMBER 4

TIME OF EXPOSURE OF HEAT PAPER AT -65°F to 750°F
LIGHT BEAM BEFORE IGNITION

Heat paper from MC-860
Lot 101
310527-00
ET-1836-F7



M.L.
9-17-57

UNCLASSIFIED

[redacted]

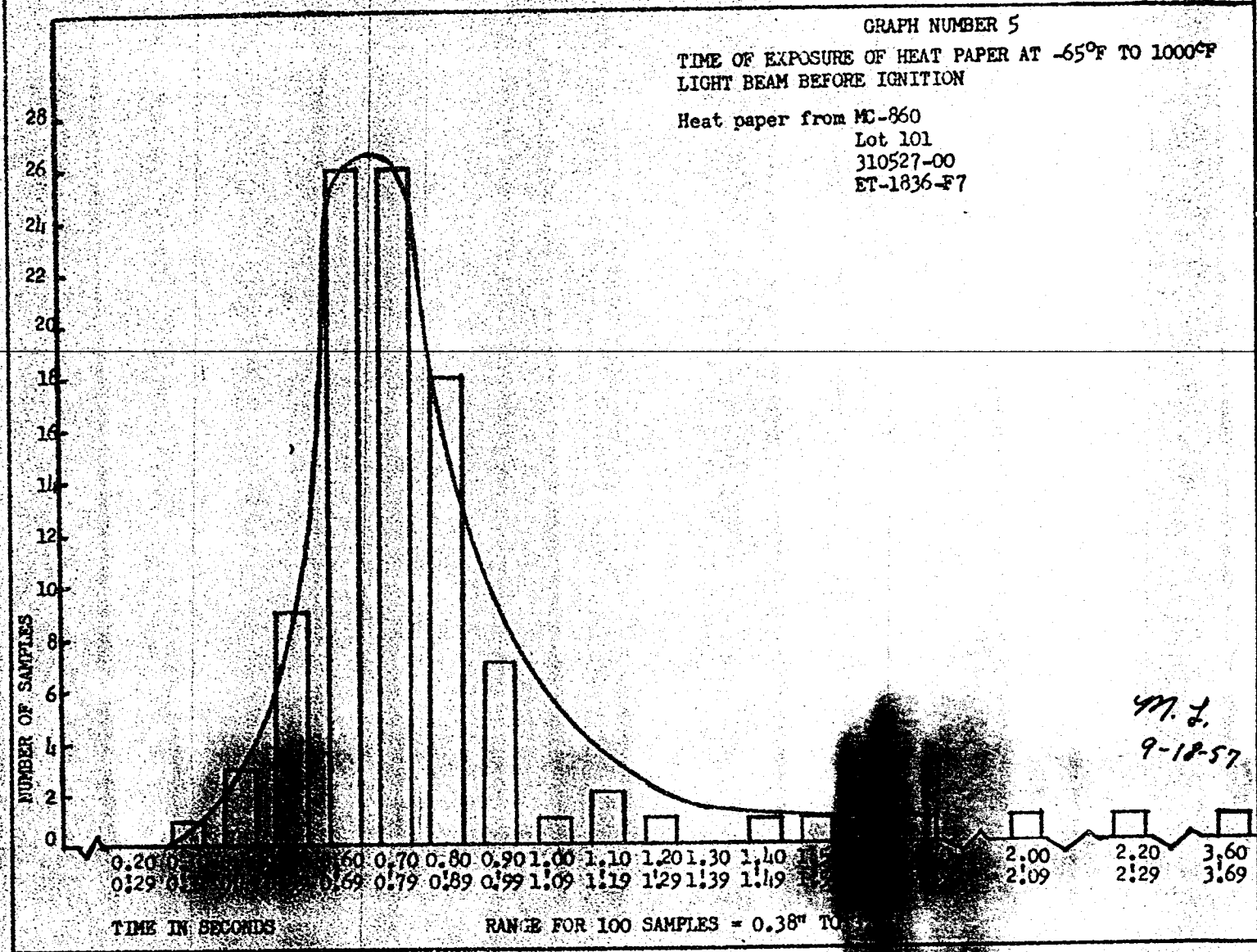
UNCLASSIFIED

[redacted]

GRAPH NUMBER 5

TIME OF EXPOSURE OF HEAT PAPER AT -65°F TO 1000°F
LIGHT BEAM BEFORE IGNITION

Heat paper from MC-860
Lot 101
310527-00
ET-1836-F7



M. L.
9-18-57

UNCLASSIFIED

[redacted]

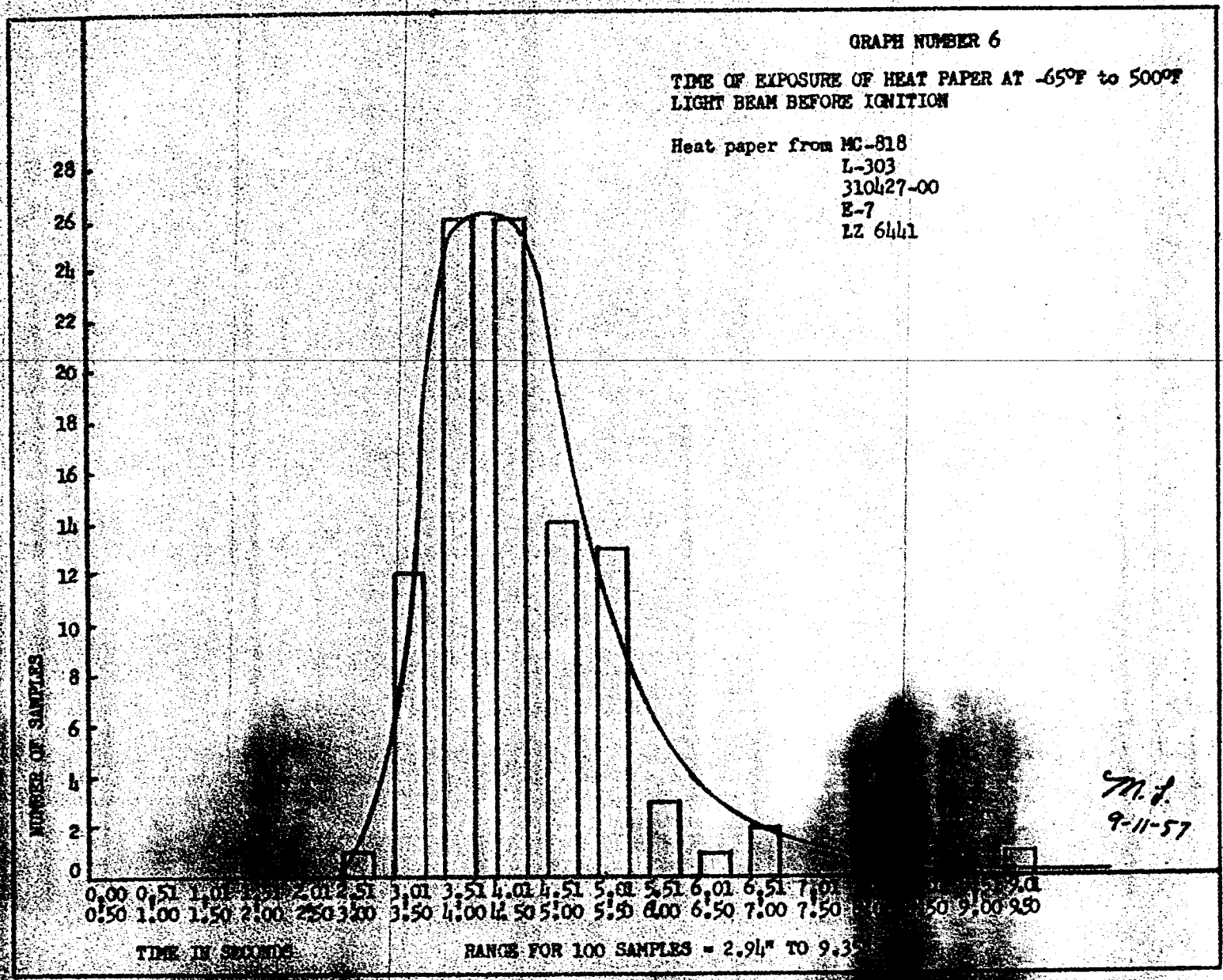
[redacted]

UNCLASSIFIED

GRAPH NUMBER 6

TIME OF EXPOSURE OF HEAT PAPER AT -65°F to 500°F
LIGHT BEAM BEFORE IGNITION

Heat paper from MC-818
L-303
310427-00
E-7
LZ 6441



M.J.
9-11-57

UNCLASSIFIED

[redacted]

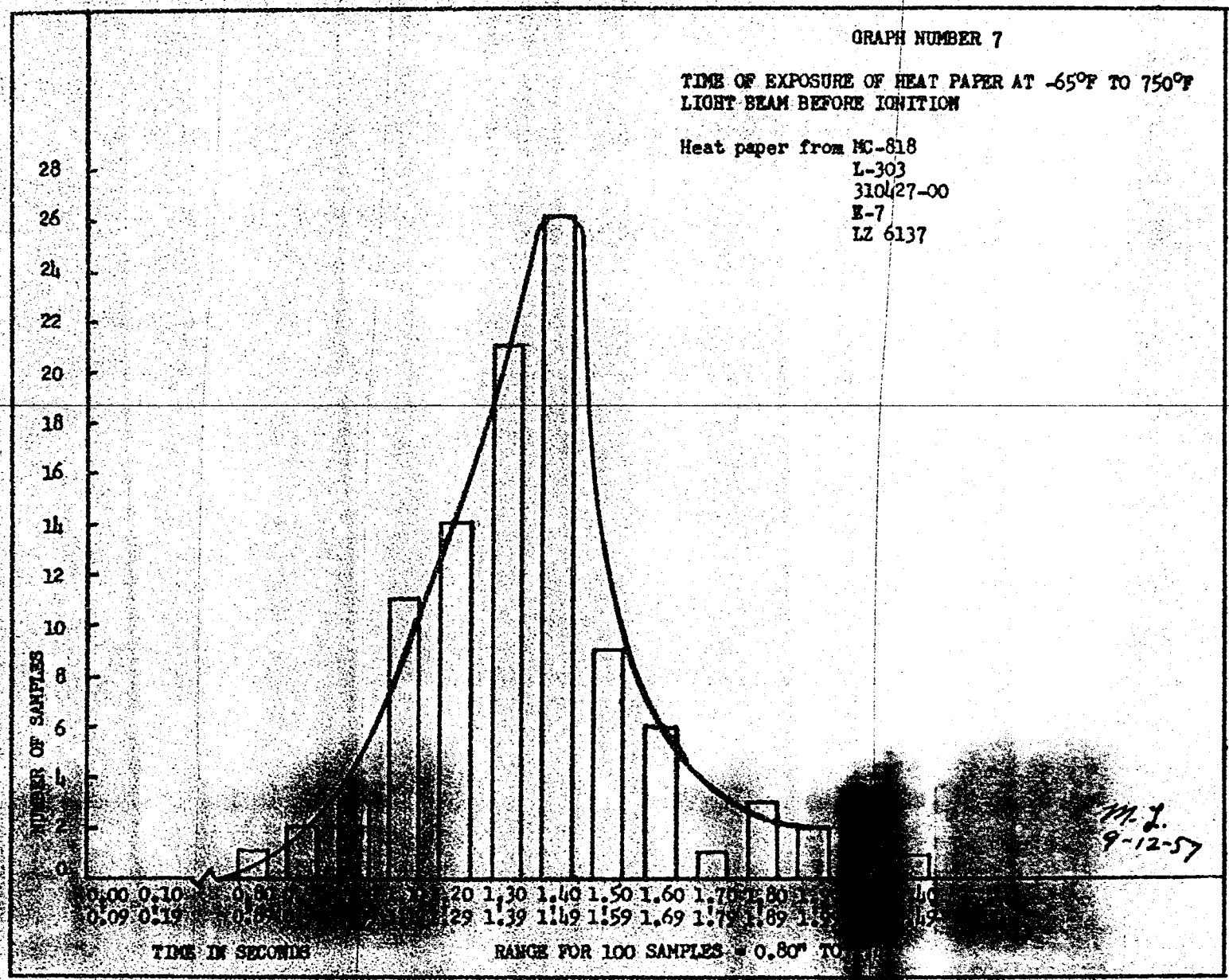
[redacted]

UNCLASSIFIED

GRAPH NUMBER 7

TIME OF EXPOSURE OF HEAT PAPER AT -65°F TO 750°F
LIGHT BEAM BEFORE IGNITION

Heat paper from MC-818
L-303
310427-00
E-7
LZ 6137



M. L.
9-12-57

UNCLASSIFIED

[redacted]

1555

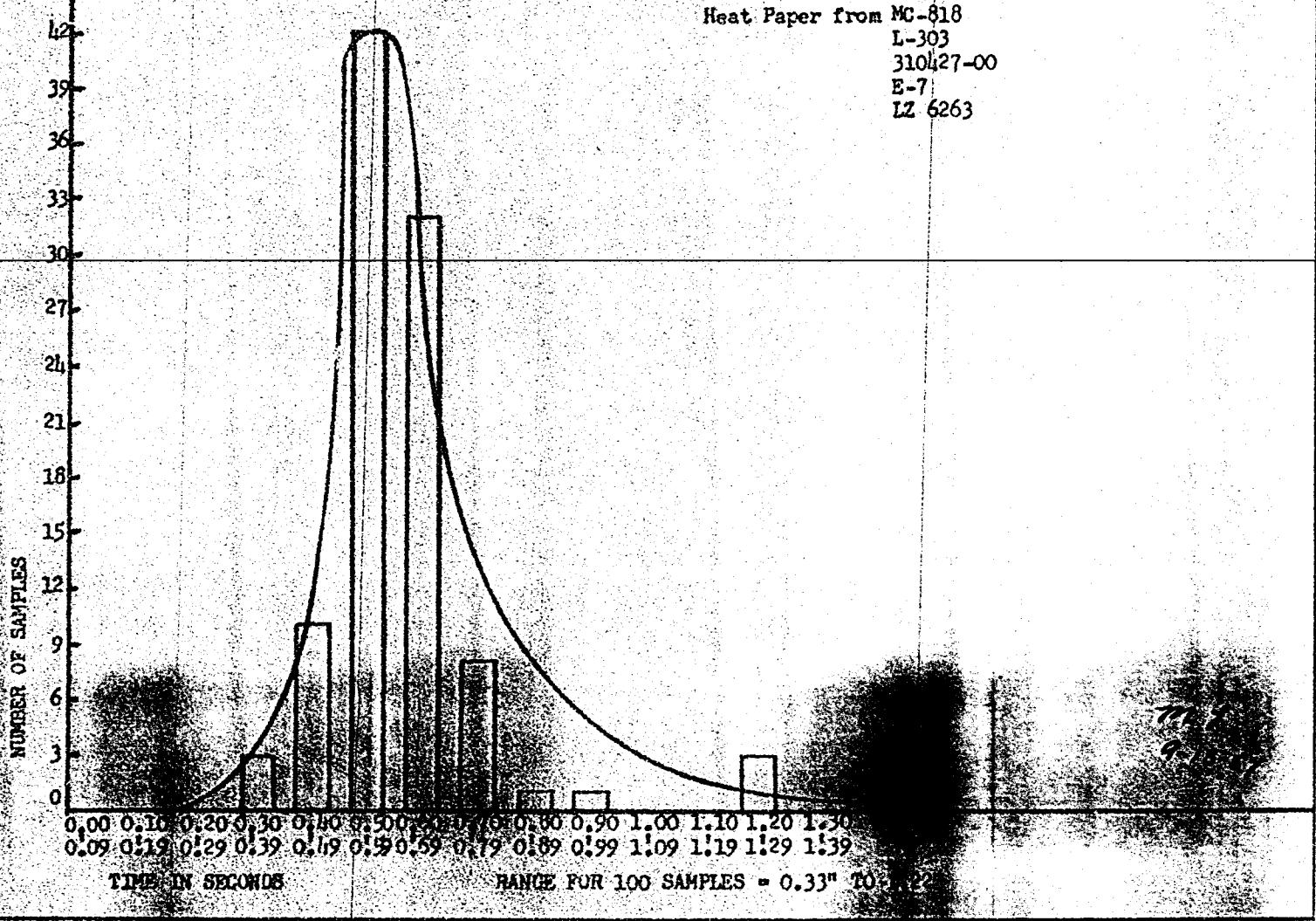
[redacted]

UNCLASSIFIED

GRAPH NUMBER 8

TIME OF EXPOSURE OF HEAT PAPER AT -65°F TO 1000°F
LIGHT BEAM BEFORE IGNITION

Heat Paper from MC-818
L-303
310427-00
E-7
LZ 6263

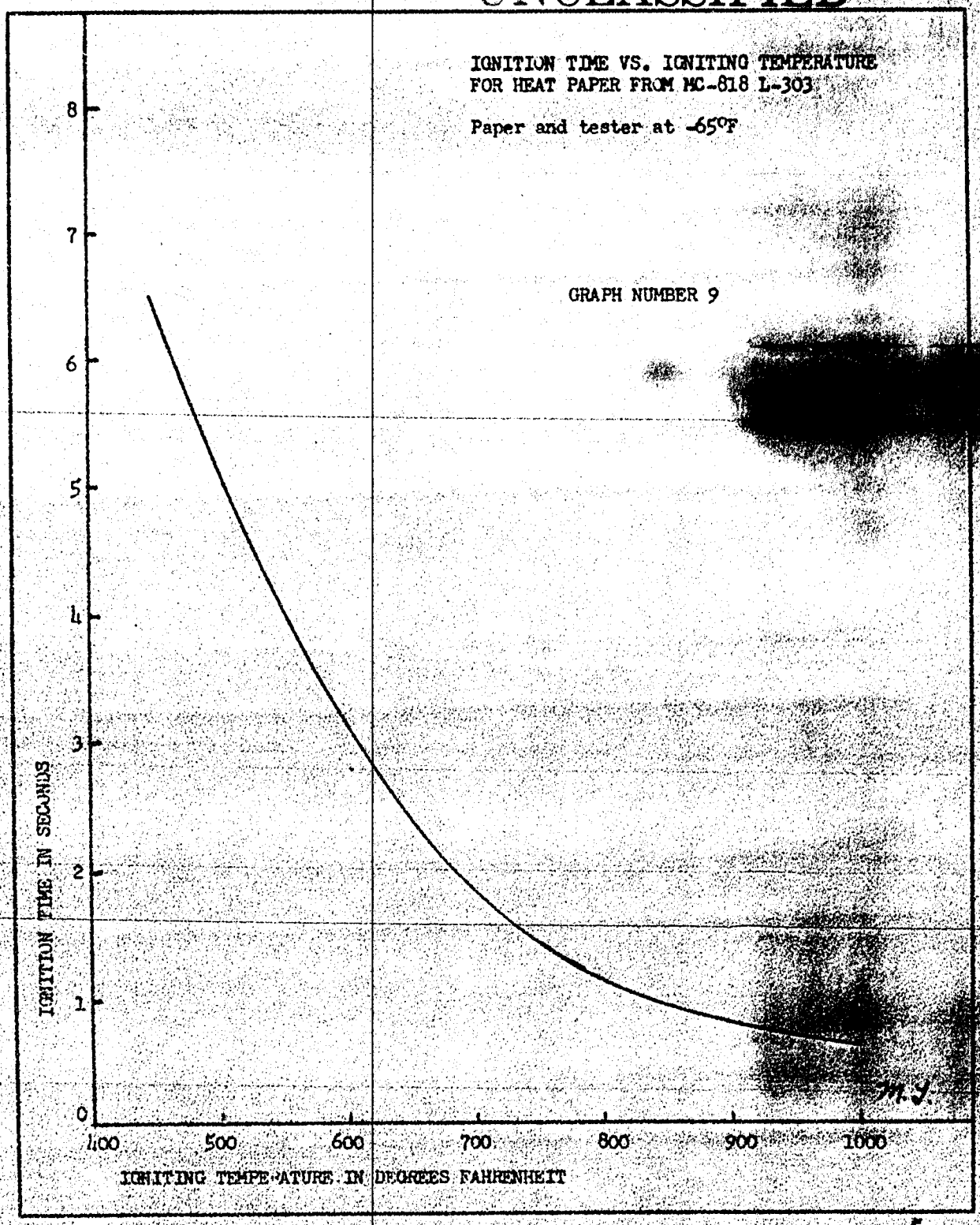


UNCLASSIFIED

[redacted]

1556

UNCLASSIFIED

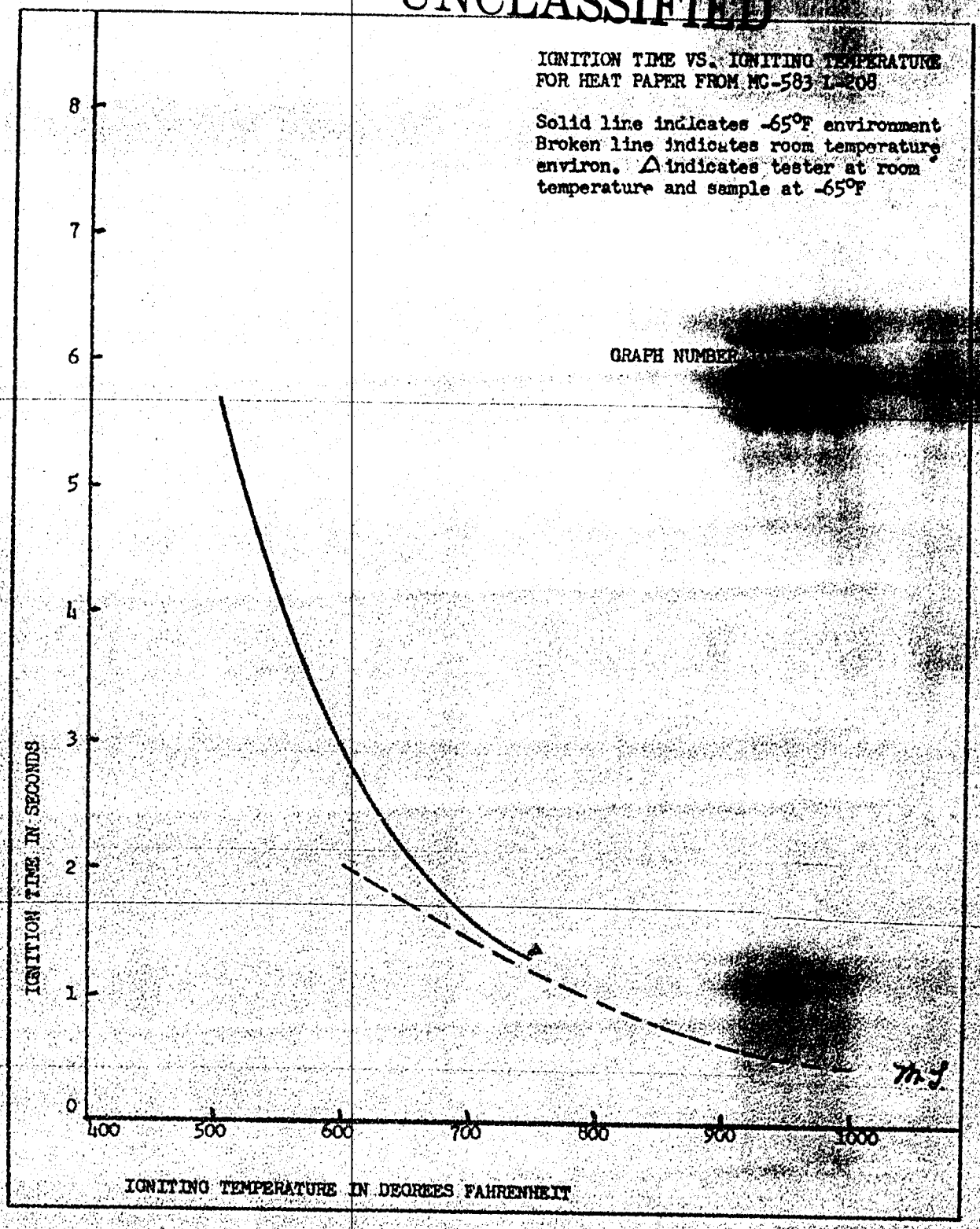


UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

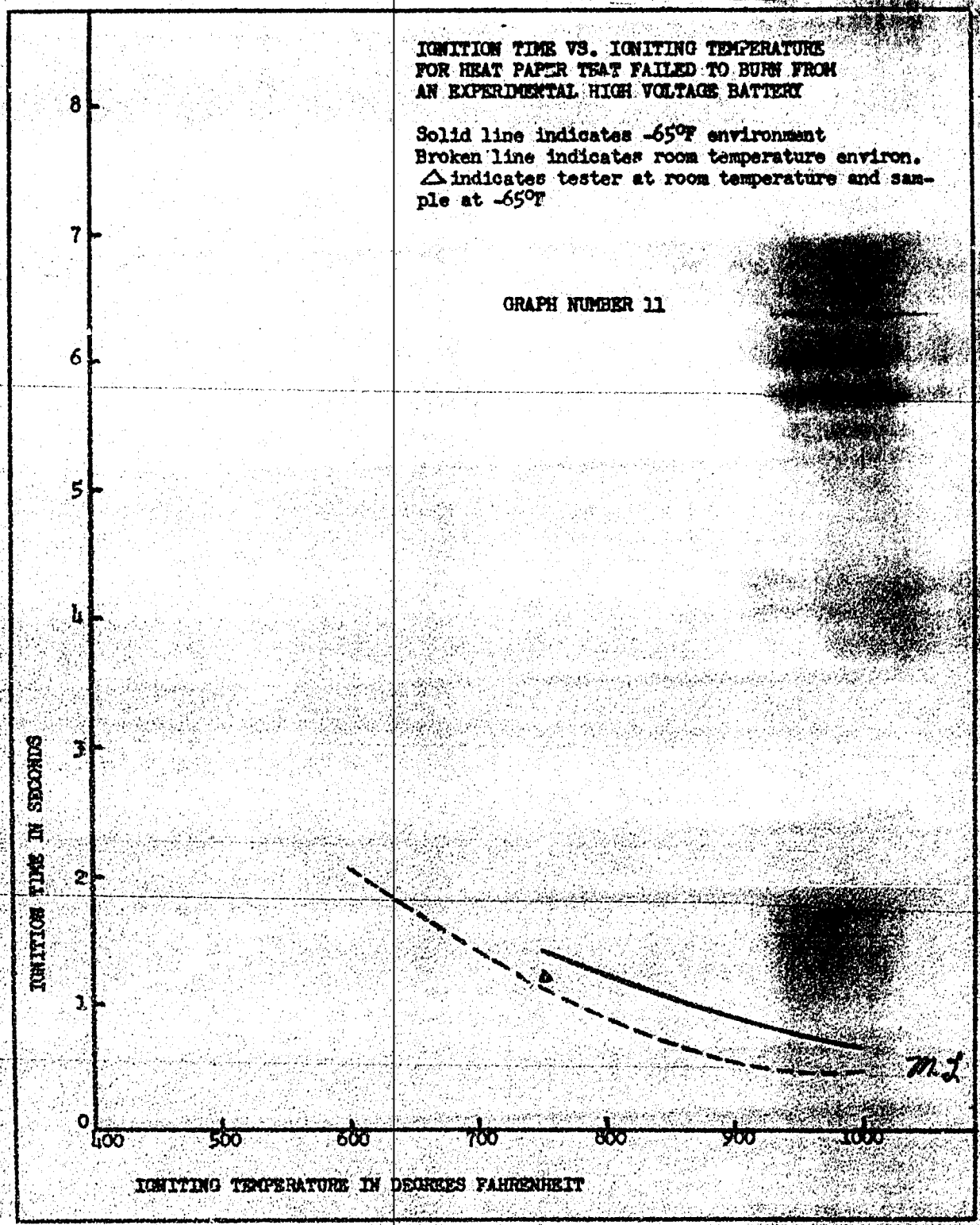


UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED



UNCLASSIFIED

[redacted]

Table I -- Average ignition times for 300 samples of MC-860 heat paper at 500°, 750°, and 1000°F

No. samples	Temperature samples (°F)	Temperature igniter (°F)	Ignition temperature (°F)	Average ignition time (sec)
100	-65	-65	500	8.42
100	-65	-65	750	2.24
100	-65	-65	1000	0.82

Table II -- Average ignition times for 441 samples of MC-583 heat paper at 500- to 1000-degree temperatures

No. samples	Temperature samples (°F)	Temperature igniter (°F)	Ignition temperature (°F)	Average ignition time (sec)
25	-65	-65	500	5.80
25	-65	-65	550	4.29
25	-65	-65	600	2.79
25	-65	-65	650	[illegible]
25	-65	-65	700	[illegible]
102	-65	-65	750	[illegible]
28	-65	RT	750	[illegible]
63	RT	RT	800	[illegible]
52	RT	RT	750	1.26
25	RT	RT	875	0.70
26	RT	RT	950	0.52
25	RT	RT	1000	0.47

Table III -- Average ignition times for 400 samples of MC-818 heat paper at 450- to 1000-degree temperatures

No. samples	Temperature samples (°F)	Temperature igniter (°F)	Ignition temperature (°F)	Average ignition time (sec)
25	-65	-65	450	6.61
135	-65	-65	500	4.45
10	-65	-65	550	4.60
10	-65	-65	600	3.70
10	-65	-65	650	2.58
10	-65	-65	700	2.12
100	-65	-65	750	1.38
100	-65	-65	1000	0.60

UNCLASSIFIED

Table IV -- Average ignition times for 269 samples of heat paper from an experimental battery at 500- to 1000-degree temperatures

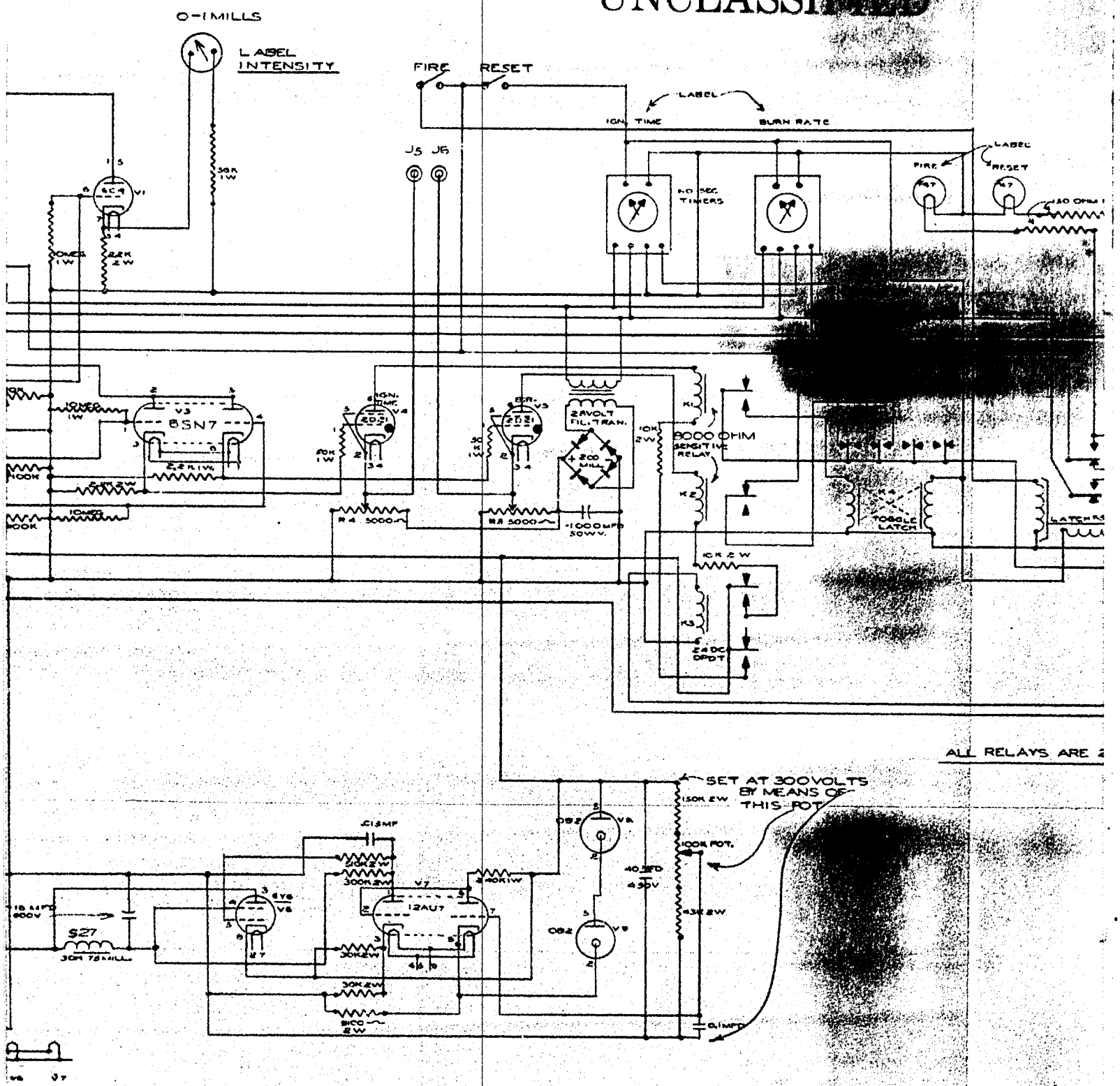
No. samples	Temperature samples (°F)	Temperature igniter (°F)	Ignition temperature (°F)	Average ignition time (sec)
[redacted]				
10	-65	-65	500	>30
10	-65	-65	750	2.14
25	-65	-65	800	0.98
25	-65	-65	850	0.82
25	-65	-65	900	0.69
25	-65	-65	950	0.56
10	-65	-65	1000	0.86
30	-65	RT	750	1.20
20	RT	RT	600	2.07
49	RT	RT	750	1.01
20	RT	RT	875	0.59
20	RT	RT	1000	0.42

UNCLASSIFIED

[redacted]

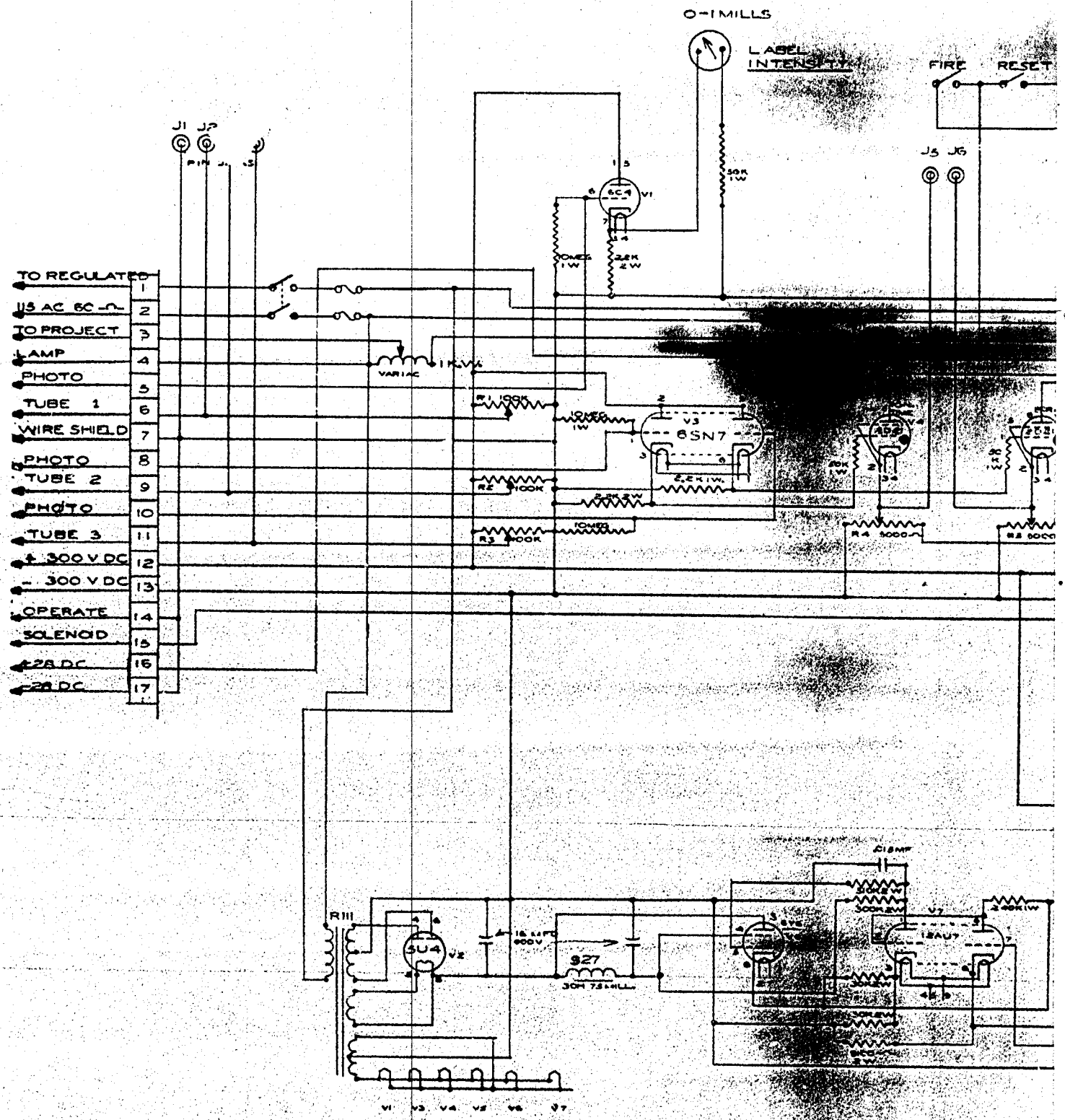
[redacted]

UNCLASSIFIED

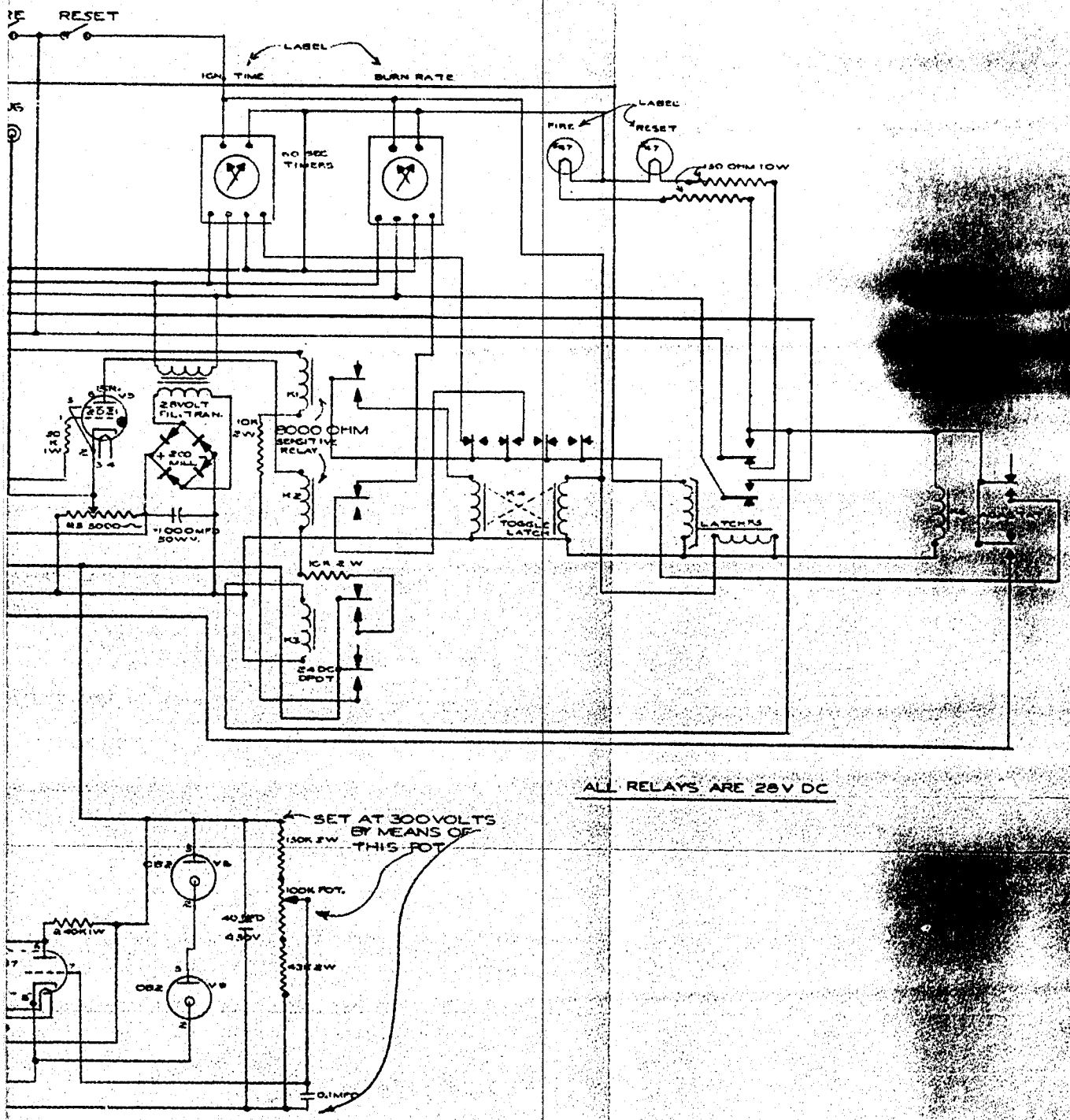


Schematic Number 1 -- Heat-paper tester

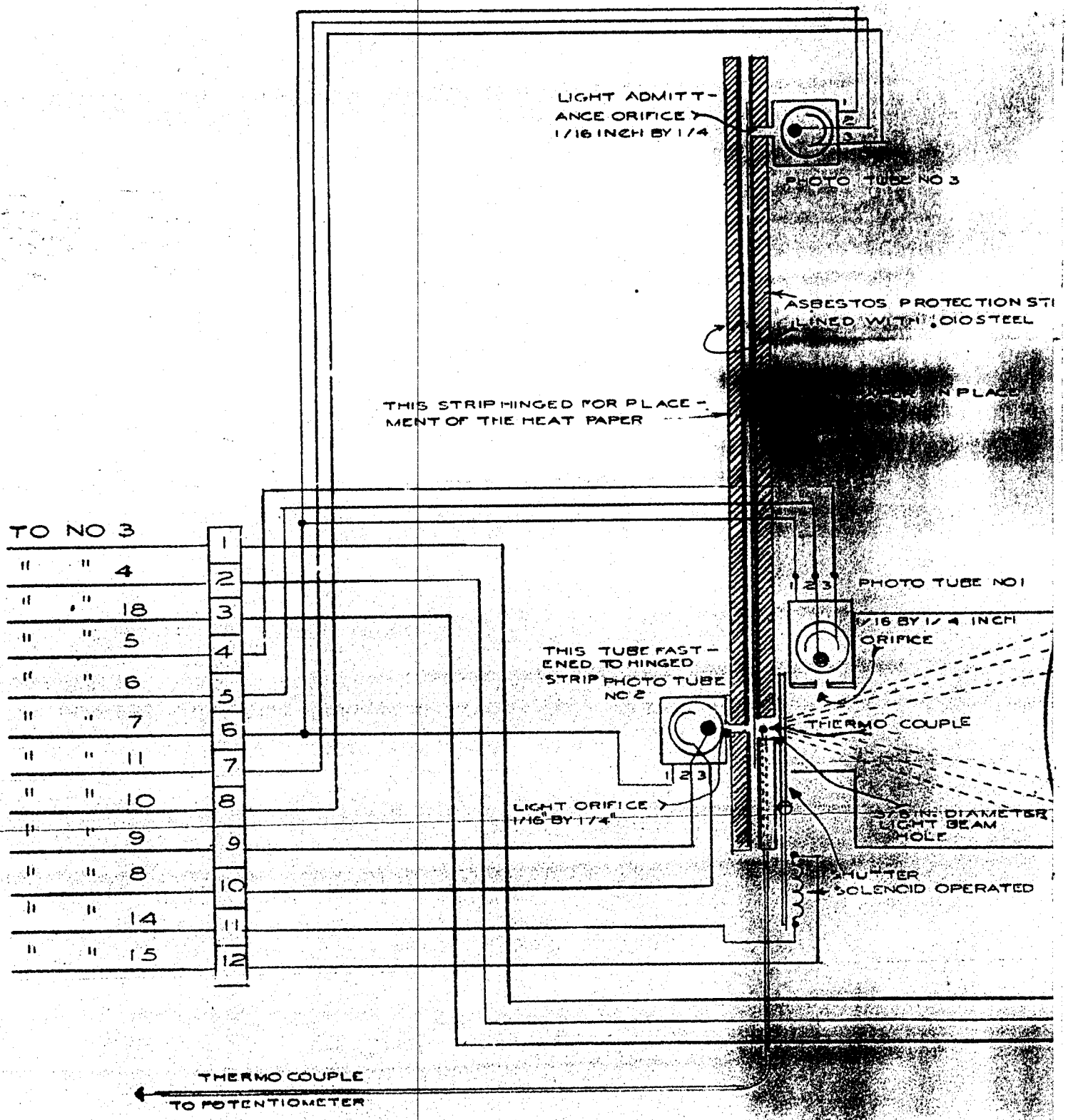
[redacted] UNCLASSIFIED



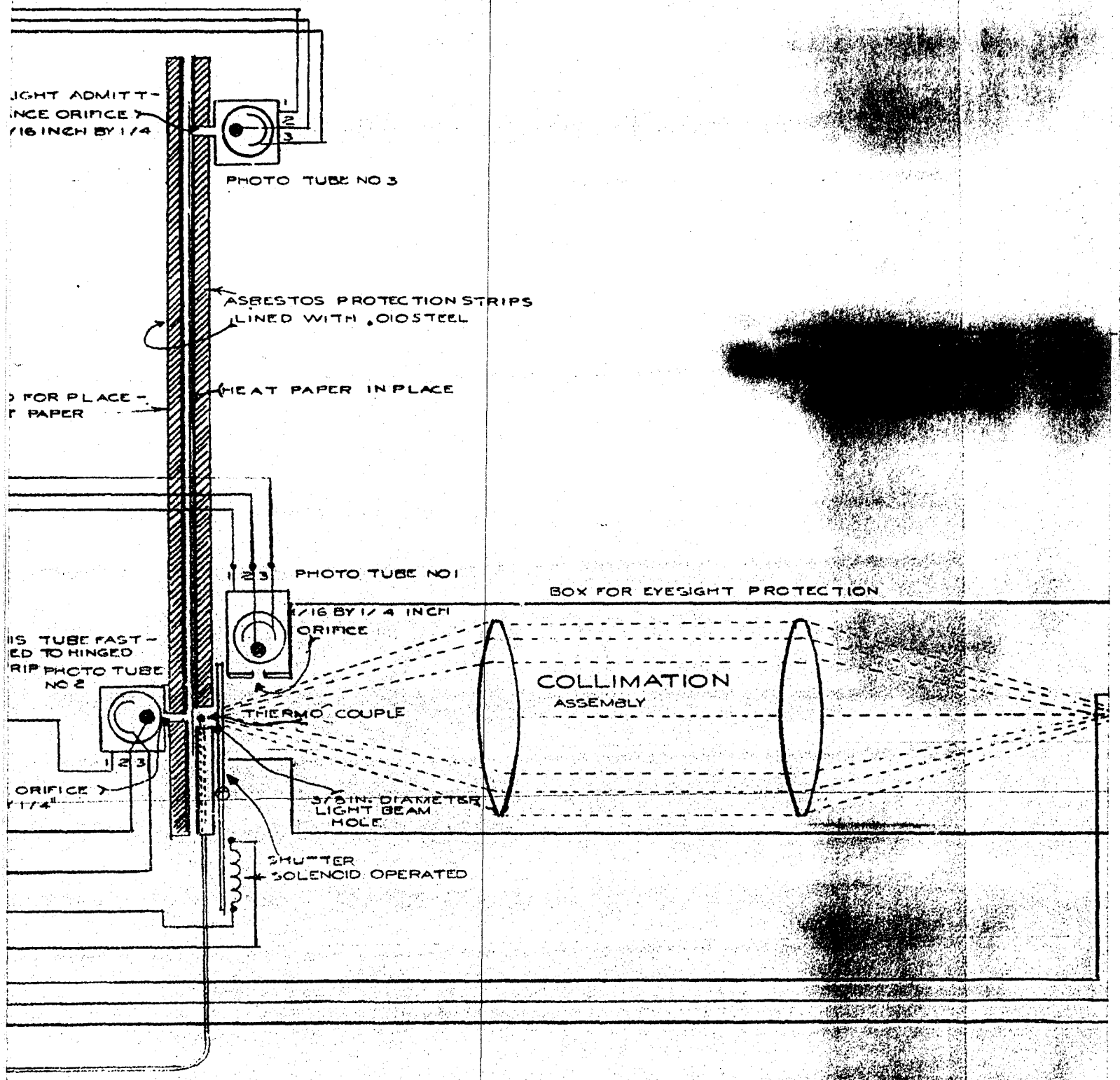
Schematic Number 1 -- Heat-pape



Heat-paper tester

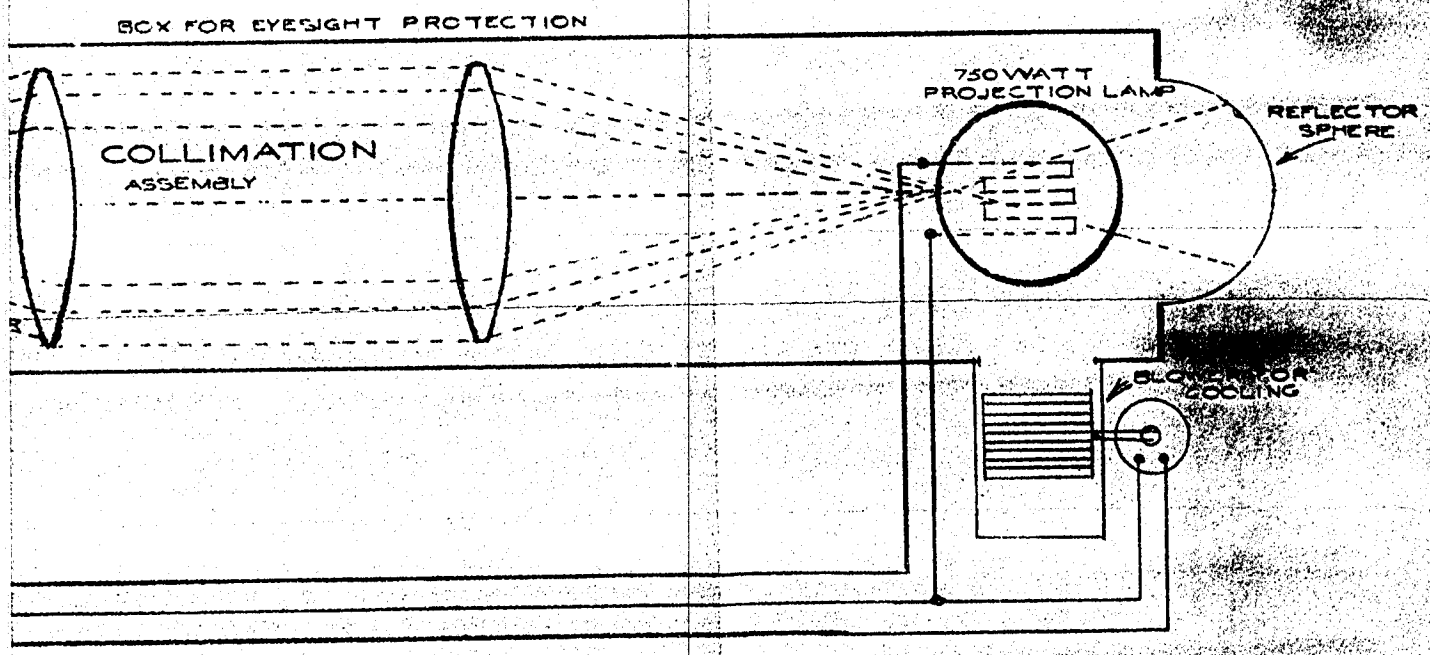


Schematic Number 2 --



Schematic Number 2 -- Layout of optical system (igniter)

TRIPS



- Layout of optical system (igniter)