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OSRD No. 382

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NATIONAL DEFENSE RESEARCH COMMITTEE

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Report on "The Development of Oil Incendiary Bombs"

by

R. P. Russell, Executive Vic-President

Standard Oil Development Company

OSRD No. 382

Serial No. 176

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Division B
NATIONAL DEFENSE RESEARCH COMMITTEE
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Report on "The Development of Oil Incendiary Bombs" (CWS-21)

Endorsement (1) From R. P. Russell, Member Section B-7-D, to E. P. Stevenson, Chairman, Section B-7. Forwarding report.

(2) From E. P. Stevenson, Chairman, Section B-7 to Roger Adams, Chairman, Division B. Forwarding Report and noting:

> "Four pound bombs containing gasoline gels appear to be as effective as four pound magnesium bombs for setting fire to wooden structures, such as attics, and markedly superior to four pound thermate bombs. Rubber gels and soap gels are equally good in non-explosive bombs."

(3) Twenty-three copies forwarded to Dr. Irvin Stewart, Secretary of the National Defense Research Committee, as Progress Report under Contract B-204, OEMsr-183 with Standard Oil Development Company.

Roger Adams, Chairman
by Harris M. Chadwell
Technical Aide

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C O N T E N T S

STANDARD OIL DEVELOPMENT COMPANY

C O N F I D E N T I A L

QUARTERLY PROGRESS REPORT ON

"THE DEVELOPMENT OF OIL INCENDIARY BOMBS"

to the

National Defense Research Committee

of the

Office of Scientific Research and Development

Quarterly Progress Report No. 1

S.O.D. Project No. 20907

N.D.R.C. Project No. 199

Contract N.D.R.C.-OEMsr-183

January 20, 1942

I. Abstract

A quarterly progress report outlining the Standard Oil Development Company's work under N.D.R.C. Project No. 199, Contract OEMsr-183 on the development of air-borne incendiary bombs to provide a substitute for the present 4-lb. magnesium bomb may be summarized as follows:

A. The preponderance of official information is to the effect that most incendiaries come to rest in attics and hence many or most fires started by such incendiaries initially were attic fires. In view of this information primary attention has been paid to developing mixtures and methods of application which would cause destructive attic fires. It has been assumed temporarily that a technique successful in this direction would also be satisfactory as regards ability to fire other structures as well. It has been found that attic structures can be destructively burned with the minimum amount of fuel if the incendiary is placed near or discharged into the eaves line where the roof lath and rafters serve as kindling.

100°F

B. Petroleum mixtures of 10 to 12 pounds per sq.in. Reid vapor pressure, corresponding to average motor gasoline, give satisfactory ignition characteristics down to -40°F. and can be handled in light weight containers (with proper allowance for outage) up to 150°F.

C. Light petroleum fuels, such as pentane or lighter and unthickened gasoline give rapid, flash burns which are ineffective. Heavy oils, such as gas oil or fuel oil give long burning but too low flames and are difficult to ignite at low temperatures. Gasolines or naphthas having final boiling points of from 350 to 500°F. when properly thickened with rubber or soaps, do not flash burn nor bleed unduly, are long burning, are adhesive and cohesive, and give the most effective destruction for a given weight of fuel.

D. Studies of various thickening agents have shown that (1) if rubber is used, less latex than crepe or smoked sheet is required for a given degree of thickening, (2) crepe rubber is simplest in application since strips of crepe may be immersed in the gasoline and thickening is accomplished without heating or stirring, (3) cold sett gasoline soaps duplicate the burning characteristics of these gasoline-rubber gums, maintain their consistency reasonably well from 150° to -40°F., do not bleed unduly or flash burn, and can be compounded by a simple technique which it is believed can be readily applied in the field.

The most satisfactory gasoline soap, Formula 122, has the following composition:

Stearic acid (or hydrofol)	3.5 wt.%
Rosin	1.8 "
Cottonseed oil (or castor oil)	3.0 "
Caustic soda	1.1 "
Water	2.2 "
Motor gasoline	88.4 "
	100.0 wt.%

E. Burning tests have been carried out in several attic structures in which destructiveness and completeness of any fire are taken as the criteria. Various attic structures have shown the same general conclusions:

1. With a given weight of fuel located at a given distance from the eaves, thickened gasoline is equal to magnesium and is distinctly superior to thermate.

2. Gasoline-rubber gums and gasoline soaps are equally effective.

3. Destructive fires are not started by discharging discreet particles into and adhering onto the underside of the roof, near the ridge pole.

4. A given weight of fuel which causes a destructive fire when fires on a single discreet particle may not start a destructive fire if separated into several smaller particlos.

5. Gasoline soaps discharged from the end of a 3 inch diameter bomb into the eaves line may cause destructive fires with as little as 2 pounds of fuel.

F. Preliminary designs indicate that a bomb of approximately 4 pounds total weight will contain approximately 2 pounds of soap thickened gasoline. It is believed that such a bomb will be nearly as effective as the 4-lb. magnesium bomb (1.2 lb. of magnesium) and distinctly superior to the present standard 4-lb. thermate bomb.

G. Further work is planned including the testing of 4-lb. gasoline soap bombs by projecting them from a mortar through typical roof structures to permit final data for design purposes.

II. Introduction

A. Purpose of the Report

The purpose of this report is (a) to outline the progress of the Standard Oil Development Company's work for N.D.R.C. to date (i.e. from October 20, 1941 to January 20, 1942) on development of air-borne incendiary bombs and (b) to present Development's tentative conclusions based on data obtained from Professor L. F. Fieser of Harvard, from Mr. S. W. Adey of the British Petroleum (Warfare) Board, and from Development's own investigations.

B. Statement of the Problem

The primary problem as understood by the Standard Oil Development Company is the development of an air-borne oil type incendiary bomb approaching as nearly as possible the effectiveness of the present 4-lb. magnesium incendiary for firing either (a) debris produced from ordinary wood and brick structures by the action of demolition bombs, or (b) ordinary light construction such as wood or brick walled dwellings, shops, warehouses, and light factory construction.

The problem is understood to be further sub-divided into (a) the earliest possible development of an immediate substitute for the 4-lb. magnesium bomb and replacement for the thermate bomb until late 1942, at which time adequate supplies of magnesium are expected to become available, and (b) development, if possible, over whatever development period is necessary, of an oil type incendiary bomb as a satisfactory long-term replacement of or supplement to the 4-lb. magnesium incendiary bomb.

The preponderance of official information made available thus far is to the effect that most incendiaries come to rest in attics and therefore most of the fires in dwellings which have been started by incendiaries have initially been attic fires. Firing of attic structures, therefore, has been taken as the first objective on the assumption that a bomb of maximum effectiveness for causing destructive attic fires could be made equally effective for firing other parts of the structure or debris as well. It has also been assumed that the attics have been cleared of rubbish as a preliminary air-raid precaution and therefore auxiliary kindling material is absent.

III. Fuel Quality

As shown in Table 1, hydrocarbon fuels have greater calorific values than an equal weight or volume of thermite or magnesium and hence the work thus far has dealt principally with various petroleum mixtures.

A. Ignition Characteristics of Hydrocarbon Fuels

An important requirement of a hydrocarbon fuel for use in an incendiary bomb is that it be readily ignitable under all temperature conditions to which it may be subjected. Hydrocarbon fuels can be ignited and will continue to burn if the fuel temperature is above its fire point. Kerosene, for example, has a fire point slightly above 110°F. and therefore is not suitable for ignition at a room temperature of 60°F. Since the bombs are carried at high altitudes for considerable periods of time, it is quite probable that the fuel temperature in the bomb will approach that of the surrounding atmosphere (see Appendix I).

Temperatures at altitudes reached in bomber flights are as low as -40°F. and therefore the fuel should have a fire point below this temperature. The volatility of the fuel controls the fire point, which is not readily determined directly with precision at low temperatures and accordingly the Reid vapor pressure at 100°F. in pounds per square inch has been adopted as the criterion for the suitability of a fuel for low temperature ignition.

The relationship of Reid vapor pressure at 100°F. in lb./sq.in. to the flash and fire point is given in Table 2, for synthetic blends of butane and kerosene. The best information on the required R.V.P., however, is determined by filling a bomb with the fuel in question, cooling to -40 or -60°F. and exploding the bomb. Such tests (see Appendix IV) indicate that a fuel is required with a R.V.P. of 10 to 12 lb./sq.in. at 100°F. Winter grade motor gasoline is the most generally available fuel for meeting this requirement. Aviation gasoline (7 lb./sq.in. R.V.P.) is not considered to be suitable.

B. Time-Temperature Relationships for Burning Fuels

In order to evaluate the various fuels employed in this work with regard to flame duration and maximum temperature, a test apparatus was constructed which essentially comprised eight thermocouples suspended by means of

Table 1

Heat of Combustion of Various Fuels

	Basis-Pure Fuel		Basis-4 Lb. Bomb		
	Btu/Lb.	M Btu/ cu.ft.	Btu/Bomb	Btu/Lb. of Bomb	M Btu/cu.ft. of Bomb
Thermite	1,500	244*	2,340	624	72
Aluminum	13,000	2210			
Magnesium	10,780	1158	14,115	3600	470
Pine Wood	9,200	310			
Coal	14,000	840			
Fuel Oil-12°API	18,400	1130			
Motor Gasoline	18,800	880	39,600***	9900	652**

* Based on packing at 4000 #/sq.in.
** Assumed to be tailless to be equipped with streamers.
*** Est. at 2.2 lb. gasoline-soap per bomb.

Table 2

IGNITION QUALITIES

RELATIONSHIP OF REID VAPOR PRESSURE TO FLASH AND FIRE OF UNTHICKENED FUELS

	Reid Vapor Pressure	Flash* Point	Fire* Point
25% n-butane, 75% Kero.(Varsol No.1)	16 lb./sq.in.	-40°F.	-40°F.
20% " 80% " " "	15.2	-40	-40
15% " 85% " " "	12.5	-40	-40
10% " 90% " " "	8.0	-40	-40
5% " 95% " " "	4.8	-40	+20
0% " 100% " " "	0	+105	+115
Motor Benzol (90% Benzene)	3.5	+5**	+24**
Light P.C. Naphtha	8.0	-40	-40

* Open cup flash and fire test.
** Solid benzene present and temperatures may be in error.

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Figure 2

TIME - TEMPERATURE RELATIONSHIPS FOR UNTHICKENED FUELS

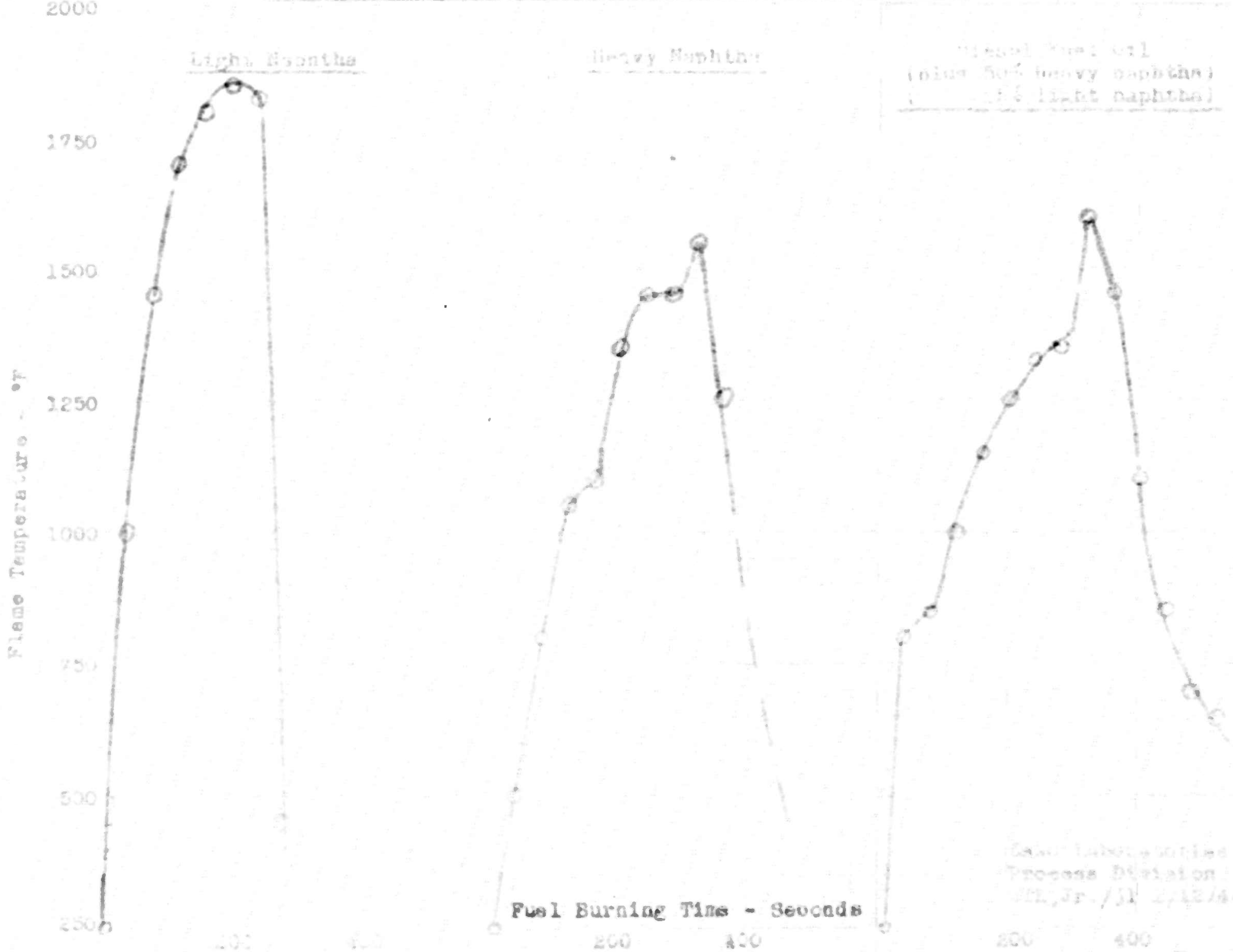


Figure 3

TIME - TEMPERATURE RELATIONSHIPS FOR LATEX-THICKENED FUELS

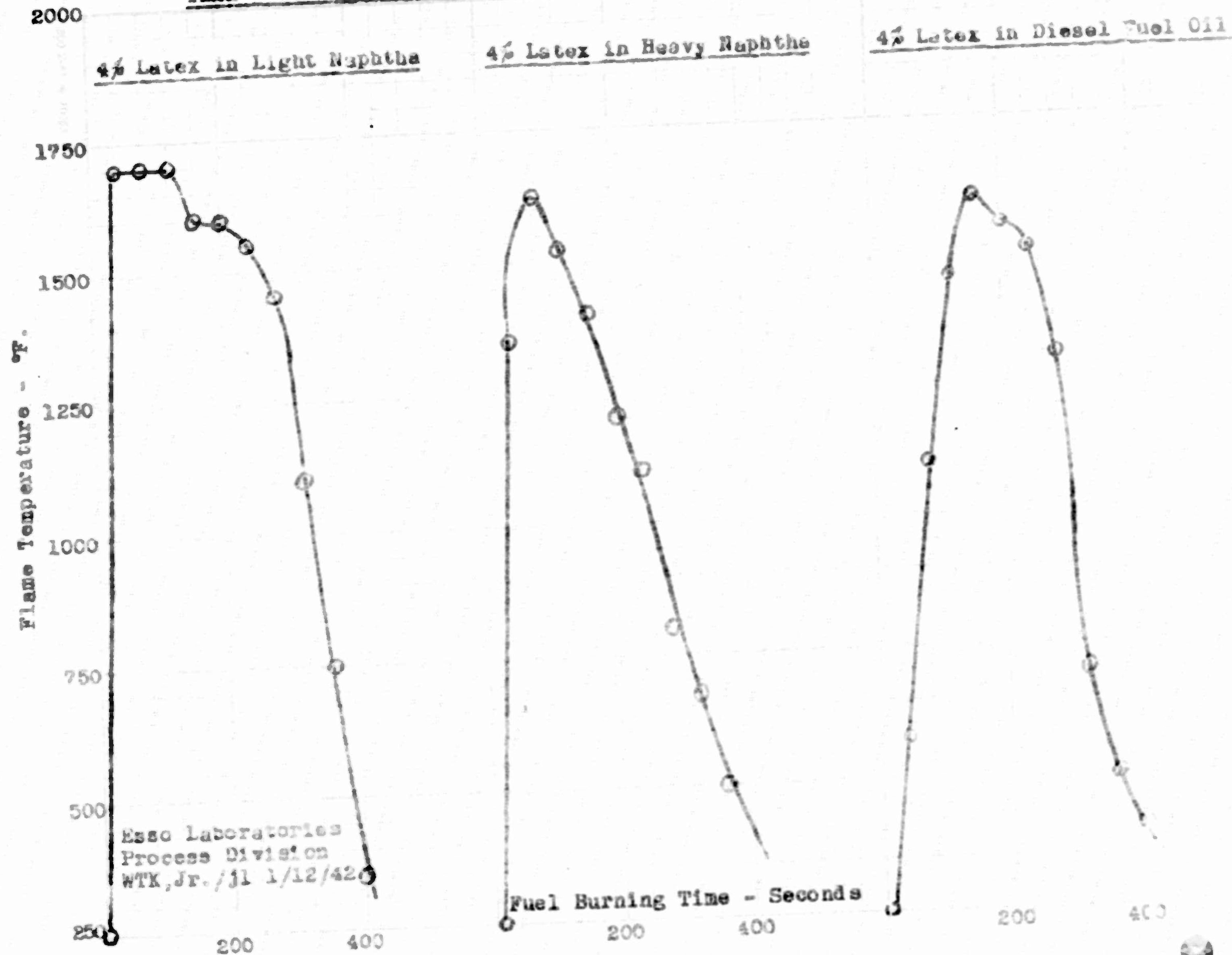
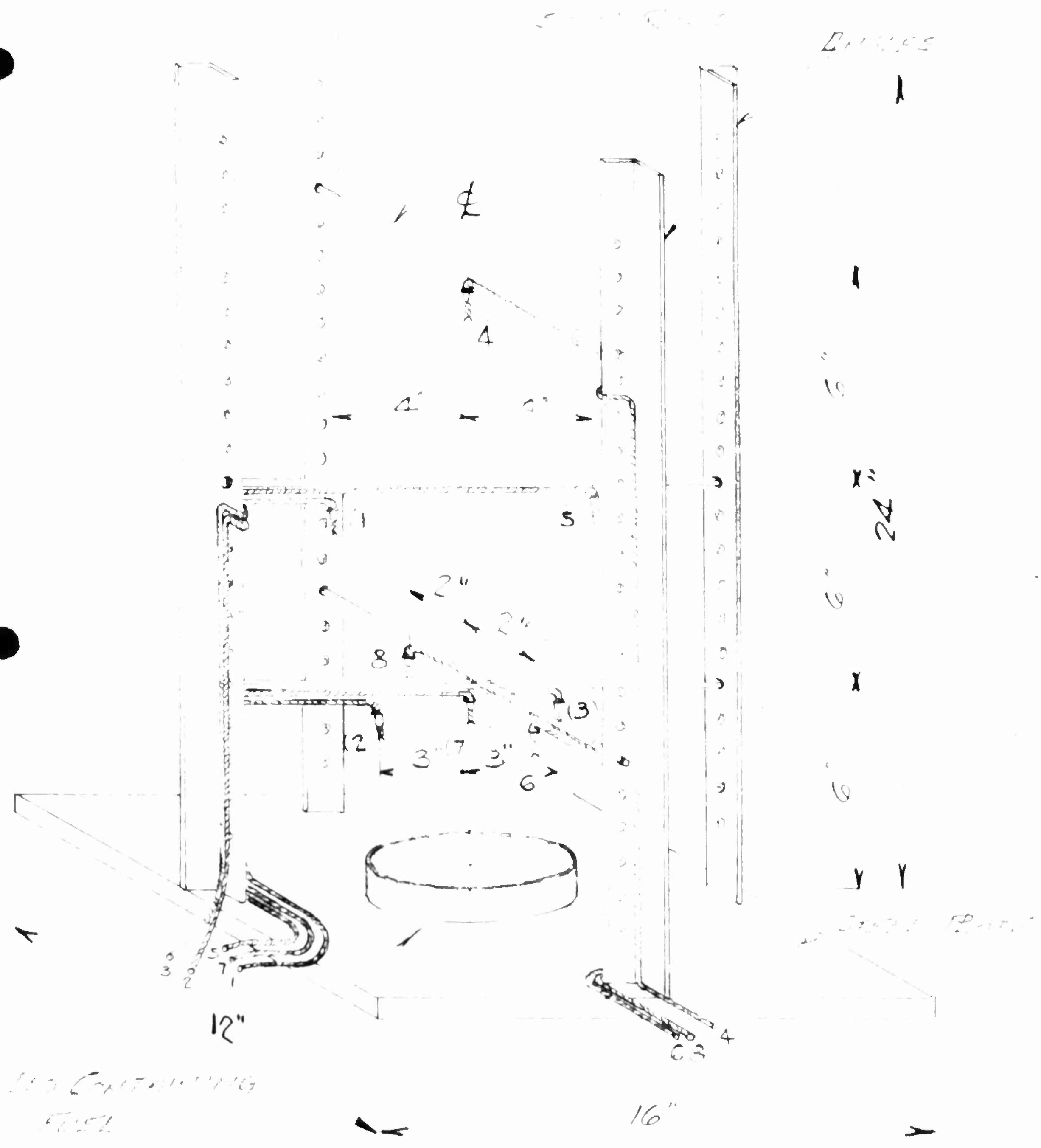


FIG. 1



APPARATUS FOR MEASURING
TIME-TEMPERATURE-RELATIONSHIPS
OF BURNING FUELS

a steel framework at varying distances above an open dish containing the burning fuel (see Figure 1). A cylindrical shield mounted on legs protected the flames from stray drafts. The dimensions of the steel framework were identical with those of the wooden test structure used by Professor L. F. Fieser at Harvard University. Temperatures were recorded by photographing meters connected with the thermocouples.

The lighter hydrocarbon fuels, such as gasoline, gave appreciably higher flame temperatures for a shorter duration than did the heavier oils, such as Diesel fuel. This was accompanied in the case of the lighter fuels by a large flame volume, whereas with the heavy fuels the flames tended to remain small and low. In Figure 2 are shown typical data obtained when burning (1) a light naphtha (120-280°F.B.P.) fraction, (2) a heavy naphtha (300-400°F.B.P.) fraction, and (3) a Diesel fuel oil (400-600°F.B.P.) blended with 50% gasoline for ignition purposes. The relatively high temperatures (1800°F.) and short burning time (250 seconds) associated with the light naphtha, and the long burning time (500+ seconds) and relatively low temperatures (1300°F.) of the Diesel oil, as well as the intermediate characteristics of the heavy naphtha fraction are clearly evident.

In an attempt to increase the burning time of the light naphtha fraction without sacrificing any of its high temperature advantage, various materials, such as latex, crepe, and smoked sheet rubber, were used as thickening agents. Figure 3 shows the data obtained when burning (1) 4% latex in light naphtha, (2) 4% latex in heavy naphtha, and (3) 4% latex in Diesel fuel oil. By comparison with Figure 1, it will be seen that the addition of 4% latex increased the active burning time of the light naphtha by 20-30%, with little decrease in flame temperature. The effect of the latex on the Diesel fuel was quite different from its effect on the light naphtha; the heavier oils were made to burn faster, probably due to the wick action of the gel structure. However, it is significant that these heavier fuels did not produce as hot flames as the light naphtha, even though their burning rate was considerably increased. On the basis of these data and similar tests employing crepe and smoked sheet rubber, and bearing in mind supply considerations as well as the fuel characteristics necessary for ignition, a petroleum fraction boiling from about 100-400°F. (regular motor gasoline) has been selected as the best base stock for petroleum incendiary bombs.

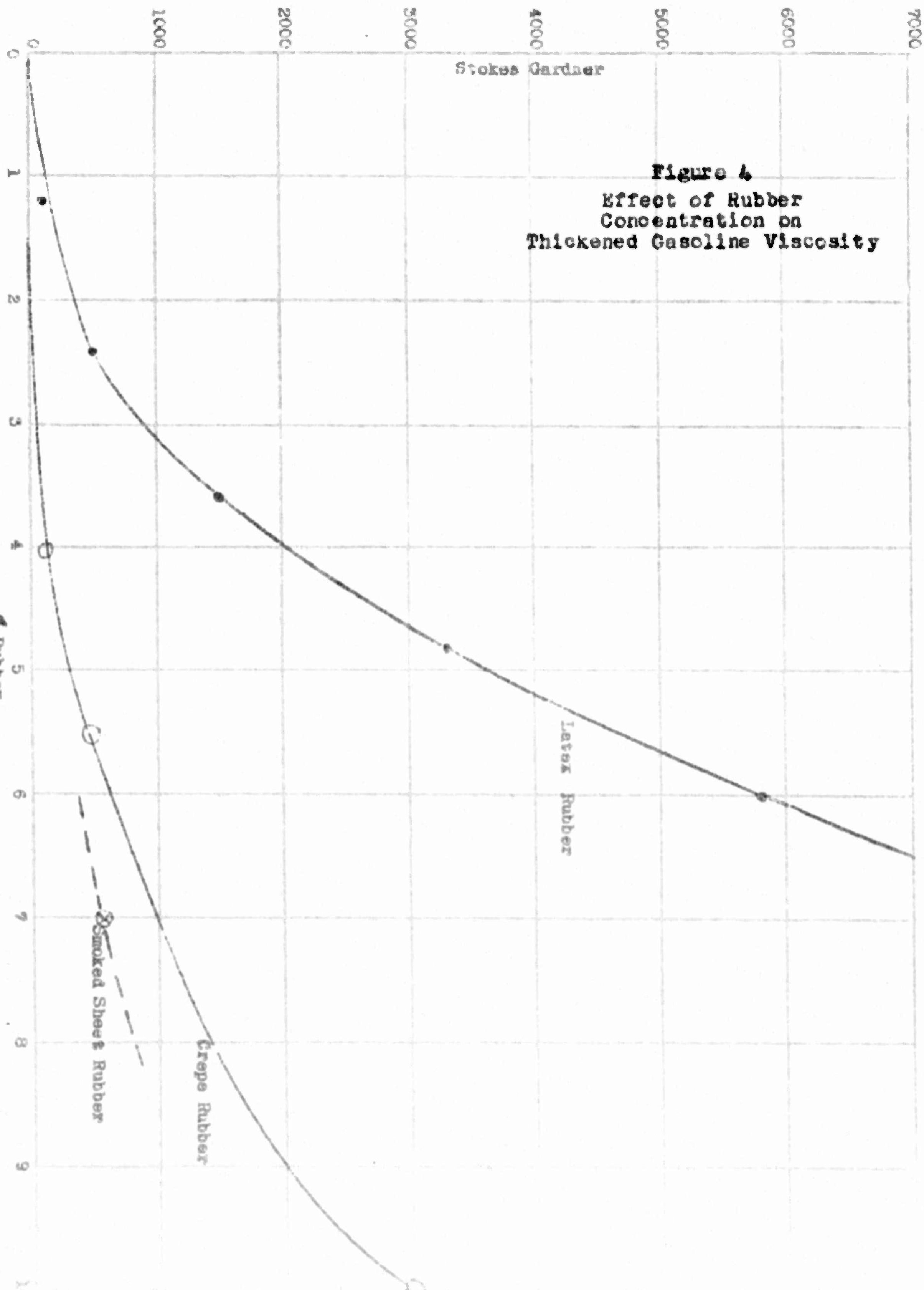
IV. Fuel Thickeners

Early burning tests had shown that thickened gasolines had good ignition characteristics and gave long burning, high temperature flames. Thickened fuels also possessed the advantage of being cohesive, thus preventing flash firing and shattering when ejected from a bomb.

A. Rubber Gums

The British had investigated the merits of benzene thickened with rubber and further work has been done on rubber gums at Harvard. On the basis of this early work, two standard gums were prepared by dispersing smoked sheet rubber in benzene and naphtha for burning studies.

Figure 4
Effect of Rubber Concentration on Thickened Gasoline Viscosity



Work was next undertaken on the use of latex since latex gums required less agitation for solution, and less rubber was required for a given consistency. Latex gels benzene on merely stirring into solution. However, in more paraffinic solvents, an acid is required as a coagulant. Oleic acid was first used usually being neutralized to utilize the soap as a further thickening agent. It was found, however, that less acetic acid was required, so this was used in the later latex work. The processing was as follows: the warm (70°F.) gasoline was stirred rapidly with a propellor while the latex was added. The acid was then added, and stirring continued until thickening had ceased, not over 5 minutes being required. The alkali (in 33-1/3% solution) was then added, and the batch stirred slowly until homogeneous. The alkali caused a great increase in viscosity. This produced a satisfactory gum when the following conditions were observed:

1. The temperature must not be too low, as this slows coagulation.

2. The time of stirring must be limited, and the speed not too great, to prevent permanent depolymerization of the rubber.

3. A moderate (10%) concentration of aromatics is required to speed coagulation.

4. The gasoline must be doctor "sweet" as reactive sulfur compounds cause partial loss of viscosity in a few days.

As is shown in Figure 4, the latex blends require much less dry rubber than those made from processed rubber. Like all rubber blends, they separate slightly at -40°F., especially those coagulated with oleic acid. Those containing sodium acetate cause slight surface rusting of steel, in spite of the free alkali present.

At this time, the advantages of crepe rubber were disclosed by the work at Harvard. Because of the porous nature of this form of rubber it disperses readily on merely standing in the solvent. As a result of its high molecular weight, a 5.5% blend is equal in viscosity to 7% smoked sheet. The investigation of this material disclosed several pertinent facts. Swelling is much more rapid in aromatic fuels than in paraffinic ones. Temperature is an important factor, swelling being extremely slow below 40°F. It is difficult to obtain homogeneous mixtures by swelling small percentages of crepe rubber in fuel, but homogeneous mixtures may be made by cutting back concentrated mixtures in a kettle with paddles. The product is intermediate in structure between latex and smoked sheet blends, having some of the gel-like body of the former.

The shortage of rubber closed the above lines of investigation, and tests were made on reclaimed rubber. This material appeared entirely unsatisfactory, since it is composed of broken down rubber and vulcanized material, the former having little or no thickening power, and the latter does not disperse. In view of the inadequate supply of synthetic polymers, no investigation has been made of these thickeners.

B. Soap Thickened Gasolines

The first soaps considered for use as thickeners to replace rubber were the stringy aluminum ones. Aluminum naphthenate, oleate and stearate were tested, but proved very difficult to manufacture. All required compounding at about 250°F., though when the soap content was reduced to about 20% they could be mixed at about 150°F. This mixing required the use of pressure equipment, or the addition of considerable heavy oil. The alternative method of cold ball milling would be very cumbersome. The soap must be made by double decomposition and should be well washed for satisfactory results. All of these soaps have been found unreliable and difficult to use in grease making. In addition, the temperature susceptibility proved worse than that of rubber blends causing the gum to melt and flash on ignition and to become very hard at -40°F. For these reasons, the investigation of aluminum soaps was dropped.

Calcium soaps were also considered though the product was not at all like a rubber blend. It is an old process to gel oils with a mixture of lime and rosin oil to produce "Sett Greases", and this could be done with gasoline. However, this type of soap would be very thixotropic, and the gel completely atomized on explosion. About 25% of non-fuel material would be required.

Tests were also made on batches prepared by cutting back ordinary cup greases (made from the cooked soap of pork fat) to a heavy oil consistency. These products were found to be too fluid, and gave a flash burn on explosion.

A process was developed for making a sett type of grease from fatty acids. This type was much less thixotropic than the rosin oil mixtures, but more difficult to compound. A gel was made with 15% preformed soap present, and the necessary lime was dispersed in it. This grease was then dispersed in gasoline by stirring, after which the fatty acid was added. Setting took place in about two hours. The non-fuel content was about 20%. This type will be investigated further.

The tar-lime gels used by the British have not been investigated, because the vertical gas retort coal tar required is not produced in sufficient quantities in this country.

The melted type of sodium soap gel was studied by several investigators and showed several advantages; it was easy to prepare, was of low non-fuel content, and melted sharply to a thin fluid so that it could be poured into cases. Such a material, however, was a brittle gel which tended to bleed gasoline, and required heating to about 130°F. during compounding. This required either pressure equipment or the use of a high flash, low-vapor pressure fuel. Large amounts of alcohol were also required to lower the melting point, and no readily available substitute was found. This gel was also found to shatter badly on explosion, giving a flash burn unless a binder was added. For these reasons work on this type has been suspended.

The most satisfactory soap thickener was a cold compounded sodium soap gel (Formula 122) made from a mixture of stearic and rosin acids, plasticized with a fatty oil. It had a grease-like texture, was only moderately thixotropic, and had excellent temperature characteristics.

The processing was as follows: the rosin, stearic acid, fatty oil and about 6% heavy naphtha were melted together at about 200°F. This base was a soft solid, melting at about 80°F. About 15% was dissolved in a gasoline for the final compounding, and the temperature adjusted to 90-110°F. About 4% of 33-1/3% aqueous caustic soda was then added, and dispersed by shaking or stirring. The mixture set in a few minutes to a semi-solid and hardened gradually in the next 24 hours. Many modifications of this formula have been tested, in an effort to increase the time of set, to widen the mixing temperature range, and to lower the melting point of the base. On the basis of these tests, the following conclusions were made:

1. The best grade of stearic acid for this purpose was Hydrofol, a hydrogenated fish oil acid.

2. A good grade of lump rosin was required.

3. The best proportions were two of stearic to one rosin.

4. Castor oil was the best plasticizer, though other fatty oils could be used.

5. Increasing the excess of caustic soda improved the stability slightly.

6. Replacing a large part of the caustic soda with borax gave a longer setting time, and may have broadened the mixing temperature range.

Further work is planned to determine (a) the optimum ratio of reactive ingredients, (b) the ability to substitute various fatty acids and fatty oils on the basis of availability, (c) a means for slowing down the setting time to permit easy field filling, and (d) methods for adjusting the mixing temperature to permit a wider temperature range than 90-110°F.

Formula 122 represents a solidified or thickened gasoline with the following desirable features: (a) simple and easy compounding to permit filling in the field so that empty and unarmed bomb cases can be transported; (b) the gasoline retains its good ignition characteristics even down to -40°F.; (c) the cohesive characteristics are greatly improved being about equal to that obtained with rubber gums; and (d) the burning quality of the gasoline equals that of any thickener studied. Formula 122 has the following composition:

Stearic acid (or hydrofol)	3.5 wt.%
Rosin	1.8 "
Cottonseed oil (or castor oil)	3.0 "
Caustic soda	1.1 "
Water	2.2 "
Motor gasoline	88.4 "
	100.0 wt.%

Table 3

AVAILABILITY OF INGREDIENTS REQUIRED BY FORMULA 122

Material	Million Pounds Per Year Produced in U. S. A. 1935	1937	1939	1940	Million Pounds per Year Required to Produce 9,000,000 4-lb.* Bombs/Month
Hydrofol	--	-	-	4.8	7.5
Stearic Acid	25	31	35	41	
Rosin (Gum)	800	850	-	650	3.8
Rosin (Wood)	300	420		450	
Cottonseed Oil	-	1678	1390	-	6.5
Castor Oil	-	52	76	-	
Fish Oil (Total)	-	185	210	-	
Caustic Soda			2000		2.4

*) Based on 2-lb. of Formula 122 per 4 lb.-Bomb.

A suggested method for compounding and filling Formula 122 into bomb cases in the field is described in Appendix II.

The availability of the ingredients required for Formula 122 is presented in Table 3, and appears to permit production of 9,000,000 bombs (4-lb.) per month.

A discussion of physical testing and the results of investigating various gasoline thickeners is presented in Appendix I.

V. Burning Tests in Attic Structures

A. Experimental Equipment and Procedure

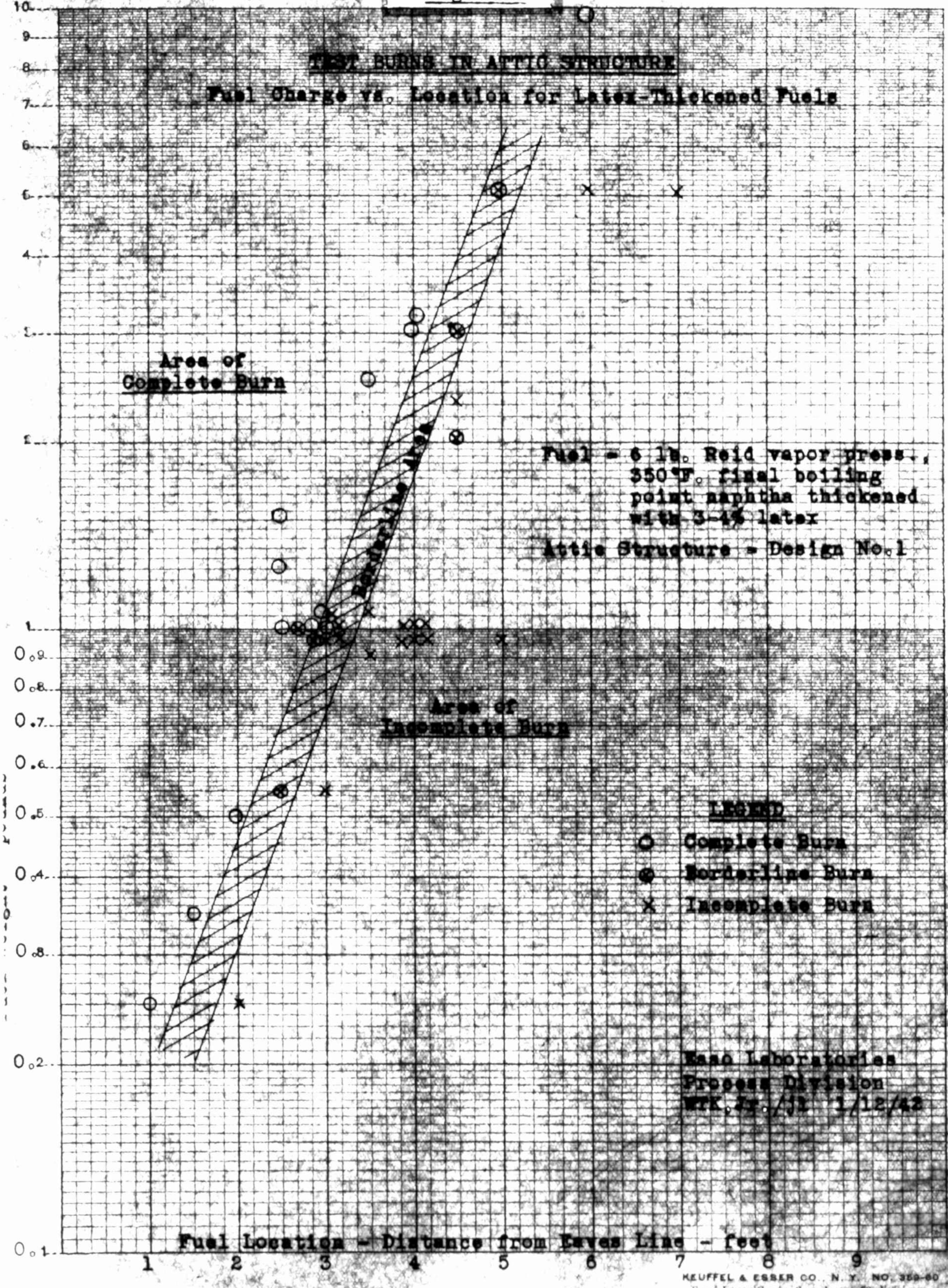
In order to evaluate the burning characteristics of various fuels, wooden test structures were constructed simulating a section of an attic. Two general types of attic structure were employed -- Design No. 1 ("American" type) was built with 2x6 joists and 2x4 rafters on 16 inch centers, and wooden boards underneath the joists; Design No. 2 ("European" type) was constructed with 2x6 joists and rafters on 24 inch centers, and a plastered ceiling underneath the joists. A non-combustible roof of transite or sheet metal, simulating corrugated tile, with regular shingle lath on 6-7/8 inch centers were employed. Drawings of the test structures are shown in Appendix Figures A and B.

The majority of tests were made on this small structure, open on three sides, representing that section of an attic roof and floor within 6 ft. of the eaves lines. Some tests were made on a double structure formed by placing two single structures together in order to obtain the effect of a complete roof. Large scale tests were conducted in a structure closely approximating in size a typical attic (actual dimensions - 28x14x7 ft.). A replaceable wooden center section 10 ft. long was actually employed for test purposes; 9 ft. long metal end sections were attached merely to provide an air volume approximately equal to that of a normal attic. Test burnings in this large-scale structure were generally carried out with all doors closed in order to resemble the actual conditions existing in a typical attic.

The procedure employed for making test burns consisted of placing the fuel charge on the flooring at a given distance from the eaves, lighting the fuel, and at the completion of the burn determining the extent to which the flames had damaged the test structure. Adequate ventilation free from drafts was maintained. In some cases, the fuel charge was flung or smeared against the roof laths and rafters, in which instances a portion of the burning fuel usually dropped to the floor and continued burning there. Tests were made in which the fuel charge was blown from a 3 inch diameter bomb casing towards the test structure. For the purposes of these tests, a "destructive" burn was defined as one in which either (1) the flames were definitely increasing at the end of ten minutes burning time, or (2) the structure was burned to such an extent that it collapsed.

Burning tests involving magnesium and thermate were generally carried out employing a double thickness (1-3/4 inches) of floor board. It was

Figure 5



TEST BURNS IN ATTIC STRUCTURE
Fuel Charge vs. Location for Latex-Thickened Fuels
Area of Complete Burn
Borderline Area
Area of Incomplete Burn
Fuel - 6 lb. Reid vapor press., 350°F. final boiling point naphtha thickened with 3-4% latex
Attic Structure - Design No. 1
LEGEND
Complete Burn
Borderline Burn
Incomplete Burn
Esso Laboratories
Process Division
WRK, Jr./JI 1/12/42
Fuel Location - Distance from Eaves Line - feet
1
2
3
4
5
6
7
8
9
10
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
KEUFFEL & ESSER CO., N. Y. NO. 359-60
Semi-Logarithmic, 2 cycles × 60 divisions

recognized that this test method measured solely the destructive effect of these incendiaries in the attic structure. However, it was found that the burning properties of the magnesium and thermate bombs in the attic test structures were considerably aided by the double wooden flooring. No attempt has yet been made to determine the effectiveness of various incendiaries as regards burning through several floors of a building.

B. Burning Tests Employing Rubber Gums

At the outset of work on this problem the supply of the various types of rubber was not critically limited; consequently, a large number of tests were made using rubber gums made from latex, crepe rubber, and smoked sheet rubber added to various fuels. Detailed data for these tests are presented in Appendix III.

The relationship existing between size of fuel charge and its distance from the eaves for petroleum gums containing 3-4% by weight of latex (equivalent to 1.8-2.4 wt.% rubber) is shown in Figure 5. No appreciable deviation from this curbe was noticed even when using such different fuels as pentane and diesel fuel oil, although normal motor gasoline appeared to possess the optimum boiling range. This curve clearly demonstrates the advantage gained by placing the fuel charge as near as possible to the eaves as, for example, from a tail-ejection bomb.

A significant difference was noted in the behavior of fuel charges below one pound in size and those above two pounds. When using the larger fuel charges it was found that the degree of destructive burning was considerably greater than with the smaller charges. Thus, it was observed that in the majority of cases a destructive burn resulting from a one pound charge was confined to one or possibly two sections of the floor and roof; whereas, a destructive burn caused by a 3 pound charge generally led to a collapse of the test structure.

The burning characteristics of petroleum gums made with crepe and smoked sheet rubber were essentially idential with those of latex gums, as evidenced by the data presented in Appendix III. Latex gums were much less tacky than those made from crepe or smoked sheet rubber, and consequently, did not adhere to roof surfaces as well as the latter.

In an attempt to evaluate the property of adhesivity as applied to gum incendiaries, numerous tests were made employing latex, crepe, and smoked sheet rubber gums in which all or a portion of the fuel charge was smeared or thrown against the roof. In no instances, regardless of the fuel distribution between roof and floor, was there a destructive burn, although had the fuel charge been placed on the floor at an equal distance from the eaves, in most cases a destructive burn resulted. These data indicated, therefore, that the maximum effectiveness of an incendiary material in the attic was realized when placing that material on the floor instead of spreading the fuel over the roof and floor. From this it follows that adhesivity is not a controlling factor in developing suitable petroleum incendiaries. Preliminary tests (Appendix III, Runs H-41, 51, and 52) also have shown that the maximum effectiveness of a given weight of material resulted when that material was held together as a single large particle rather than separating it into several smaller units.

Figure 7

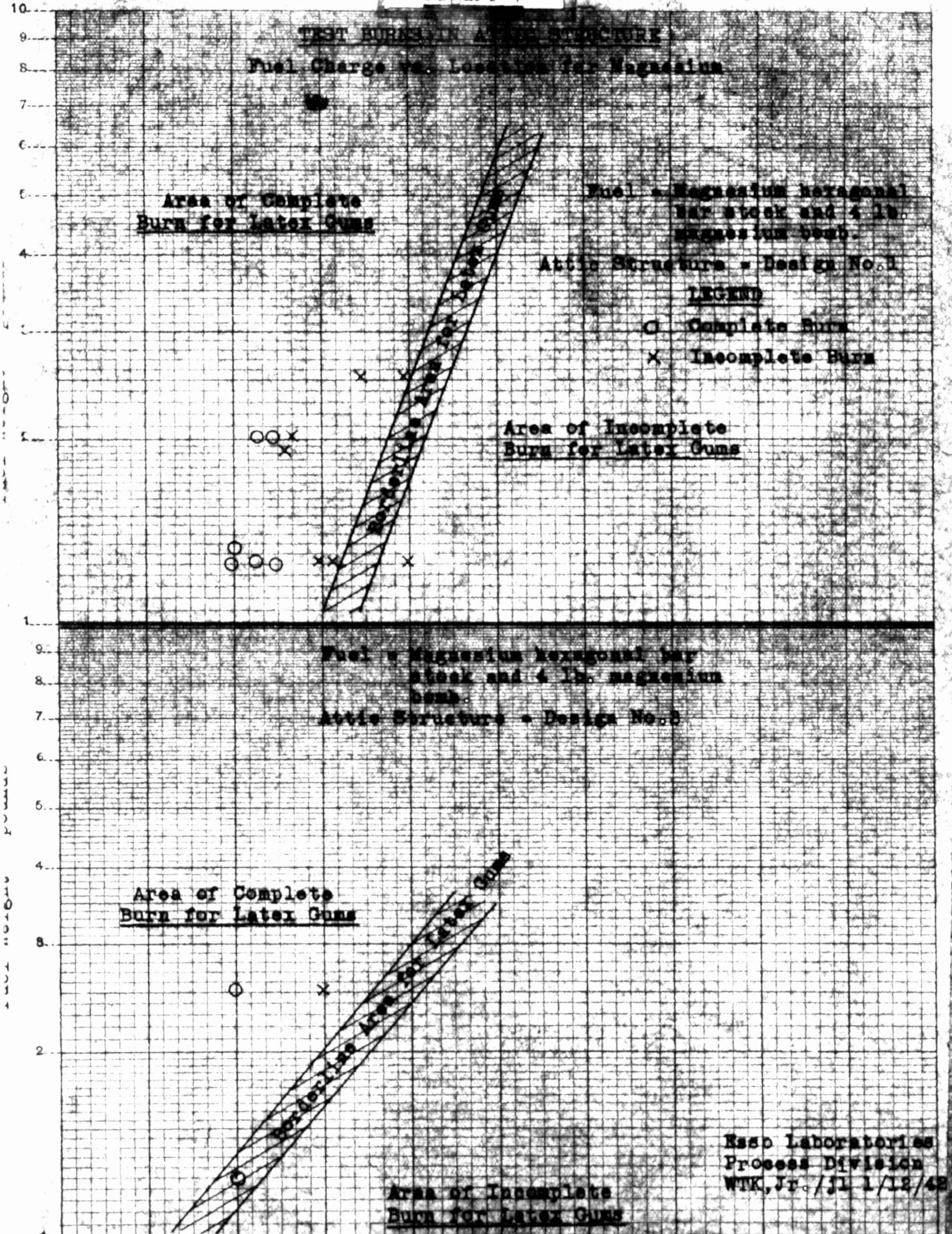
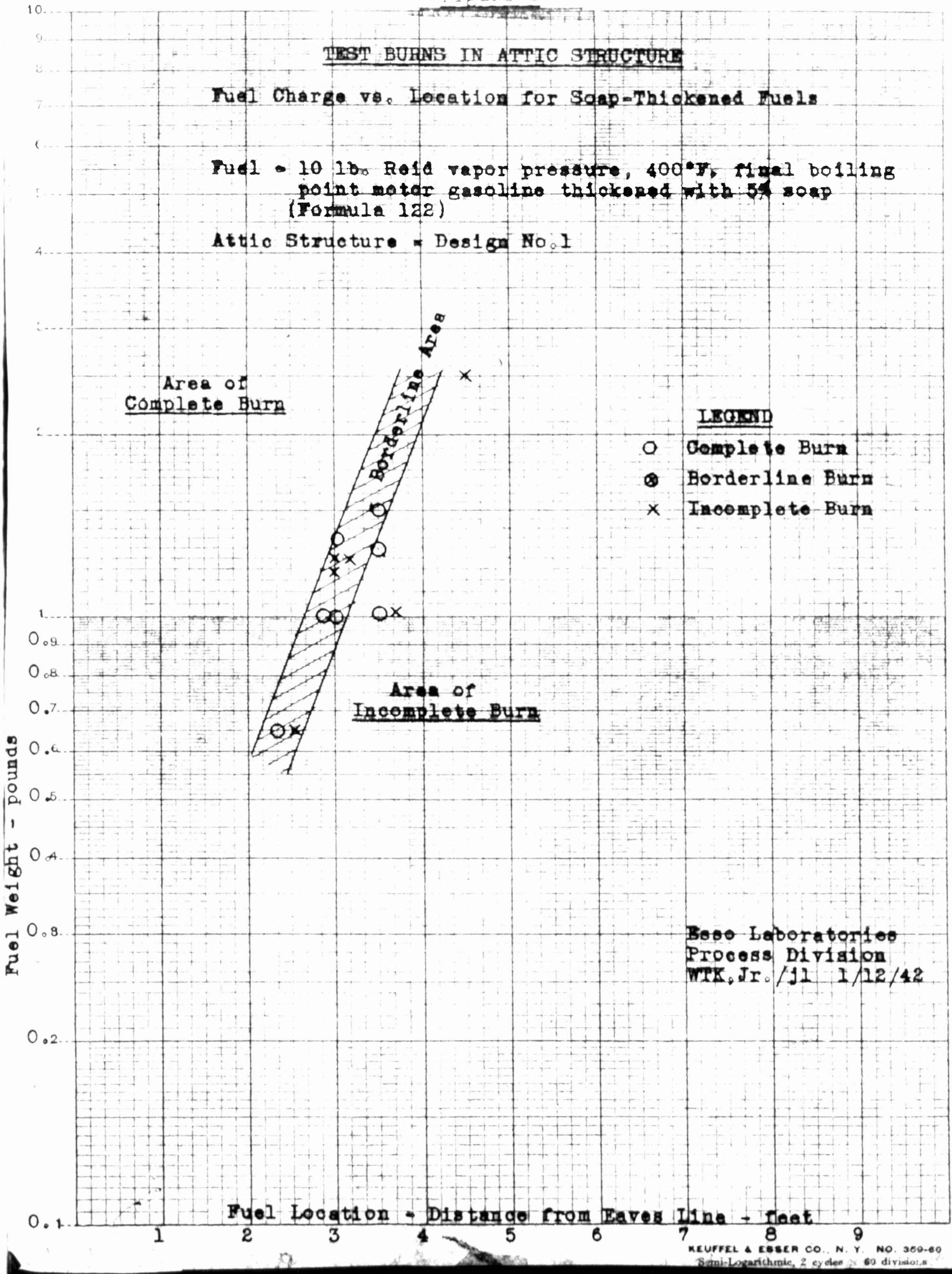

Fuel Charge vs. Location for Magnesium
Area of Complete Burn for Latex Gums
Fuel = Magnesium hexagonal bar stock and 4 lb. magnesium bomb.
Attic Structure = Design No.1
LEGEND
O Complete Burn
X Incomplete Burn
Borderline Area for Latex Gums
Area of Incomplete Burn for Latex Gums
Fuel = Magnesium hexagonal bar stock and 4 lb. magnesium bomb.
Attic Structure = Design No.3
Area of Complete Burn for Latex Gums
Borderline Area for Latex Gums
Area of Incomplete Burn for Latex Gums
Esso Laboratories
Process Division
WTK,Jr./Jl 1/12/42
1 2 3 4 5 6 7 8 9
Fuel Location - Distance from Eaves Line - feet
KEUFFEL & ESSER CO., N.Y. NO. 359-60
Semi-Logarithmic, 2 cycles × 60 divisions

Figure 6


TEST BURNS IN ATTIC STRUCTURE
Fuel Charge vs. Location for Soap-Thickened Fuels
Fuel = 10 lb. Reid vapor pressure, 400°F, final boiling point motor gasoline thickened with 5% soap (Formula 122)
Attic Structure = Design No. 1
Area of Complete Burn
Borderline Area
Area of Incomplete Burn
LEGEND
Complete Burn
Borderline Burn
Incomplete Burn
Esso Laboratories
Process Division
WTK, Jr./jl 1/12/42
Fuel Weight - pounds
Fuel Location - Distance from Eaves Line - feet
10.
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
5
6
7
8
9
KEUFFEL & ESSER CO., N. Y. NO. 359-60
Semi-Logarithmic, 2 cycles × 60 divisions

C. Burning Tests with Gasoline Soaps

The limited supply of rubber in the United States and its increasingly difficult procurement after December 7, 1941, necessitated the development of a non-rubber thickening agent. Experimental work was undertaken, therefore, on the use of various sodium stearate-oleate-rosin soaps in regular motor gasoline. Detailed data from the burning tests of these various soap-thickened gasolines are presented in Appendix III.

The relationship existing between weight of fuel charge and its distance from the eaves for gasoline soaps is shown in Figure 6. In general, gasoline soaps were equivalent to latex gums, regardless of whether the soap was produced as a relatively hard gel or as a soft gel similar in consistency to apple-sauce. However, a significant difference in burning characteristics was noticed between rubber gums and the gasoline soaps. Whereas the rubber-thickened gasolines gave a fast burn with large flames from the start, the soap-thickened gasolines usually burned slowly with moderately small flames for about one minute after the start of burning. Thus, in order to obtain the same degree of destructive burning, the active burning time of the gasoline soaps generally needed to be of about 4-7 minutes duration, as compared with the 3-4 minutes active burning time for the rubber gums.

It was expected from the nature of these soap-thickened gasolines that there would possibly be a greater tendency to "bleed" gasoline or undergo syneresis than in the case of the rubber-thickened gasolines. Consequently, an extensive program was undertaken to investigate the effect of various binding agents, such as sisal, excelsior, and cotton waste, on the cohesion of the gasoline-soap gels. Detailed data from the burning tests together with a few ejection tests of these soaps with binders are presented in Appendix III. In general, the addition of binding material to soap-thickened gasolines increased the active burning time of the fuel and simultaneously reduced the flame volume. Cotton waste was the most effective in this respect, and sisal the least effective. However, numerous tests in which gasoline soaps containing sisal were flung against the roof of the test attic structure indicated that sisal imparted nearly equally effective cohesive properties to the soap gel as did the cotton waste. As reported in the following section, ejection tests from 3 inch bombs have shown the desirability of including 1-2% of binder in order to hold the fuel charge together during firing. Recognizing that binders may be difficult to incorporate in field compounding, further tests are being conducted to determine if binders are necessary.

D. Burning Tests with Magnesium

In order to compare gasoline soaps with the present 4-lb. U.S. and British magnesium bomb, tests were made on the standard attic structure with magnesium bombs and with hexagonal magnesium bar stock (ignited by means of a welding torch). Detailed data for these tests are reported in Appendix III, and are summarized in Figure 7.

The results show that magnesium on wooden flooring (Design No. 1) was nearly as effective as soap-thickened gasoline when used in quantities of approximately one pound, but that magnesium was not as effective as gasoline soap when employed in amounts greater than 2 pounds. It was found that magnesium damaged the wooden floor of the test structure much more intensively but less extensively than petroleum fuels. However, although the magnesium bomb burned through 1-3/4 inches of wooden floor, it failed to burn through 1/2 inch thick plastered attic floors simulating the ceiling of a room below the attic. When using a plastered floor (Design No. 2) magnesium appeared to be even less effective. These tests indicate that thickened gasolines are at least equal to magnesium.

E. Burning Tests with Thermate

Detailed data obtained from several test burns employing the regular U.S. Army thermate incendiary bomb are presented in Appendix III. The conclusion reached regarding the burning characteristics of thermate was that it appeared to be quite ineffective in starting a destructive burn in the attic test structure, although it burned through either 1-3/4 inches of wooden flooring or 1/2 inch of plaster. This was illustrated by Run H-173, in which the thermate bomb was placed directly against the eaves board of the test structure. Some localized damage was done, but no self-propagating fire resulted. This indicated that the incendiary effect of thermate is almost entirely downward and very localized, as compared to the relatively widespread, upward effect of oil incendiaries. These tests indicate that in the attic structure the thermate bomb is quite inferior to either the magnesium bomb or the thickened gasoline.

VI. Bomb Ejection Tests

The technique of carrying out explosion tests by ejecting thickened fuels from bombs, has gone through several changes since the start of the project. The original test bomb consisted of a 5-lb. pail at the bottom of which was placed a powder chamber (4" I.D. x 1/4" high) with a lacquered cardboard diaphragm to keep the powder and fuel separated. A 6 in. length of 1/4 in. pipe extended from the powder chamber to the outside of the pail and a safety fuse was inserted through this pipe. The pail was approximately 6 in. diameter by 5-1/2 in. high and held 3 lbs. of fuel. The bomb was placed in a vertical position, was exploded usually with 20 gms. of black powder, sporting grade, and the degree of fuel scattering and ignition was noted. Usually the fuel was scattered in small pieces over a radius of 20 ft. and the ignition was excellent down to -40°F. if a fuel of 10 lb./sq.in. or higher R.V.P. was used.

A markedly different result as to scattering was obtained (Appended IV, exp. 14) if the bomb was placed on its side. The fuel could be heaved a considerable distance without excessive shattering. Some improvement in fuel cohesion was obtained by adding cotton waste, excelsior, sisal, etc., as a binder to the fuel, although the necessity for binders has not been firmly established.

Latex blends proved to be very difficult to ignite when ejected from the 3 in. diameter bombs with the powder chamber located at the bottom. Coarse magnesium turnings and coal particles mixed into the powder did not

TABLE 4

COMPARISON OF THERMAL EFFICIENCIES

Type Unit	Gross Wt. of Unit	Gross Wt. of Fuel	Per Cent Fuel to Gross Wt.	BTU Per Unit	BTU Per Lb. of Unit	Sectional Density
4-lb. Mg.	3.91 lb.	1.86 lb.	47.6%	14,115	3,600	1.58
4-lb. Thermite	3.75	1.55	41.3	2,340	624	1.41
4-lb. SOD STD. Fuze 20 Ga. Case	5.5	2.00	36.4	36,000	6,540	.778
4-lb. SOD New Fuze 20 Ga. Case	4.48	2.00	44.7	36,000	8,030	.634
4-lb. SOD STD. Fuze 28 Ga. Case	4.64	2.00	43.2	36,000	7,760	.656
4-lb. SOD New Fuze 28 Ga. Case	4.0	2.20	55.1	39,600	9,900	.566

BTU/Lb. Mg. = 10,780
BTU/Lb. Thermite = 1,500
BTU/Lb. SOD = 18,000

Sectional Density of German 1 Kilo Mg. Bomb = .700

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help ignition. Later it was found that a long narrow tube (3/8 in. radio spaghetti tubing) completely filled with powder, placed coaxially in the bomb, produced good ignition. Formula 122 fuels are not as difficult to ignite as the latex fuels and the importance of the coaxial powder tube is not as great with the gasoline soaps.

The results of all the explosion tests are given in Appendix IV and may be summarized as follows:

1. Gasoline with a Reid vapor pressure of at least 10 lb./sq.in. at 100°F. is required to insure ignition at the low temperatures encountered at high altitudes (-40°F.).

2. Hard setting gasoline greases are not suitable because they shatter excessively and flash-burn in mid-air.

3. Rubber gels (5.5% crepe) and soft non-bleeding gasoline soap (Formula 122) give the best results because they do not shatter unduly and give desirable burning characteristics.

4. Binders such as sisal and excelsior while important in the scattering type of bomb, are not quite as important in tail-ejection bombs where the scattering of the fuel is reduced. However, sufficient work has not yet been done to show whether binders can be excluded.

VII. Design and Testing of Small Petroleum Incendiary Bombs

Test data have shown that the most effective method of burning the test attic structures consisted in placing the fuel charge as near the eaves line as possible. In order to assure the placing of the fuel near the eaves, a bomb has been constructed in which the fuel is ejected from the tail after the bomb has come to rest. The advantages of having the incendiary material thrown against surrounding objects are obvious.

Preliminary design studies have shown the desirability of using a bomb casing of minimum wall thickness in order to obtain the maximum fuel content. However, it is understood that the Army Air Corps would be opposed to case thicknesses less than 20 gage (.035 in.). It is also understood that any change in nose fuse design over those now approved for the 4-lb. thermate or the M-46 and M-47 (M 108) bombs might result in considerable delay in obtaining final approval for a new incendiary. Consequently, two bomb designs are now under development, both being of the tail ejection type approximately 15 in. long and 3 in. diameter with a cloth streamer to help control ballistic and terminal velocity characteristics. The first design utilizes a 20 gage case with the standard thermate nose fuse (see Appendix Figure C) with an estimated gross weight of 5.5 lb. and containing 2.0 lb.

of fuel (Formula 122). The second design will incorporate the minimum wall thickness consistent with good impact resistance together with a new light weight fuze design (see Appendix Figures D and E). Tests are under way to determine this minimum case thickness, but if 28 gage material can be used, then this bomb would have an estimated gross weight of 4.0 lb. and would contain 2.2 lb. of fuel. This latter design lends itself to methods now used in can production. As shown in Table 4, the 28 gage case and new fuze design improve the ratio of fuel to gross weight, and either design of oil bomb shows an advantage over the magnesium and thermate bombs when compared on a basis of calorific value per bomb or per unit weight of bomb.

Firing tests have shown that the can seam developed by Continental Can Co. is suitable for use in so far as withstanding the powder explosion is concerned. This type of seam is limited to 28 gage or thinner metal. If 20 gage metal is required, the bomb casing may be made of seamless, lap-welded or butt-welded tubing.

Further tests are under way wherein the 20 gage and 28 gage cases will be fired from a mortar into a roof structure to determine the impact resistance and ignition and burning characteristics obtained with both the thick and thin cases. Tests will also be conducted with the standard and new fuzes.

According to present information, these bombs will be carried in a bomb crib 15 inches diameter by 61 inches long with a maximum permissible weight of 120 pounds. The proposed 3 inch diameter bomb will thus permit a bundle of 19 bombs which will weigh approximately 100 pounds, although this procedure will leave about three-fourths of the crib empty. Weight limitations aside, four bundles (76 bombs) with 15-1/4 inch maximum bomb length or three bundles (57 bombs) with 20 inch maximum bomb length could be carried.

Present development is concerned with a bomb of approximately 4 lb. gross weight to be approximately equal in effectiveness to the 4-lb. magnesium bomb. Additional data are needed to establish the optimum size of oil bomb and tests are in progress on various types of structures to determine the most effective bomb size, which may be larger than 4 lb.

VIII. Future Work

1. A mortar has been built from which bombs will be fired through typical roof construction in order to determine (1) the necessary casing and nose strength, (2) velocities corresponding to roof penetration alone and roof plus plastered ceiling penetration, (3) time delay necessary to insure fuel discharge below the roof, and (4) the reliability of fuze design.

2. Further gasoline soap work is under way to increase the gelling time during compounding, to decrease the temperature limitations required for mixing the soap and gasoline, and to provide the widest range in substitution of ingredients.

3. Several other attic designs will be studied to determine the optimum fuel charge required for an effective small sized oil bomb.

IX. Conclusions

The Development staff has reached the following highly tentative conclusions:

a) It is believed that a 4-lb. air-borne oil incendiary bomb more effective (per ton of bombs released) than the 4-lb. thermate bomb and possibly as effective as the 4-lb. magnesium bomb for firing light structures and perhaps debris will result provided the 4-lb. oil incendiary possesses the following characteristics:

1) A bomb case approximately 3 inches in diameter with a black powder bursting charge which will cause tail ejection of the bomb contents as nearly as possible as a single discreet particle for a distance of approximately 20 feet from the point at which the bomb comes to rest.

2) Ignition of all particles assured through use of an ignition tube which will bring the bomb contents during ejection into contact with part of the flame produced by the black powder bursting charge.

b) A bomb designed to incorporate the principles expressed above appears to lend itself to mass production with available ingredients and materials. Such a bomb can be made to meet the safety requirements of the Army Air Corps and Chemical Warfare Service in so far as these safety requirements have been disclosed.

APPENDIX I

GASOLINE THICKENERS

Physical Tests

The viscosity was at first determined by the falling ball method recommended at Harvard. In this test, a 5/32" still ball is timed for a fall of 10 cm. This method fails on latex blends, since the slight rigidity of the blend suspends the ball indefinitely. The Gardner Mobilometer was, therefore, adopted for control tests. This consists of a tube 20 cm. long and 3.5 cm. I.D., in which moves a loose-fitting perforated piston which may be loaded. For this purpose the piston disk had four 1/4" holes. The load was so adjusted that the time of fall was approximately 100 seconds. The viscosity was calculated as "stokes = 0.250 x load x time", the constant having been determined by tests on known oils. It was found that the curve stockes vs. time was a straight line on log-log paper, so that any two loads and times served to determine the viscosity at 100 seconds. The viscosity of such blends varies greatly ith the flow rate, and the 100 seconds time represents a rate similar to running down a vertical wall.

The mobilometer is not suitable for the soap-thickened products, so the A.S.T.M. grease penetrometer was used. This instrument uses a double-pitch cone weighing 150 grams. The distance is tenth-millimeters penetrated in 5 seconds is reported as the penetration.

The apparent densities of latex and soap blends have been determined. The latex blend, which contained some air, was 0.729g/cc., and the soap mixture (Formula 122) was 0.750g/cc.

Vapor pressure tests were made on a few batches, using a modified Reid vapor pressure bomb, and the results were found to agree perfectly with those on the unthickened fuel. Bleeding and shrinkage tests were made by visual observation. Stability was judged by penetrations after storage, shaking one hour in a laboratory shaker, and freezing to -40°F.

The heat transfer characteristics of Batch 42 (Latex blend) were studied by cooling tests in an air bath at 0°F. The tests were of forced and natural convection of the cooling medium over a typical bomb case. The heat transmission was of the unsteady state type. The data was correlated by use of Gurney-Lurie charts which gave integrated forms of the differential cooling once time-temperature-position ratios were established.

The tests showed that cooling was relatively rapid and that in normal bombing operations of two or three hours duration at high altitudes would result in cooling the fuel bombs to the temperature of the surroundings. This means that ignition of the incendiary fuel must occur at temperatures in the range of -40°F., requiring the fuel to have an adequate vapor pressure at this temperature to give unfailing ignition. This stipulation demands use of a fuel similar to a 400° E.P. motor gasoline of at least 10 lb. Reid vapor pressure.

Physical constants determined are:

C_p = 0.61 Btu/3 x °F.

= 45.5 3/ft^3

k = 0.17 Btu/hr. x ft^2 x °F. x ft^{-1}

h_t = 1.80 Btu/hr. x ft^2 x °F. (natural convection, as anticipated in operation with bomb bay closed).

Appendix I

1. Rubber Batches

A. Smoked Sheet Rubber

Batch No.	% Rubber	Fuel	Viscosity	Remarks
12	7	Motor Benzene	315 Sec. Ball 560 Stokes Gardner	Ball mill 36 hours
13	7	P.C. Naphtha	540 Sec. Ball 930 Stokes Gardner	Ball mill 36 hours
63	7	10% Benzene 90% P.C. Naphtha	-	Soaked 3 days

B. Latex

Batch No.	% Rubber	Fuel	% Acid	% Alkali	Viscosity	Remarks
4	6.5	Motor Benzene	0	0	1200 Sec. Ball	Stirred 1 hour.
5	3.25	Motor Benzene	2% Oleic	0.3% NaOH	Too thick	Stirred 2 hours.
7	3.8	Summer Gasoline	1.8% Oleic	0.28% NaOH	Too thick	Stirred 10 minutes.
8	6.5	Summer Gasoline	1.0% Oleic	0	20 Sec.	-
10	6.5	Motor Benzene	0	0	480 Sec.	Stirred 15 minutes.
11	9.75	Summer Gasoline	1.0% Oleic	0	840 Sec.	-
14	4.9	P.C. Naphtha	1.5% Oleic	0.23% NaOH	Too thick	-
15	4.9	P.C. Naphtha	6.0% Oleic	0.23% NaOH	-	Put NaOH in Latex. Very poor.
16	5.5	P.C. Naphtha	1.5% Oleic	0.23% NaOH	-	Solid at 0°F.
17	5.5	P.C. Naphtha	1.5% Tall Oil	0.23% NaOH	660 Stokes Gardner	Like #16.
18	7	P.C. Naphtha	2% Oleic	NH_4OH	1000 Stokes Gardner	Very corrosive.
20	3.25	54 Naphtha	15% Oleic	2.7% $Ca(OH)_2$	245 Penetration	Heated to 150°F.
21	3.25	54 Naphtha	10% Stearic	1.6% $Ca(OH)_2$	-	Heated to 110°F.
24	6.0	Motor Benzene	1% Oleic	NH_4OH	2600 Stokes Gardner	New Latex (used hereafter)
25	3.6	#3 & #6 Naphtha	2% Oleic	0.15% NaOH	-	10% Sawdust
26	5.1	#3 & #6 Naphtha	0.5% Acetic	0.5% NaOH	2800 Stokes Gardner	-
26A	6.0	Motor Benzene	1.0% Acetic	0.8% NaOH	5800 Stokes Gardner	For viscosity curve

Batch No.	% Rubber	Fuel	% Acid	% Alkali	Viscosity	Remarks
26B	4.8	Motor Benzene	0.8% Acetic	0.8% NaOH	3300 Stokes Gardner	For viscosity curve.
26C	3.6	Motor Benzene	0.6% Acetic	0.6% NaOH	1500 Stokes Gardner	For viscosity curve.
26D	2.4	Motor Benzene	0.4% Acetic	0.4% NaOH	500 Stokes Gardner	For viscosity curve.
26E	1.2	Motor Benzene	0.2% Acetic	0.2% NaOH	97 Stokes Gardner	For viscosity curve.
26F	1.8	Motor Benzene	0.3% Acetic	0.3% NaOH	320 Stokes Gardner	For viscosity curve.
27	2.4	P.C. Naphtha	0.6% Acetic	0.6% NaOH	450 Stokes Gardner	Bleeds at -40° F.
28	2.4	P.C. Naphtha	0.4% Acetic	0.4% NaOH	300 Stokes Gardner	Mixed at 45°F. 25 lb. batch.
29	2.4	P.C. Naphtha	0.6% Acetic	0.6% NaOH	295 Stokes Gardner	Mixed at 55°F. 25 lb. batch.
29A	2.4	P.C. Naphtha	0.6% Acetic	0.6% NaOH	420 Stokes Gardner	Laboratory batch.
29B	2.4	P.C. Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	510 Stokes Gardner	Laboratory batch.
30	3.0	Pentane + 10% Benzene	0.75% Acetic	0.75% NaOH	-	-
31	2.4	50% P.C. Naphtha 50% #3 Naphtha	0.6% Acetic	0.6% NaOH	670 Stokes Gardner	
32	2.4	Sour P.C.Naphtha	0.6% Acetic	0.6% NaOH	-	Very thin.
33	2.4	Sour P.C.Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	750 Stokes Gardner	
34	2.4	P.C. Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	640 Stokes Gardner (610 one month later)	Mixed at 69° F. 25 lb. batch.
35	0.4	P.C. Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	625 Stokes Gardner	Mixed at 71°F. 25 Lb. batch.
37	2.4	Sour P.C.Naphtha	0.6% Acetic	0.6% NaOH	570 Stokes Gardner)	
38	2.4	95% Sour P.C. Naphtha + 5% Motor Benzene	0.6% Acetic	0.6% NaOH	500 Stokes Gardner)	To study effect of aromatics.
39	2.4	90% Sour P.C. Naphtha + 10% Motor Benzene	0.6% Acetic	0.6% NaOH	600 Stokes Gardner)	
40	2.4	80% Sour P.C. Naphtha + 20% Motor Benzene	0.6% Acetic	0.6% NaOH	650 Stokes Gardner)	
41	2.4	P.C. Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	800 Stokes Gardner	25 lb. batch.

Batch No.	% Rubber	Fuel	% Acid	% Alkali	Viscosity	Remarks
42	2.4	Sour P.C.Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	620 Stokes Gardner (275 two weeks later)	Loss of viscosity due to sourness.
43	2.4	Diesel Fuel Oil	0.6% Acetic	0.6% NaOH	430 Stokes Gardner	25 lb batch.
44	2.4	Pentane + 10% Lube Oil + 10% Benzene	1.5% Acetic	2.0% NaOH	-	Mixed at 40°F.
46	2.4	Pentane + 10% Lube Oil + 15% Benzene	1.2% Acetic	1.2% NaOH	-	Mixed at 50°F.
47	2.4	#3 Naphtha + 6% P.C. Naphtha	0.6% Acetic	0.6% NaOH	400 Stokes Gardner	25 lb. batch.
48	2.4	Sour P.C.Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	570 Stokes Gardner	25 lb. batch.
49	2.4	Winter Gasoline	0.6% Acetic	0.6% NaOH	580 Stokes Gardner	25 lb. batch.
50	2.4	Kerosene + 10% #3 Naphtha	0.6% Acetic	0.6% NaOH	376 Stokes Gardner	25 lb. batch.
51	2.4	Medium Fuel Oil + 10% #3 Naphtha	0.6% Acetic	0.6% NaOH	450 Stokes Gardner	35 lb. batch.
53	2.4	Sour P.C.Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	250 Stokes Gardner	75 lb. batch.
67	2.1	Sour P.C.Naphtha + 10% Benzene	0.5% Acetic	0.5% NaOH	320 Stokes Gardner (250 five days later)	50 lb. batch.
74	2.4	Winter Gasoline	0.6% Acetic	0.6% NaOH	410 Stokes Gardner	50 lb. batch.
117	2.1	Sour P.C.Naphtha + 10% Benzene	0.6% Acetic	0.6% NaOH	-	25 lb. batch.

C. Crepe Rubber

Batch No.	% Rubber	Fuel	Temp. °F.	Time	Viscosity	Remarks
57	5.5	Sour P.C.Naphtha	77	24 hours	-	Grainy
58	5.5	Pure Benzene	77	7 hours	-	Smooth
59	5.5	Sour P.C.Naphtha + 10% Benzene	77	24 hours	-	Grainy
62	5.5	Pentane	35	2 weeks	-	Not dispersed
64	5.5	Sour P.C.Naphtha	77	24 hours	400 Stokes Gardner	50 lb. batch

Batch No.	% Rubber	Fuel	Temp. °F.	Time	Viscosity	Remarks
65	5.5	Sour P.C.Naphtha	-10°F.	2 weeks	-	Not dispersed
66	5.5	Pure Benzene	77	8 hours	450 Stokes Gardner	25 lb. batch
68	10	Sour P.C.Naphtha	77	3 days	3000 Stokes Gardner	Very smooth
69	3	Sour P.C.Naphtha	77	3 days	-	Not homogeneous
70	2	Sour P.C.Naphtha	77	3 days	-	Not homogeneous
71	1	Sour P.C.Naphtha	77	3 days	-	Not homogeneous
72	5.5	25% Benzene + 75% Sour P.C.Naphtha	77	3 days	-	Naphtha added after 1 hour - did not disperse
75	5.5	Winter Gasoline	77	24 hours	-	75 lb. batch
76	2	Winter Gasoline + 20% Sour P.C.Naphtha	77	-	Too thin	Cut back from 10%
77	4	Winter Gasoline + 40% Sour P.C.Naphtha	77	-	98 Stokes Gardner	Cut back from 10%
79	2.9	Winter Gasoline	77	-	-	Cut back from 5.5%. 9.1% cotton waste.
80	2.3	Winter Gasoline	77	-	-	Cut back from 5.5%. 9.1% cotton waste.
81	1.5	Winter Gasoline	77	-	-	Cut back from 5.5%. 9.1% cotton waste.
82	10	Winter Gasoline	77	20 hours	-	Slightly lumpy.
126	5.5	Winter Gasoline	70	-	-	Cut back from 10%

D. Reclaimed Rubber

Batch No.	% Rubber	Type	Fuel	Remarks
3	8	Black Reclaimed	Benzene	Did not disperse - swelled only.
3A	16	Black Reclaimed	Benzene	Did not disperse - swelled only.
5	12	Tube Reclaimed	Benzene	Did not disperse - swelled only.
36	6	Light Reclaimed Emulsion	Benzene	Dispersed to give a non-stringy gel.

2. Soap Batches

A. Aluminum Soaps

Batch No.	% Soap	Type	Fuel	Manufacture	Viscosity	Remarks
19	11.4	Naphthenate	54 Naphtha	Ball Mill 40 hrs.	40 Sec. Ball	Paint Drier Soap
45	10	Stearate	P.C. Naphtha + 10% Kerosene	Heated to 225°F., Added Winter Gasoline as it cooled.	-	Contains 1% Glycerol
120	8	Naphthenate	Kerosene	Heated to 200°F.	Too thin	Paint Drier Soap
121	10	Naphthenate	Kerosene +	Heated to 250°F.	1620 Stokes Gardner	Grease Making Soap
123	6.2	Oleate	Winter Gasoline + 15% Kerosene	Heated to 300°F., Added Winter Gasoline as it cooled.	-	From Cottonseed oil
134	8	Naphthenate	Winter Gasoline + 32% Lube Oil	Heated to 175°F., Added Winter Gasoline as it cooled.	-	-
135	8	Oleate	Winter Gasoline + 32% Lube Oil	Heated to 190°F., Added Winter Gasoline as it cooled.	-	From Cottonseed oil

B. Calcium Soaps

Batch No.	% Soap	Type	Fuel	Penetration	Remarks
1	19	Rosin Oil	Motor Benzene	350	Spatters badly.
109	6.2	Hog fat	Winter Gasoline + 30% Lube Oil	Fluid	From #3 Cup Grease
110	9.5	Rosin Oil	Kerosene	-	Did not gel
111	11	Stearic Acid	Kerosene	-	Did not gel
119	6	Hog fat	Winter Gasoline + 25% Lube Oil	Fluid	From #3 Cup Grease
127	6	Hog fat	Winter Gasoline + 25% Lube Oil	Fluid	From #3 Cup Grease

Batch No.	% Soap	Type	Fuel	Penetration	Remarks
136	4	Hog Fat	Winter Gasoline + 15% Lube Oil	Fluid	From #5 Cup Grease
137	12	Oleic acid	Winter Gasoline + 6% Lube Oil	298	Used cup grease to suspend lime.
139	12	Oleic Acid	Winter Gasoline + 20% Kerosene	-	Did not set without cup grease present
145	13	Oleic acid	Winter Gasoline + 1.3% Lube Oil	318	Used Batch 137 to replace cup grease

C. Melted Sodium Soaps

Batch No.	% Acid	% Rosin	% Plasticizer	Fuel	Temp. °F.	Penetration	Remarks
22	5 Hydrofol	2	5 Isopropanol	Kerosene + 20% 64 Naphtha	130	221	Open cooked
723	8 Hydrofol	4	8 Isopropanol	P.C. Naphtha + 41% Kerosene	130	83	Open cooked
730	3.9 Hydrofol	3	3.9 Isopropanol	P.C. Naphtha + 31% Kerosene	130	88	Open cooked
732	2.4 Hydrofol	1.2	2.4 Isopropanol	P.C. Naphtha + 13% Kerosene	130	155 (109 @ -10°F.)	Open cooked
78	2.4 Hydrofol	1.2	4.0 Isopropanol	Winter Gasoline	130	146	Open Cooked
83	2.4 Hydrofol	1.2	2.4 Isopropanol	Winter Gasoline	130	138	Cooked at 25 p.s.i.
84	2.4 Hydrofol	1.2	2.4 Isopropanol	Winter Gasoline	130	150	Cooked at 17 p.s.i.
86	2.4 Stearic	1.2	2.4 Isopropanol	Kerosene	160	168	Open cooked
85	2.4 Tallow	1.2	2.4 Isopropanol	Kerosene	160	Separated	Open cooked
87	2.4 Oleic	1.2	2.4 Isopropanol	Kerosene	160	Fluid	Open cooked
88	2.4 Stearic	1.2	2.4 Water	Kerosene	190	240	Open cooked
89	2.4 Tallow	1.2	2.4 Water	Kerosene	190	Fluid	Open cooked
90	2.4 Cotton	1.2	2.4 Isopropanol	Kerosene	180	218	Open cooked
91	2.4 Hydrofol	1.2	2.4 Castor Oil	Kerosene	160	102	Open cooked
92	2.4 Cotton	1.2	1.2 Isopropanol	Kerosene	175	250	Open cooked
93	2.4 Hydrofol	1.2	2.4 Cotton Oil	Kerosene	200	132	Open cooked
94	2.4 Oleic	1.2	2.4 Castor Oil	Kerosene	187	400+	Open cooked

Batch No.	% Acid	% Rosin	% Plasticizer	Fuel	Temp. °F.	Penetration	Remarks
95	2.4 Hydrofol	1.2	2.4 Fish Oil	Kerosene	210	187	Open cooked
97	2.4 Hydrofol	1.2	2.4 Rapeseed Oil	Kerosene	195	100	Open cooked
98	2.4 Hydrofol	1.2	5 Glycerol	Kerosene	160	165	Open cooked
99	2.4 Hydrofol	1.2	4.8 Castor Oil	Kerosene	220	137	Open cooked
100	2.4 Hydrofol	1.2	5.4 Methanol	Kerosene	150	141	Open cooked
101	2.4 Hydrofol	1.2	1.2% Castor Oil 1.2 Isopropanol	Kerosene	195	155	Open cooked
113	2.4 Hydrofol	1.2	2.4 Castor Oil	Kerosene	198	-	Open cooked
114	2.4 Hydrofol	1.2	3.2 Isopropanol	Winter Gasoline	137	-	Cooked at 10 p.s.i.
115	2.4 Hydrofol	1.2	3.2 Isopropanol	Winter Gasoline	137	-	Cooked at 8 p.s.i.
116	2.4 Hydrofol	1.2	3.2 Isopropanol	Winter Gasoline	132	180	Cooked at 12 p.s.i.
124	2.4 Hydrofol	1.2	3.2 Isopropanol	Winter Gasoline	132	162	Cooked at 10 p.s.i.
125	2.4 Hydrofol	1.2	3.2 Isopropanol	Winter Gasoline	132		Cooked at 13 p.s.i.

D. Cold Made Sodium Soaps

Basic Formula

Batch No.	% Acid	% Rosin	% Plasticizer	Temp. °F.	Penetration	Bleeding	Stability	Remarks
122	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100	240	Trace	Excellent	Added fillers.
136	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100		Trace	Excellent	Added fillers.
141	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100	-	Trace	Excellent	Added fillers.
142	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100	-	Trace	Excellent	2% Chopped Sisal added before alkali
143	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100	-	Trace	Excellent	-
152	3.5 Hydrofol	1.8 W.G. (Wood)	3.0 Castor Oil	100	-	Trace	Excellent	1% Long Sisal
167	3.5 Hydrofol	1.8 W.G.	3.0 Castor Oil	100	-	Trace	Excellent	No filler.

I. Effect of Changing Acid Type

Batch No.	Acid	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
150	Stearic	207	Medium	-	-	Difficult	Grainy
160	Cotton	-	-	-	-	-	Did not set

II. Effect of Changing Rosin Grade

Batch No.	Rosin	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
146	"B" Grade	-	Bad	-	-	-	Separates
153	W.G. (Gum)	199	Trace	Excellent	Slight	Good	Equal to basic formula

III. Effect of Acid-Rosin Ratio

Batch No.	% Hydrofol	% Rosin	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
156	4.3	1.0	234	Trace	Good	Normal	Good	-
161	4.8	0.5	205	Trace	Good	Normal	Good	Sets a little slower
163	0.5	4.8	-	Bad	-	-	-	Separates
164	1.8	3.5	248	Medium	Poor	-	Bad	Sets a little slower

IV. Effect of Fatty Oil Changes

Batch No.	% Fatty Oil	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
103	None	-	25%	Poor	-	-	Lower soap content
104	1 Castor Oil	-	Medium	Fair	-	-	Lower soap content
105	2.4 Castor Oil	-	Slight	-	-	-	Lower soap content
149	3 Fish Oil	195	Medium	Good	Medium	Difficult	Sets slower
154	3 Cottonseed Oil*	254	Trace	Good	-	Good	Smoother
157	1 Fish Oil	258	Trace	Good	Medium	Good	-
162	6 Castor Oil	251	None	Good	Little	Excellent	
170	3 Sperm Oil	223	Medium	-	-	-	Smooth
171	3 Refined Cottonseed Oil	196	Medium	-	Medium	-	Sets slower
172	3 Blown Rapeseed Oil	225	Slight	-	-	Excellent	-
178	1 Castor Oil 1.5 Cottonseed Oil	350	Bad	-	-	-	-
183	3 Castor Oil 1.5 Fish Oil	Soft	-	-	-	-	Sets slower

* Heat treated

V. Effect of Alkali Content

Batch No.	% NaOH	% Water	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
122	1.25	2.5	240	Trace	Excellent	Slight	Excellent	Basic Formula
165	1.07	2.14	280	Trace	Excellent	Slight	Excellent	Sets normally
166	0.89	1.78	235	Medium	Good	Medium	Poor	Rubbery
168	0.72	1.44	226	Bad	Fair	Medium	Poor	Sets slower
180	1.79	3.58	-	None	Good	Slight	Good	Sets normally

VI. Effect of Borax

Batch No.	% Borax	% NaOH	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
184	6.0	0	-	-	-	-	-	Sets very slowly
185	3.0	0.65	240	Medium	-	Slight	Medium	Sets in 1 hour
186	1.2	0.93	270	Bad	-	Slight	Good	Sets normally

VII. Effect of Mixing Temperature

Batch No.	Temperature °F.	Penetration	Bleeding	Stability	Shrinkage	Reworking	Remarks
129	40	-	Bad	-	-	-	Separates
130	85	220	Medium	Fair	-	Good	-
131	105	197	None	Good	-	Good	Best

APPENDIX II

SUGGESTED METHOD FOR COMPOUNDING AND FILLING FORMULA 122 IN THE FIELD

In places where rubber is available, it may be used as a satisfactory thickening agent. The crepe rubber is cut or torn into strips about one inch wide, and 5.5-6% is stuffed into the empty bomb cases (10 oz. in an M-46 case, or 2 lb. 3 oz. in an M-47 case). The cases are then filled to 90% of their volume with motor gasoline, capped and allowed to stand in a warm place (not less than 70°F., preferably 100°F.) for two days.

Where it is desired to use the gasoline soap, two ready-made supplies must be available, namely, Base "A" described below, and caustic soda. Base "A" can be prepared in domestic plants using the following formula:

Hydrogenated fish oil acid - 23.5%
Wood or gum rosin, W.G. Grade - 12.1%
Castor oil, No. 3 Grade - 20.1%
Heavy naphtha, 100°F. Flash - 44.3%

In the field 45 gallons of gasoline are measured into an open-head drum and warmed to 95°F. by means of a steam coil or electric heaters. To this is added 50 lb. (7-1/3 gallons) of Base "A", which should be stirred before measuring. To this is then added 4 lb. of caustic soda (lye) dissolved in one gallon of water. The mixture is well stirred with a paddle during the addition of the lye, and for a few minutes thereafter. The gasoline will thicken rapidly. It is then ready to fill into bomb cases, using large grease guns or ordinary dippers. Occasional stirring will keep the grease soft enough to pour for about one hour. (Note--Usual precautions required for handling ethyl gasolines should be observed).

Field supplies required are:

52 gallon open-head drums of Base "A".
4 lb. cans of lye (caustic soda).
Open-head 52 gallon mixing drum.
Heater coil and steam supply or electric heater and current.
5 gallon measure, graduated in 1/8 gallons.
Grease gun or large funnel and dipper.

If desired, the mixing can be done directly in the bomb cases, by shaking well after addition of Base "A" and again after addition of lye solution. This is recommended only for the M-46 or M-47 case, which is of a convenient size.

Appendix III

TEST BURNS - ATTIC STRUCTURE

Latex Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A) Left	Laths(A) Cent.	Laths(A) Right	Remarks
H-10	0.25	3.0	No	Batch 29	-	-	0	0	0	0	0	0	Charge flung against roof; 75% fell to floor.
H-16	0.25	2.0	No	"	3.0	7	1	1	0	0	0	0	
H-17	0.25	1.0	Yes	"	2.0	10+	3	4	4	0	4(2)	0	Very marked low point at 6 mins.
H-19	0.35	1.5	Yes	Batch 30	1.0	10+	4	4	8	5	4(3)	5	Eaves afire at 1 min.; low point at 6 min
H-9	0.65	6.0	No	Batch 29	-	-	0	0	0	0	0	0	Charge flung against roof; 75% fell to floor.
H-13	0.55	3.0	No	"	3.0	7+	2	2	0	0	1	0	
H-14	0.55	2.6	Brdle	"	3.0	6+	2	2.5	0	0	2	0	
H-15	0.50	2.0	Yes	"	4.0	10+	4	6	10	4	9(7)	3	
H-12	0.85	5.0	No	Batch 34	4.5	10	4	4	0	0	0	0	
H-4	0.95	4.0	No	Batch 29	3.5	7+	2	3	0	0	0	0	
H-20	1.00	4.0	No	Batch 34	1.5	5	2	2	2	0	1	0	Charge flung against roof; 60% fell to floor.
H-27	1.00	4.0	No	"	4.0	8	2	2	0	0	0	0	Flame volume seemed unusually small.
H-31	0.95	4.0	No	(B)	5.0	10	4	4	0	0	0	0	Small smoky flame.
H-50	1.00	4.0	No	Batch 41	4.0	6	2	4	0	0	0	0	Variable draft conditions during test.
H-42	0.95	4.0	No	Batch 55	3.0	5	3	4	0	0	0	0	Flame licked roof sporadically.
H-30	0.90	3.5	No	Batch 44	4.0	7	4	4	2	0	2	0	
H-57	1.05	3.5	No	Batch 41	4.0	6	2	4	0	0	0	0	Variable draft conditions during test.
H-28	0.95	3.0	No	Batch 34	4.0	10	4	4	2	0	2	0	Flame volume seemed unusually small.
H-52	0.95	3.0	Brdle	(B)	5.0	10	6	8	16	0	6	0	Heat intensity lower than with naphtha gums.
H-35	1.00	3.0	Yes	Batch 47	-	4.5	-	-	-	-	-	-	

Footnotes: All runs made on Design #1 structure.
(*) Fuel composition data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.
(B) 4% latex in 50% diesel fuel oil, 25% heavy naphtha, 25% light naphtha.

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TEST BURNS - ATTIC STRUCTURE

Latex Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A) Left	Laths(A) Cent.	Laths(A) Right	Remarks
H-38	1.00	3.0	No	Batch 41	4.0	8	2	4	3	0	0	0	Variable draft conditions during test.
H-39	1.00	3.0	Yes	"	4.0	10+	Complete destruction of all three sections (roof and floor) in 10 minutes.						Variable draft conditions during test. Flames directed into eaves from start of burn.
H-40	1.00	3.0	No	"	4.0	5	2	5	0	0	0	0	30% fuel unburned after 5 mins.
H-41	1.00	3.0	Yes	Batch 55	4.0	10+	Complete destruction of all three sections (roof and floor) in 10 minutes.						Fuel very fluid - spread over 2 sq.ft. area.
H-78	1.25	2.5	Yes	Batch 67	4.0	30+	Complete destruction of all three sections (roof and floor) in 30 minutes.						
H-79	1.25	2.3	Yes	"	4.0	30+	10	20	25	5	14(12)	14(10)	
H-5	2.00	4.5	Brdle	Batch 29	5.0	10+	4	6	14	-	-	-	
H-32	2.50	3.5	Yes	Batch 47	5.0	10+	8	8	20	8	14(12)	-	
H-21	3.00	4.5	Brdle	Batch 34	5.5	20+	8	8	16	3	6	3	
H-22	3.00	4.0	Yes	"	4.5	9+	Complete destruction of all three sections (roof and floor) in 9 minutes.						Structure collapsed.
H-24	3.00	4.0	Yes	Batch 45	5.0	10+	Complete destruction of all three sections (roof and floor) in 10 minutes.						
H-25	3.00	4.0	No	Batch 34	3.0	10	12	12	8	3	4	3	Charge blown towards roof from 5# can(15 g. black powder). Large flame volume.
H-6	5.00	7.0	No	Batch 29	5.0	14+	3	8	0	0	0	0	
H-7	5.00	6.0	No	"	5.0	8+	4	8	2	0	4	0	
H-8	5.00	5.0	Brdle	"	5.0	10+	5	8	15	4	5(3)	4	
H-26	9.65	6.0	Yes	Batch 34	-	8+	Complete destruction of all three sections (roof and floor) in 8 minutes.						Large amount of floor afire seemed to be deciding factor in propogating burn.

Footnotes: All runs made on Design #1 structure.
(*) Fuel composition data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.

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TEST BURNS - ATTIC STRUCTURE
Latex Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes: Active	Burning Time Minutes: Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A): Left	Laths(A): Cont.	Laths(A): Right	Rafter Type	Remarks
H-53	0.95	4.0	No	Batch 67	3.5	7	1.5	1	0	0	0	0	2x6 fir	Flame spreading hindered by floor construction.
H-54	1.00	3.0	No	"	3.0	7	2.5	3	2	0	5	0	"	Initial large flame; but rapid decrease.
H-70	1.05	3.0	No	"	3.5	13	5.0	7	10	0	11	0	2x6 w.pine	Flame behavior similar to H-54.
H-55	1.00	2.5	No	"	3.5	7	5.0	6	8	0	11	0	2x6 fir	
H-67	1.00	2.5	No	"	3.5	8	5.0	2	2	0	4	0	2x4 w.pine	Small rafters not as effective as predicted.
H-56	1.00	2.0	No	"	3.5	15	4.0	5	8	0	13(2)	0	2x6 fir	Structure appeared well caught for 5 mins.
H-58	1.00	1.5	No	"	3.0	12	3.0	4	8	0	11(2)	0	"	Center section ablaze for 3 mins.
H-60	1.00	1.0	No	"	3.0	15	5.0	6	12	0	14(1)	0	"	Ditto above.
H-68	1.00	1.0	Yes	"	3.5	17	5.0	6	15	10(3)	14(11)	10(5)	2x4 w.pine	Roof completely afire at 7 mins.
H-57	2.95	5.0	Brdle	"	6.0	11	5.0	5	8	0	10(2)	0	2x6 fir	Char deeper than with 1 pound charges.
H-59	3.00	4.0	Yes	"	5.5	10	8.0	10	20	0	14(11)	0	"	Good blaze while fuel lasted. Floor mass of embers.
H-69	3.05	3.5	Yes	"	4.0	-	7.0	8	18	-	14(14)	-	2x4 w.pine	Structure collapsed after 10 mins.
H-61	1.00	3.5	No	"	4.0	-	1.0	1	0	-	-	-	"	Floor laths only slightly charred.
HH-83	1.00	2.0	No	"	3.0	7	4.0	4	8	0	15	0	2x6 fir	
H-62	1.00	1.0	No	"	2.5	-	4.0	5	10	0	-	-	2x4 w.pine	Floor laths not burned through.
H-65	1.00	1.0	No	"	2.5	-	4.0	5	10	-	-	-	"	Ditto above. Plaster adhered to laths well.
HH-84	2.50	3.0	Brdle	"	4.0	10	6.0	6	18	12	15(6)	12	2x6 fir	
HH-85	2.50	2.0	Yes	"	4.0	10+	10.0	10	50	17(1)	17(15)	17(2)	"	Tremendous flames. Ridgepole charred for 6 ft.
H-63	2.95	3.0	No	"	4.0	-	-	-	-	-	-	-	2x4 w.pine	4 floor laths burned thru; plaster still adhered to floor structure.
H-64	3.00	3.0	No	"	2.0	3	-	-	-	-	-	-	"	Charge spread over 1 sq.ft. area. Ditto above.
H-66	3.00	3.0	No	"	4.5	14	-	-	-	-	-	-	"	Floor laths burned thru over 6 sq.ft. area. Plaster adhered but could be easily loosened.

Footnotes: First 12 runs(H-53 thru H-69) made on Design #2 structure using sand instead of plaster.
Last 9 runs(H-61 thru H-66) made on Design #2.
(*) Fuel composition data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.

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TEST BURNS - ATTIC STRUCTURE

Latex Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths (A) Left	Laths (A) Cent.	Laths (A) Right	Remarks
H-47	0.95	3.0	No	Batch 41	4.0	6	2	5	0	0	5	0	10% charge on roof; 90% on floor.
H-48	1.00	3.0	No	Batch 55	3.5	5	5	4	12	0	12	0	20% charge on roof; 80% on floor. Tremendous flames. Roof ablaze at 1 min., out at 2.5 mins.
H-51	1.05	2.8	No	"	1.0	3	12	18	15	9	9	9	(33% charge placed in each floor section. (Mass of flames penetrated to eaves in 1 min., but (died down sharply after fuel was exhausted.
H-52	1.05	2.5	No	"	1.0	5	12	18	15	8	10	9	
H-174	1.00	3.0	Brdle	Batch 117	2.5	5	6	8	12	7	13	8	Old wood(not planed) from dismantled house.
H-177	1.00	3.0	No	"	2.5	5	2	4	8	5	9	5	New wood. Flames did not reach eaves.
H-178	1.00	2.8	Brdle	"	2.5	10	6	8	12	5	13	-	Old wood. Eaves afire at 1.5 mins.
H-179	1.00	2.8	Brdle	"	2.5	8	4	6	12	6	13(2)	-	New wood. Flames nearly reached eaves.
H-180	1.00	2.5	Yes	"	-	15+	5	6	10	6	12(4)	7	Old wood. Eaves afire at 1.5 mins. Low point at 4 mins. Deep char.
H-181	1.00	2.5	Yes	"	-	15+	5	6	14	8(5)	12(9)	9(5)	New wood. Eaves afire at 2mins. Low point at 5 mins. No spreading to other sections.
H-186	1.50	2.5	Yes	"	3.5	10+	6	8	20	9	14(4)	8	
H-199	2.30	4.5	No	"	3.5	11	3	6	6	0	9	3	Used structure with 20 in. of board to form a peaked roof. No evidence that such construction helped flames.

Footnotes: All runs made on Design #1 structure. Runs H-47,48,51 & 52 made on double structure formed by placing two open-end structures together.
(*) Fuel composition data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Smoked Sheet Rubber Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths Left	Laths Cent.	Laths Right	Remarks
H-2	1.00	4.0	No	Batch 13	4.0	4.5	2	3	0	0	0	0	
H-3	1.00	3.0	Yes	"	4.0	10+	5	8	12	9	12	0	
H-1	0.95	2.0	Yes	Batch 12	-	10+	4	8	14	9	9	9	
H-11	0.25	8.0	No	Batch 13	-	-	0	0	4	0	6	0	Charge flung against roof; 35% fell to floor.
H-12	0.25	8.0	No	"	-	-	0	0	4	0	8	0	Smeared over 2 sq.ft. area on roof.
H-46	0.55	2.0	No	Batch 12	3.0	6	1	1	3	0	7	2	50% charge smeared on roof; 50% placed on floor.
H-23	1.00	4.0	No	Batch 13	3.0	6	0	0	4	0	5	0	Smeared on roof; 50% fell to floor.
H-29	1.00	4.0	No	Batch 12	3.0	8	0	0	-	0	-	0	Ditto above.
H-43	1.00	3.5	No	"	1.0	3	2	0	0	0	0	0	Smeared on roof; 25% fell to floor.
H-44	1.00	3.5	No	"	1.5	3	0	0	15	4	10	9	Smeared on roof; 5% fell to floor.
H-45	1.00	3.0	No	"	3.5	8	3	3	4	0	6	2	35% charge smeared on roof; 65% placed on floor.

Footnotes: All runs made on Design #1 structure. Runs H-43,44,45 & 46 made on double structure formed by placing two open-end structures together.
(*) Fuel composition data shown on attached sheet.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Crepe Rubber Gums Without Binder

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A) Left	Laths(A) Cent.	Laths(A) Right	Remarks
H-49	1.00	6.0	No	Batch 58	3.0	5	0	0	4	0	0	0	Charge smeared around ridgepole; 1/3 charge dropped to floor.
H-151	2.30	-	Yes	Batch 75	4.0	10+	20	22	36	14(9)	14(9)	14(9)	Charge blown into eaves from 3" bomb casing(20 grams black powder). Moderate low point at 5 mins.
H-184	1.50	4.5	No	"	3.0	5	1.5	4	0	0	1	0	Tremendous flames but little damage.
H-191	1.50	4.5	No	"	4.0	10+	1	2	0	0	0	0	
H-185	1.50	2.5	Brdls	"	3.0	8	6	11	24	8	14(1)	8	Eaves afire at 2 mins.; tremendous flames while fuel lasted.
H-192	1.50	2.0	Yes	"	-	10+	Complete destruction of attic(roof and floor) in approximately 10 minutes.						
HH-197	2.30	7.0	No	"	3.0	10	4	8	8	2	2	2	Charge blown onto ridgepole from 3" bomb casing (20 grams black powder).
HH-92	5.95	3.5	Yes	"	2.0	10+	33	33	98	--- 104(10) -----			

Footnotes: First 7 runs - H49 to HH-197 made on Design #1 structure; HH-92 on Design #2.
See also Runs HH-89,90 and 91 for crepe rubber used with cotton waste.
(*) Fuel composition on data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Magnesium

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A) Left.	Laths(A) Cent.	Laths(A) Right	Structure	Remarks
H-71	1.25	4.0	No	Hex.	7.0	30	1.5	4	0	0	0	0	Design #1	Charred through floor(1-3/4"); joists(1/2")
H-73	1.25	3.0	No	"	10.0	20+	1.5	4	0	0	0	0	"	Ditto above.
H-138	1.25	3.0	No	"	8.0	20+	2.0	6	0	0	0	0	"	Ditto above.
H-76	1.25	2.5	Yes	"	-	30+	Complete destruction of entire attic(roof and floor) after 30 minutes. Burn aided by torch and by oil flames nearby.(Design #1)							
H-75	1.25	2.3	Yes	"	-	30+	3	6	12	0	14(11)	3	Design #1	
H-72	1.25	2.0	Yes	"	-	20+	Complete destruction of entire attic(roof and floor) after 20 minutes. Burn considerably aided by torch. (Design #1)							
H-74	1.25	2.0	Yes	"	4.0	20	2	4	8	0	12(9)	5	Design #1	High flames at start - rapid decrease.
H-80	2.50	4.0	No	"	4.0	15+	3	8	12	8	10	9	"	
H-81	2.50	3.5	No	"	6.0	20+	4	4	12	2	11(3)	2	"	
HH-86	1.25	2.0	Yes	"	4.0	10+	4	4	16	8	14(8)	7	Design #2	Floor laths charred thru. Ridgepole slightly burned.
HH-87	2.50	5.0	No	"	5.0	12+	6	6	14	2	17	2	"	
HH-88	2.50	2.0	Yes	"	6.0	10+	8	8	20	15(6)	17(17)	-	"	Plaster fell through on touching.
H-147	4.00	2.5	No	Bomb	8.0	15+	2	4	4	0	9	4	Design #1	Much spluttering. Active thermate burn = 1-1/2 mins.
H-199	4.00	2.5	Edle	"	8.0	15+	4	8	10	5	7(3)	4	"	Burn aided by oil flames nearby.
HH-195	4.00	2.5	Yes	"	6.0	10+	4	8	14	7	14(5)	6	"	Spreading to adjacent sections after 10 mins.
H-200	4.00	2.5	No	"	6.0	11	1.5	3	0	0	0	0	"	Low point at 2 mins. Plaster seemed to retard flames. Definitely did not burn through plaster or weaken plaster appreciably.

Footnotes: First 9 runs(H-71 thru H-81) on Design #1 structure; next 3 runs(H-86 thru H-88) on Design #2 structure; next 3 runs(H-147 thru HH-195) on Design #1; last run (H-200) on Design #1 except plastered floor.

(*) Hexagonal Mg bar stock 1-1/2" dia. - fired by oxy-acetylene torch or regular Army Mg bomb.

(A) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Thermate

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(A) Left	Laths(A) Cent.	Laths(A) Right	Remarks
H-77	2.00	2.5	No	Grenade	0.3	5	1	2	0	0	0	0	Sputtered considerably. Charred through 1-1/2" floor.
H-148	4.00	2.5	No	Bomb	1.5	5+	1	2	0	0	0	0	
HH-175	4.00	2.5	No	"	1.5	-	1	2	0	0	0	0	
H-187	4.00	2.5	No	"	0.5	10+	1	2	0	0	0	0	Charred through 1-3/4" floor.
HH-194	4.00	2.5	No	"	0.5	10+	2	4	0	0	0	0	
H-173	4.00	0.0	No	"	0.9	15+	1	2	6	5(4)	7(5)	6(3)	Flame dying rapidly at 15 min. Low point at 1-1/2 mins.
H-201	4.00	2.5	No	"	1.0	5	0.5	0	0	0	0	0	At 1 min. burned 3 small holes in ceiling 1/8-1/4" dia. Molten material running through formed stalactites..

Footnotes: First 6 runs (H-77 to H-173) made on Design #1 structures; H-201 on Design #1 except plastered floor.
(*) Regular Army thermate hand-grenade or air-borne incendiary bomb.
(A) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Gasoline Soap Without Binder

Run No.	Wt. of Charge (Lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths (A) Left	Laths (A) Cent.	Laths (A) Right	Remarks
H-114	0.65	2.5	No	Batch 115	2.0	5	2	4	8	5	8	0	Charge flung against roof; 95% dropped to floor in 1 ft. circle.
H-98	0.65	2.5	Yes	Batch 73E	2.5	10+							Slow starting. Hard gel retarded flames.
H-115	0.65	2.0	No	Batch 115	1.0	2	4	5	9	9	11	8	Charge flung against roof; splattered over entire structure.
H-105	1.00	3.5	No	Batch 83	4.5	6	2	4	1	0	2	0	Rapid extinction after fuel was exhausted.
H-108	1.00	3.5	Brdle	Batch 112	3.5	6	2	4	7	5	8	5	More rapid burning than Batch 83. Softer gel.
H-106	1.00	3.0	Yes	Batch 83	4.5	12+	12	15	25	14(4)	14(9)	14(4)	Eaves afire after 2 mins., rapidly spreading flames.
H-109	1.00	3.0	Yes	Batch 112	3.5	10+	6	8	10	6	12(8)	-	Section ignited after 1 min. Low point at 4 minutes.
H-139	1.25	3.0	No	Batch 125	2.0		4	5	11	6	12	9	Flash burn.
H-140	1.25	3.0	No	"	2.0	8	4	6	14	5	12	5	Flash burn.
H-103	1.30	3.5	Brdle	Batch 73E	3.5	8	6	8	16	7	13(1)	8	Rapid extinction after fuel was exhausted.
H-119	1.35	3.0	Brdle	Batch 115	3.0	10+	5	8	14	9	13(3)	11	
H-107	1.50	3.5	Yes	Batch 83	6.0	10+	8	10	18	14	14(6)	14	Eaves afire after 4 mins., low point after 7 minutes.
H-155	2.30	3.5	No	Batch 134	4.0	5.5	8	11	20	14	14	14	Tremendous flames for 4 minutes. Rapid extinction.
H-187	2.30	3.5	Yes	Batch 135	3.5	10+							Entire structure(roof & floor) afire at 10 minutes. Complete destruction. Eaves afire at 2 minutes, entire roof afire at 3 minutes, low point at 5 minutes.
H-126	2.50	4.5	Brdle	Batch 112	5.0	10+	9	12	26	12	14(6)	-	Flames reached eaves just as fuel was exhausted.
H-182	2.30	-	Yes	Batch 167	2.0	10+	2	4	6	12(4)	14(7)	12(5)	Charge blown into eaves from 5" bomb casing(20 g. black powder). Only 60% of charge went into eaves. Moderately low points at 4, 8 and 10 minutes.
H-137	1.20	3.0	No	Batch 115	3.5	10	2	4	6	0	7	2	Plastered floor retarded spread of flames.
HH-112	1.00	2.5	No	Batch 112	4.0	8	1.5	2	1	0	5	0	
HH-113	2.00	3.0	No	"	5.0		7	7	16	-	12	1	Eaves afire only after 5 minutes, charred slightly.
HH-127	2.50	3.5	No	"	4.0	6	5	5	12	5	12(3)	4	Plastered floor retarded spread of flames.
HH-128	2.50	2.5	Yes	"	5.0	12	6	6	14	-	14(4)	5	Eaves afire at 2 mins. Transite roofing exploded, blowing out large parts of the flame.
HH-129	4.00	3.5	Yes	Batch 118	8.0	10+	10	10	20	-	18(5)	6	Eaves afire at 4 mins. Ditto above.

Footnotes: First 18 runs (H-114 to H-182) made on Design #1 structure; Run H-137, Design #1 except plastered floor; last 5 runs(HH-112 to HH-129) Design #2.

(*) Fuel composition data shown on attached sheet.

(A) Numbers in parentheses refer to number of laths burned through.

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Appendix XII

TEST BURNS - ATTIC STRUCTURE
Excelsior Binds in Soap-Thickened Gasoline

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes: Active	Burning Time Minutes: Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths(‡): Left	Laths(‡): Cent.	Laths(‡): Right	Percent Binder	Remarks
H-39	1.00	3.5	No	Batch 83	3.5	10+	1.5	2	0	0	0	0	10	Good burn for 3 minutes, low flame during remainder of fuel burn.
H-110	1.00	3.0	No	Batch 112	6.0	10+	3	4	0	0	0	0	10	Fuel molded around [illegible]nder while liquid; flame definitely retarded by binder
H-100	1.00	2.5	No	Batch 83	3.0	5+	1.5	2	0	0	0	0	10	25% fuel unburned after 5 minutes.
H-111	1.00	2.5	Yes	Batch 112	6.0	10+	6	8	10	-	10(8)	8	10	Eaves afire at 4 mins., no low point due t consistent fuel flame.
H-101	2.00	3.5	No	Batch 83	4.0	10+	4	4	8	2	6	4	10	
H-118	0.65	2.0	Brdle	Batch 115	1.5	10+	3	4	8	-	11(1)	4	1	Charge flung against roof, 95% fell to floor in one foot circle.
H-119	0.65	2.0	Yes	"	2.5	10+	4	5	10	7	9(5)	7	2	Ditto above. Fuel glob more cohesive.
H-122	1.00	3.0	No	Batch 116	10	10+	0	0	5	0	8(3)	6(5)	1.5	Charge flung against roof and stayed in lath-rafter corner.
H-117	1.55	3.0	Yes	Batch 115	2.5	10+	6	8	12	5	14(8)	-	1	Charge flung against roof, 95% fell to floor in one foot circle.
H-123	2.50	4.5	No	Batch 116	6.0	10+	3	4	2	0	2	0	1.5	
H-166	2.30	3.5	No	Batch 141	10	10+	2	3	0	0	0	0	2	25% fuel unburned after 10 minutes.
H-169	2.30	3.5	No	Batch 140	7.0	10+	2	3	0	0	0	0	2	30% " " " "
H-170	2.30	3.0	Yes	"	7.0	15+	Complete destruction. Eaves afire at 7 minutes. All roof section afire at 10 minutes. All floor sections afire at 14 minutes.							
H-171	2.30	3.0	Yes	Batch 141	10	20+	5	8	18	8(2)	14(9)	7(3)	2	Seemingly a faster burn than H-170.

Footnotes: All runs made on Design #1 structure.
(*) Fuel composition on data shown on attached sheet.
(‡) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Sisal and Moss Binder in Various Fuels

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths (A) Left	Laths (A) Cent.	Laths (A) Right	Percent Binder	Remarks (Moss binder used only in Runs H-131 & 133)
H-133	1.00	3.0	No	Batch 118	4.5	8	1.5	2	0	0	0	0	1.5	Moss binder retarded flames too much.
H-131	1.30	3.0	No	"	2.0	7	3	5	8	2	10	7	1.5	Charge flung against roof. Moss binder not as retentive of fuel as sisal. (H-130).
H-132	0.65	2.5	Yes	"	2.0	10+	6	8	9	8	11(6)	6	0.4	Charge flung against roof - seemingly held together as well as with 1.5% binder. (H-130).
H-130	1.30	3.3	No	"	3.0	8	2	4	2	0	3	0	1.5	Charge flung against roof, 95% fell to floor in 1 ft. circle.
H-141	1.25	3.0	Yes	Batch 125	3.5	10+	6	8	12	8	12(7)	-	1.5	Binder retarded flames for optimum burning time.
H-149	1.25	2.5	Yes	"	3.5	10+	4	5	9	8	12(7)	8	1.5	
H-142	2.30	3.5	No	Batch 127	3.5	12	4	6	12	6	12	10	2.0	Fuel too fluid to be retained by binder.
H-143	2.30	3.5	No	"	4.0	15+	3	5	8	0	10	1	4.0	Increased percentage binder retarded flames somewhat. However, fuel burned too rapidly.
H-144	2.30	3.5	Brdle	"	4.5	15+	4	6	12	-	11(3)	6	4.0	
H-150	2.00	2.5	Yes	Batch 122	5.0	10+	5	6	16	8	14(9)	8	0.4	Eaves afire at 3 mins.
H-157	2.30	3.5	No	"	8.0	12+	2	3	0	0	0	0	1.5	Sisal binder and fuel mixed by hand. Burning time too long.
H-158	2.30	2.5	Yes	"	8.0									Complete destruction of all three sections (roof and floor) in approximately 10 mins. Eaves afire at 2 mins.; right section afire at 7 mins.; left section at 10 mins. Fuel & binder same as H-157.
H-161	2.30	3.5	No	Batch 136	5.0	10+	1	2	0	0	0	0	1.5	25% fuel unburned after 10 mins.
H-160	2.30	3.0	Yes	"	5.0	25								Complete destruction of all three sections (roof and floor) in 20 minutes. Eaves afire at 7 mins., low point at 15 mins. Fuel and binder same as H-161.
H-162	1.25	3.0	No	"	3.5	10+	1.5	3	0	0	0	0	1.5	
H-163	1.25	2.3	No	"	4.0	20+	2.5	4	1	0	2	0	1.5	
H-164	1.25	2.0	Yes	"	3.5	15+	6	8	24	12(6)	14(12)	12(7)	1.5	Eaves afire at 2 mins. Structure collapsed at 15 mins.
H-168	2.30	3.5	No	Batch 135	7.0	10+	2	3	0	0	0	0	2.0	25% fuel unburned after 10 mins. Chopped sisal employed instead of usual long-fiber sisal.

Footnotes: All runs made on Design #1 structure.
(*) Fuel composition on data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned thru.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Sisal Binder in Various Fuels

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths (A) Left	Laths (A) Cent.	Laths (A) Right	Percent Binder	Remarks
H-165	2.30	3.5	No	Batch 141	8.0	10+	2	3	0	0	0	0	0.8	20% fuel unburned after 10 mins.
H-172	2.30	3.5	Brdle	"	3.0	7	6	9	18	8	12(1)	7	0.8	Fuel spread over 1.5 sq.ft. area(3/8" thick).
H-188	2.30	2.5	Yes	Batch 167	-	12+	Complete destruction of all three sections(roof & floor) in 12 mins.						1.0	
H-190	2.30	2.5	Yes	"	-	12+	Ditto above.						1.0	
HH-176	2.30	2.5	Yes	Batch 136	7.0	15+	Complete destruction of entire attic in 15 mins.(all 14 sections)						1.5	Eaves afire at 5 mins., two adjacent sections afire at 8 mins.
HH-196	2.30	2.5	Yes	Batch 167	-	10+	10	14	30	12(5)	17(10)	14(6)	1.0	Adjacent sections afire at 8 mins.
H-185	2.30	Charge blown into eaves from 3"bomb casing(20g. black powder)	Yes	Batch 152	5.0	10+	12	20	32	14(7)	14(12)	14(8)	3.0	All floor and roof sections afire at 10 mins., no low point noticeable.
H-193	2.30		Yes	Batch 167	-	10+	10	20	30	14(7)	14(12)	14(7)	1.0	
HH-198	2.30	" "	Yes	"	-	10+	Complete destruction of entire attic in 10 mins. (all 14 sections)						1.0	
H-202	2.30	2.5	Yes	Batch 209	-	20+	5	8	24	14(7)	14(9)	14(8)	1.0	Eaves afire at 5 mins., no low point. Rafters in center section charred through at eaves. Plastered floor held together firmly.

Footnotes:

(*) Fuel composition on data shown on attached sheet.

(A) Numbers in parentheses refer to number of laths burned thru.

First 9 runs(H-165 thru HH-198) on Design #1 structure; Run H-202 on Design #1 except plastered floor.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Cotton Waste Binder in Various Fuels

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes: Active	Burning Time Minutes: Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths (A): Left	Laths (A): Cent.	Laths (A): Right	Percent Binder	Remarks
H-34	0.70	3.5	No	P.C.Naph.		5	5	6	6	0	3	0	20.0	Fuel leaked through floor.
H-35	0.85	4.0	No	"		5	5	4	0	0	0	0	16.5	Ditto above.
H-94	1.10	3.5	No	Esso Base	2.5	7+	2	3	0	0	0	0	20.0	Floor cracks sealed with putty - no fuel leaked thru.
H-95	1.00	2.5	Yes	"	3.0	12+	4.5	7	12	6	9(3)	6	20.0	Ditto above.
H-93	1.70	3.5	No	"	3.0	10+	1	1	0	0	0	0	12.5	Fuel leaked through floor.
H-102	1.00	3.5	No	Batch 83	4.5	10+	1.5	2	0	0	0	0	10.0	Flash burn at start, followed by low flame for long period.
H-124	1.00	3.0	No	Batch 118	5.0	10+	1.5	2.5	0	0	0	0	1.5	Small amount of fuel left unburned.
H-120	1.00	2.5	Yes	Batch 112		10+	4	6	10	7	14(7)	14(12)	10.0	Eaves afire at 2 minutes, no low point.
H-125	1.00	2.5	Yes	Batch 116	5.0	10+	5	6	11	8	10(6)	8	1.5	Eaves afire at 4.5 minutes.
H-146	2.00	3.5	No	Batch 123	2.0	20+	3	6	4	0	4	0	4.0	Flash burn at start, followed by low flame for long period.
H-104	2.00	3.0	Yes	Batch 83	6.0	12+	6	8	12		14(8)	-	10.0	Eaves afire at 4.5 minutes.
H-145	2.30	5.5	No	Batch 127	2.5	20+	2	4	2	0	3	0	6.0	
H-121	0.90	3.0	No	Esso Base		10+	1	2	0	0	0	0	20.0	Flash burn.
HH-89	1.05	2.0	No	Batch 81		10+	0.5	0	0	0	0	0	9.1	Flash burn at start, followed by low flame for long period; 40% fuel unburned after 10 minutes.
HH-90	2.10	2.0	No	"	1.5	11+	1	1	2	0	4(1)	0	9.1	40% fuel unburned after 10 minutes.
HH-91	3.00	2.0	No	"	2.0	14+	4	3.5	8	2	10(3)	0	9.1	

Footnotes: First 12 runs (H-34 to H-145) made on Design #1 structure; Run H-121, Design #1 except plastered floor; last 3 runs on Design #2.
(*) Fuel composition data shown on attached sheet.
(A) Numbers in parentheses refer to number of laths burned through.

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Appendix III

TEST BURNS - ATTIC STRUCTURE

Cotton Bags With Various Fuels

Run No.	Wt. of Charge (lbs.)	Distance from Eaves (ft.)	Positive Burn	Fuel (*)	Burning Time Minutes Active	Burning Time Minutes Total	Amount Charred or Burned: Floor (sq. ft.)	Joists (ft.)	Rafters (ft.)	Laths Left.	Laths Cent.	Laths Right	Remarks
H-50	1.10	4.0	No	Batch 3A			2	3	0	0	0	0	Small fire. Major portion of fuel leaked thru floor.
H-96	1.25	3.5	No	Esso Base	1	10+	4	4	6	3	10	-	Perforated cardboard mailing tube used to disteng bag. Flash burn.
H-97	1.30	3.5	No	Batch 4A	2								Double bag used to contain fuel.
H-152	1.20	3.0	No	Batch 127	7	10+	1.5	2	0	0	0	0	Fuel drained from bag very slowly.
H-153	1.40	3.0	No	Batch 127A	6	10+	2	4	4	0	5	0	Ditto above.
H-154	1.35	3.0	No	Batch 127B	5	8	2	4	4	0	5	0	Ditto above.
H-158	1.40	3.0	No	Batch 58A	8	10+	2	3	0	0	0	0	Ditto above.
H-159	1.30	3.0	No	Batch 58B	6	10+	2	3	0	0	0	0	Ditto above.
- - - -	- - - -	- - - -											
H-134	1.80	3.0	No	Batch 4A	2	5	6	9	12	7	12	7	Flash burn effect. Plastered floor helped direct fuel toward eaves.
H-135	1.25	3.5	No	Batch 4A	3	10	3	5	8	3	6	-	Fuel spreading retarded by plaster ridges on floor.
H-136	1.20	3.0	No	Batch 4B	2.5	8	3.5	6	8	-	8	4	Increased proportions of Essodiesel in fuel charge did not appreciably lengthen burning time.

Footnotes: First 8 runs on Design #1; last 3 runs on Design #1 except plastered floor.
(*) Fuel composition data shown on attached sheet.

Esso Laboratories
Process Division
WTK,Jr./jl 1/2/42

COMPOSITION OF FUELS USED IN TEST BURNS
Appendix III

A. Straight Fuels

P.C. Naphtha	8 pound Reid vapor pressure, 360°F. E.P. gasoline.
Esso Base	0 " " " " , 400°F. " " , winter grade.
Batch 3A	90% heavy naphtha(300-400°F. B.P.), 10% light naphtha(110-285°F.B.P.).
Batch 4A	50% Esso Base, 50% Diesel fuel oil(395-660°F.B.P.).
Batch 4B	40% " " , 60% " " " "

B. Crepe Rubber Blends

	Base Stock	Crepe Rubber, wt.%
Batch 58	Benzol	5.5
" 58A	Esso Base	0.12
" 58B	" "	0.04
" 75	" "	5.5
" 81	" "	1.5

C. Smoked Sheet Rubber Blends

	Base Stock	Smoked Sheet Rubber, wt.%
Batch 12	Benzol	7.0
" 13	P.C.Naph.	7.0

D. Latex Blends (1)

	Base Stock	Latex, wt.%	Additive, wt.%	NaOH, wt.%	Oleic Acid, wt.%	H_2O, wt.%
Batch 30	Pentane	5.0	Benzol - 10.0	0.7	0.7	1.6
" 34	P.C. Naph.	4.0	- -	0.6	0.6	1.2
" 41	" "	4.0	Benzol - 10.0	0.6	0.6	1.2
" 43	Diesel Fuel Oil	4.0	-	0.6	0.6	1.2
" 44	Pentane	4.0	Lube Oil Dist. 10.0	0.6	0.6	1.2
" 47	Light Naph.	4.0	- -	0.6	0.6	1.2
" 50	Heavy Naph.	4.0	Light Naph. - 10.0	0.6	0.6	1.2
" 51	Heating Oil	4.0	" " - 10.0	0.6	0.6	1.2
" 55	P.C. Naph.	3.0	Benzol - 10.0	0.5	0.5	0.8
" 67	P.C. Naph.	3.5	- -	0.5	0.5	0.8
" 117	Esso Base	3.5	- -	0.5	0.5	0.8

E. Gasoline Soap Blends

	Base Stock	Hydrofol Acid	Rosin	NaOH	H_2O	Heavy Naph.	i-PrOH	Castor Oil	Temp.°F.	Press.-#/sq.in.	Pen./77°F.
		Composition - Wt. %									
Batch 73E	P.C. Naph.	2.4	1.2	0.5	3.0	12.0	2.4	-	120	Atmos.	156
" 83	Esso Base	2.4	1.2	0.5	1.0	-	2.4	-	150	25	138
" 112	" "	3.5	1.8	0.5	1.0	3.6	-	3.0	90	Atmos.	
" 115	" "	2.4	1.2	0.5	1.0	2.4	3.2	-	137	8	
" 116	" "	2.4	1.2	0.5	1.0	2.4	3.2	-	137	8	
" 118	" "	2.4	1.2	0.5	1.0	2.4	3.2	-	132	12	180
" 122	" "	3.5	1.8	1.4	2.2	3.5	-	3.0	100	Atmos.	274
" 125	" "	2.4	1.2	0.5	1.0	2.4	3.2	-	132	13	
" 127	" "	--- 30% Cup Grease(19% calcium-hog fat soap; 2% H_2O, 79% lube oil distillate).									
" 127A	" "	--- 10% Ditto above.									
" 127B	" "	--- 2% Ditto above.									
" 128	" "	--- 20% Ditto above.									
" 134	" "	--- 8% Aluminum Naphthenate, 10% Heavy Naphtha, 32% Lube Oil Distillate.									
" 135	" "	--- 10% Aluminum Oleate, 8% Heavy Naphtha, 32% Lube Oil Distillate.									
" 136	" "	3.5	1.8	1.4	2.2	3.6	-	3.0	94	Atmos.	
" 140	" "	3.5	1.8	1.4	2.2	3.6	-	1.5	100	"	195
" 141	" "	3.5	1.8	1.4	2.2	3.5	-	3.0	100	"	
" 152	" "	3.5	1.8	1.4	2.2	3.5	-	3.0	100	"	
" 167	" "	3.5	1.8	1.4	2.2	3.5	-	3.0	100	"	
" 209	" "	3.5	1.8	1.4	2.2	3.5	-	3.0	100	"	

Esso Laboratories, Process Div.
WTK, Jr./jl 1/2/42

Appendix IV

Explosion Tests

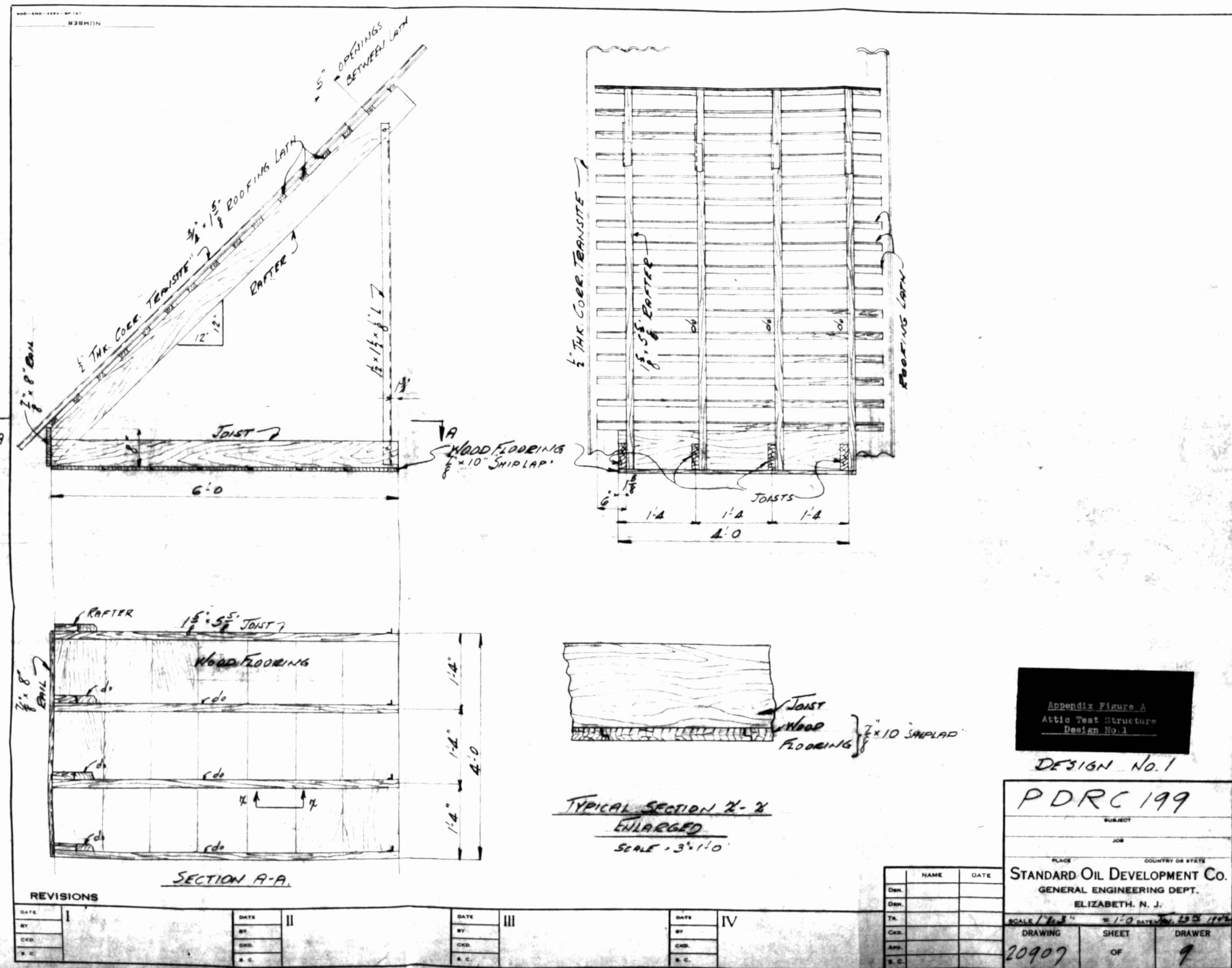
No.	Case	Powder	Fuel	Temp. °F.	Ignition	Remarks
1	5# pail	20 gms. in bottom pan	3# 2.4% rubber latex	60		Powder chamber in base satisfactory.
2	5# pail	20 gms. in bottom pan	3# 2.4% rubber latex	60		Check on No. 1.
3	5# pail	20 gms. in bottom pan	3# batch 27, 2.4% rubber latex in P.C. Naphtha	-40	Poor	90% in 1 blob.
4	5# pail	20 gms. in bottom pan	3# batch 27, 2.4% rubber latex in P.C. Naphtha	+28	Good	90% in 1 blob.
5	5# pail	20 gms. in bottom pan	3# batch 28, 2.6% rubber latex in P.C. Naphtha	+50	Good	50% in 1 blob - rest in small pieces.
6	5# pail	20 gms. in bottom pan	3# batch 28, 2.6% rubber latex in P.C. Naphtha	+50	Good	Whole charge finely divided.
7	-	-	3% rubber in pentane	+60		Lit with match - flame not different from P.C. Naphtha.
8	5# pail	20 gms. in bottom pan	3# batch 28, 2.6% rubber latex in P.C. Naphtha	+60	Good	Divided in 100+ small pieces.
9	5# pail, lid soldered on	20 gms. in bottom pan	3# batch 28, 2.6% rubber latex in P.C. Naphtha	+60	Good	Divided into many small pieces.
10	5# pail	20 gms. in bottle at bottom	3# batch 28	+60	Good	Did not eject well - half charge left in can.
11	5# pail	20 gms. in bottle at bottom	3# batch 28	+60	Good	Poor ejection - central bottom charge of powder will not do.
12	5# pail	20 gms. in bottom pan	3# batch 28 in 3 1# paper bags	+60	Good	Bags thrown out without breaking.
13	5# pail	20 gms. in bottom pan	3# batch 35, 2.4% rubber latex	+60	Poor	Fuel was much thicker than usual but many small pieces were thrown out.
14	5# pail	20 gms. in bottom pan	3# batch 35, 2.4% rubber latex	+60	Good	Bomb was laid on its side, fuel thrown 25 ft. horizontally in one gob.
15	5# pail	20 gms. in bottom pan	3# batch 35, 2.4% rubber latex	+60	Good	Waste balls controlled size of fuel gobs quite satisfactorily.
16	5# pail	20 gms. in bottom pan	3# batch 35, 2.4% rubber, latex in 2 paper bags	+60	Good	Bags ripped apart.

No.	Case	Powder	Fuel	Temp. °F.	Ignition	Remarks
17	5# pail	20 gms. in bottom pan	3# batch 35, in 1 oz. steel wool	+60	Good	Held in 1 large glob.
18	1 qt. paper milk bottle	10 gms. in center tube	1# batch 35	+60	Good	Scatter over 5' radius.
19	5# pail	20 gms. in bottom pan	3# batch 35	-25	Poor	5 blobs, none ignited. Reid 5.7#.
20	5# pail	20 gms. in bottom pan	3# batch 42, 2.4% rubber latex	-5	Good	Thrown out in 1 glob. Reid 6.7#.
21	3" pipe	20 gms. in bottom pan	3# batch 42, 2.4% rubber latex	+60	Bad	Thrown out in many small pieces.
22	5# pail	15 gms. in bottom pan	3# P.C. Naphtha in 6 waste balls	+60	Good	Thrown out in 6 balls - 5 ignited.
23	5# pail	10 gms. in bottom pan	3# P.C. Naphtha in 5 waste balls	-60	Good	
24	5# pail	15 gms. in bottom pan	3# P.C. Naphtha in 4 balls of waste	+60	Bad	Waste too tightly packed.
25	5# pail	20 gms. in bottom pan	3# batch 42 (4% latex) in P.C. Naphtha	-25	Bad	
26	5# pail	20 gms. in bottom pan	3# batch 49, 4% latex in winter gasoline	-35	Good	
27	3" pipe	15 gms. in pan + 5 gms. Mg turnings	2-1/2# batch 42	+60	Bad	Magnesium turnings did not help ignition.
28	3" pipe	15 gms. in pan	2-1/2# batch 42	+60	Bad	No ignition in tube.
29	5# pail	20 gms. in pan	2-1/2# batch 42	+60	Good	Blown into many small pieces.
30	5# pail	20 gms. in pan	2-1/2# gasoline in 4 waste globs	+60	Good	Excellent performance.
31	3" pipe	20 gms. in pan + 5 gms. Mg turnings	None	+60	-	No sign of Mg turnings igniting.
32	3" pipe	20 gms. in pan	Waste + P.C. Naphtha	+60	Bad	
33	5# pail	20 gms. in bottom pan	P.C. Naphtha in 4 waste balls	-42	Good	Distribution good.
34	5# pail	20 gms. in bottom pan	3# 2.4% rubber, latex in Winter gasoline	-71	Bad	Winter gasoline - 10.1# Reid vapor pressure.
35	5# pail	20 gms. in bottom pan	3# Winter gasoline in waste	-71	Bad	-71°F. too cold for 13# Reid vapor pressure gasoline.
36	5# pail	20 gms. in bottom pan	3# P.C. Naphtha - no thickener	+60	Good	Flash burn in mid air.

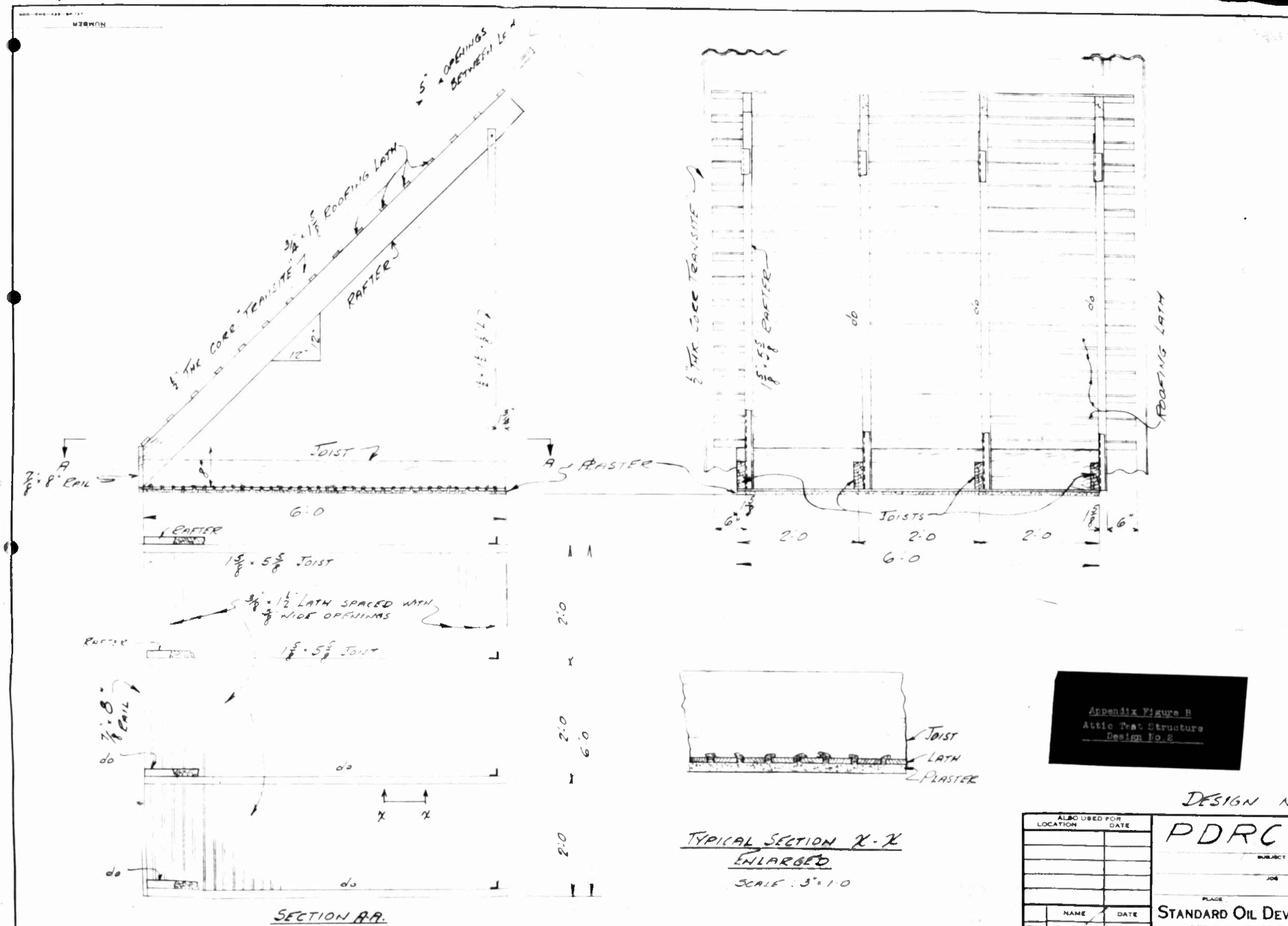
No.	Case	Powder	Fuel	Temp., °F.	Ignition	Remarks
37	5# pail	20 gms. in bottom pan	3# batch 66, 5.5% crepe in benzene	+60	Good	Splatter in many small pieces.
38	5# pail	20 gms. in bottom pan	3#, 4 cotton bags containing rubber gel	+60	Good	Good glob size control.
39	5# pail	20 gms. in bottom pan	3# batch 49, 2.4% rubber latex	-42	Good	Powder was sealed with copper disc and was much better protected from naphtha.
40	5# pail	20 gms. in bottom pan	3# batch 49	-42	Good	Electricians lacquer used to seal powder and great improvement noticed.
41	5# pail	20 gms. in bottom pan	3# P.C. Naphtha on 4 waste balls	+60	Good	Balls scattered 20 ft.
42	5# pail	20 gms. in bottom pan	3# batch 54, 2% water in 4 waste balls	+60	Poor	Packed too tight.
43	5# pail	20 gms. in bottom pan	3# batch 55, thin latex in 4 waste balls	+60	Good	
44	5# pail	20 gms. in bottom pan	3# 5.5 crepe in P.C. Naphtha	+60	Good	All small globs.
45	6" x 10" - 4 seams	30 gms. in bottom pan	5.5% crepe rubber in P.C. Naphtha	+60	Good	Did not scatter much, need
46	5# pail	15 gms. in bottom pan	Batch 735 - 5 balls of rubberless gels - M.P. 120°F.	+60	Good	Preliminary test of rubberless gels seems promising.
47	5# pail split seam	20 gms. in bottom pan	3# 5.5% crepe in P.C. Naphtha	+60	Good	Lid wired on, sides split but needs more powder to throw far.
48	3" pipe	20 gms. in bottom pan + 20 gms. coal	2-1/2# batch 48, 5.5% crepe	+60	Bad	Coal did not help ignition.
49	3" pipe	10 gms. in bottom pan	2-1/2# batch 48	+60	Bad	
50	3" pipe	5 gms. in bottom pan	2-1/2# batch 48	+60	Bad	
51	5# pail with side seams	40 gms. in bottom pan	3# batch 48	+60	Good	Splattered all over - extra side seams did not help control.
52	5# pail	20 gms. in bottom pan	3# 2% crepe in Winter gasoline - 3 wads of excelsior	+60	Good	Worked fairly well.
53	5# pail	20 gms. in bottom pan	2# batch 88 - solid gel	+60	Good	Shattered and flash burnt.

No.	Case	Powder	Fuel	Temp. °F.	Igni-tion	Remarks
54	5# pail	20 gms. in bottom pan	3# batch 88 - 4 excelsior balls	+60	Good	4 separate balls of fire formed.
55	5# pail	20 gms. in bottom pan	3# batch 88 - 3 waste balls	+60	Good	Waste holds this solid gel together.
56	5" x 24" M-46	73 gms. in center tube	10# batch 48	+60	Fair	
57	3" pipe	12 gms. in spaghetti tube	2-1/2# batch 48 - 5.5% crepe in Winter gasoline	+60	Good	First time ignition secured in 3" pipe bomb.
58	5" x 24" M-46	70 gms. in center tube	10# Winter gasoline in 1-1/4 waste	+60	Good	Too much gasoline wasted but made good fire.
59	3" pipe	17 gms. in spaghetti tube	2-1/2# hard gel	+60	Good	Flash burn.
60	3" pipe	15 gms. in center tube - bottom ignition	2-1/2# 5.5% crepe in gasoline	+60	Good	Blew out in 1 glob.
61	3" pipe	15 gms. in center tube	2-1/2# gasoline in waste	+60	Good	Blew out in 1 piece.
62	3" pipe	17 gms. in center tube of glass	2-1/2# hard soap	+60	Good	Glass tube shattered and ejection was poor.
63	3" pipe	17 gms. in fibre tube	2-1/2# batch 116 in excelsior	+60	Good	Flash burn.
64	3" pipe	17 gms. in central fibre tube	2-1/2# cup grease cut back with gasoline	+60	Good	Waste burns too long.
65	5# pail	20 gms. in bottom pan	3# hard soap in 0.4% Sisal	+60	Good	Flash burn.
66	5# pail	20 gms. in bottom pan	3# hard soap in 0.8% Sisal	+60	Good	Flash burn.
67	3" pipe	20 gms. in fibre tube	2-1/2# soap in 0.8% Sisal	+60	Good	Poor performance - too large a fibre tube used.
68	3" pipe	9 gms. in small fibre tube	2-1/2# 5.5% crepe in Winter gasoline	+60	Poor	Fibre tube did not burst along length.
69	3" pipe	15 gms. in fibre tube	2-1/2# 5.5% crepe in Winter gasoline	+60	Good	Horizontal - blown to wall at 15'. Performance excellent.
70	3" pipe	20 gms. powder in large tube	2-1/2# 5.5% crepe in Winter gasoline	+60	Poor	Same as 69.
71	3" pipe	17 gms. powder in medium tube	2-1/2# 5.5% crepe in Winter gasoline	+60	Good	Excellent performance against wall.

No.	Case	Powder	Fuel	Temp. °F.	Ignition	Remarks
72	3" pipe	17 gms. powder	2-1/2# batch 122	+60	Good	Flash burn with no filler.
73	3" pipe	17 gms. powder	2-1/2# Al naphthenate grease	+60	Good	Melted and gave flash burn.
74	3" pipe	17 gms. powder	2-1/2# formula 122 in paper cylinder	+60	Good	Flash burn.
75	3" pipe	17 gms. powder	2-1/2# formula 122, 3% Sisal	-10		Failed to eject charge.
76	3" pipe	17 gms. powder	2-1/2# formula 122, 1% Sisal	-10	Good	Performance good.
77	3" pipe	17 gms. powder	2-1/2# formula 122, 3-1/3% chopped Sisal	+60	Good	Excellent performance.
78	3" pipe	20 gms. powder	2-1/2# formula 122, 1% chopped Sisal	+60	Good	Fair performance.
79	3" pipe	20 gms. powder	2-1/2# formula 122, 2% chopped Sisal	+60	Good	Excellent performance at 15 ft.
80	3" pipe	20 gms.	2-1/2# formula 122, 2% short Sisal	-40	Good	Performance good.
81	3" tube with cork	20 gms.	2-1/2# formula 122, 2% short Sisal	+60		Split seam.
82	3" tube with cork	20 gms.	2-1/2# formula 122, 2% short Sisal	+60	Good	Soldered seam held.
83	3" tube	20 gms.	2-1/2# 5.3% crepe directed at ridge	+60	Good	Showed ridge was not the place to direct charge.
84	3" tube	20 gms.	2-1/2# formula 122	+60	Good	No explosive burn in end.
85	3" tube	20 gms.	2-1/2# formula 122	+60	Good	In roof structure aimed at roof.
86	3" tube	20 gms.	2-1/2# formula 122, 1% Sisal	+60	Good	Into eaves of roof - worked excellently.
87	3" tube	20 gms.	2-1/2# formula 122, 2% Sisal	+60	Good	Laid on side in open - case travelled farther than fuel.
88	3" tube	20 gms.	2-1/2# 5.5% crepe in winter gasoline	-60	Poor	Ignition was very poor - little splattering.
89	3" tube	20 gms.	2-1/2# 5.5% crepe in winter gasoline	+60	Good	Performance excellent.
90	3" tube	20 gms.	2-1/4# formula 122	-60	Fair	
91	3" tube	20 gms.	2-1/4# formula 122	+60	Good	Performance excellent.
92	3" tube	20 gms.	2-1/4# formula 122, 1% Sisal	-60	Fair	
93	3" tube	20 gms.	2-1/4# formula 122, 1% Sisal	+60	Fair	Performance excellent.



Appendix Figure A
Attic Test Structure
Design No. 1



Appendix Figure 8
Attic Test Structure
Design No.2

DESIGN No. 2

PDRC 199

STANDARD OIL DEVELOPMENT CO.
GENERAL ENGINEERING DEPT.
ELIZABETH, N. J.

SCALE 1" & 3" = 1'0 DATE Dec. 5th 1941

DRAWING	SHEET	DRAWER
20907	OF	10

REVISIONS

6

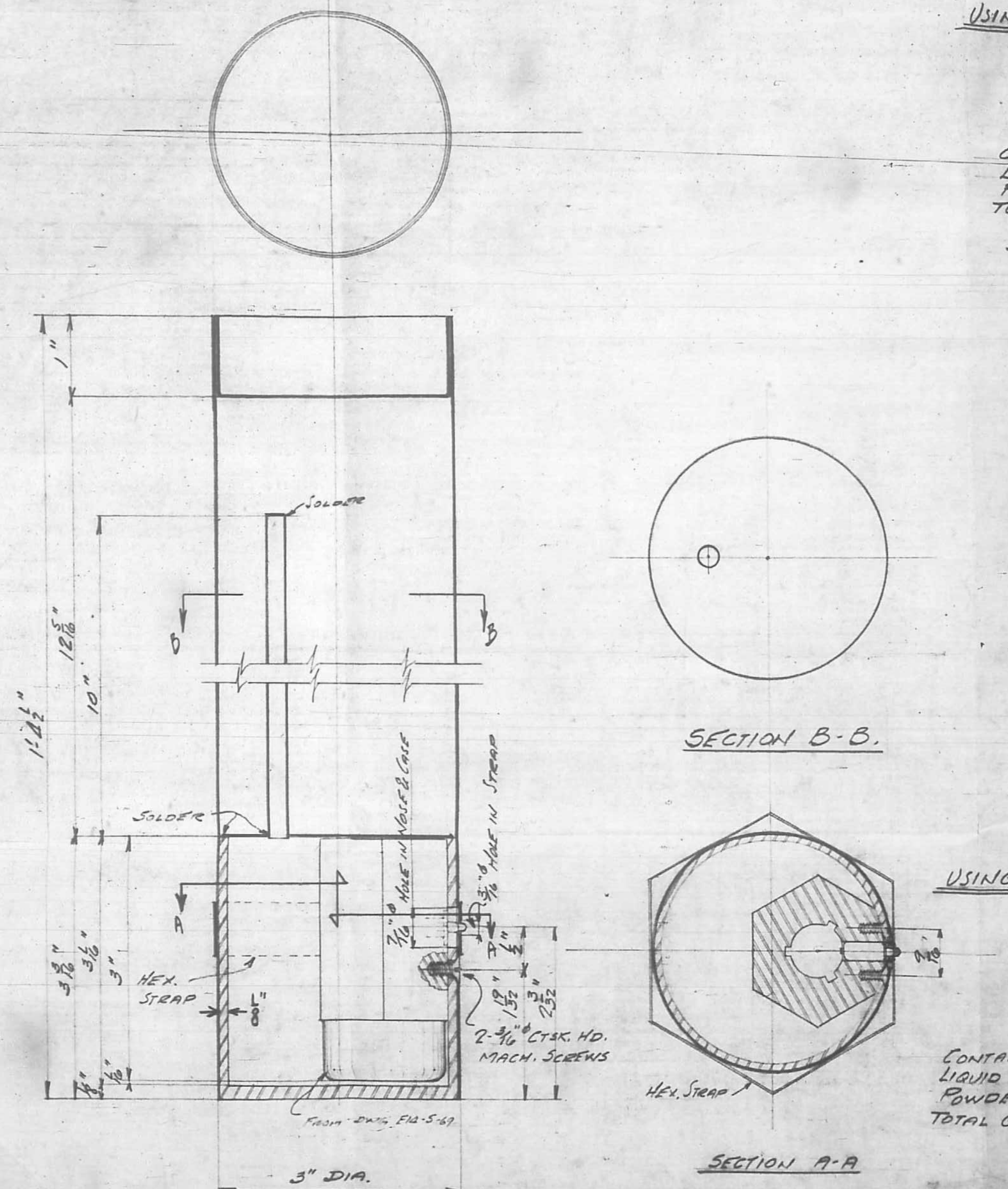
NUMBER

USING - .015" (22/28 GA.) MATERIAL FOR BODY

TOTAL WT. CONTAINER	- 2.019#
" " FUSE	- .500#
TOTAL WT.	2.519#

CONTAINER + FUSE	2.519#
LIQUID CHARGE	2.000#
POWDER "	.120#
TOTAL GROSS	4.639#

SECTIONAL DENSITY = .655



SECTIONAL DENSITY = .776

Appendix Figure C
PETROLEUM INCENDIARY BOMB
20 Gage Body and Standard Fuze

USING - .035" (20 GA.) MATERIAL FOR BODY

TOTAL WT. CONTAINER	2.879#
" " FUSE	.500#
TOTAL WEIGHT	= 3.379#

CONTAINER + FUSE	= 3.379
LIQUID CHARGE	= 2.000#
POWDER CHARGE	= .120#
TOTAL GROSS	5.499#

APPROX.

REVISIONS

DATE 1/13/42	I	Added thickness of Nose Cup. Added Dim. CHANGED 7/16 to 3/8 For Safety " 1 17/32 to 1 19/32 Plunger " 2 3/32 to 2 5/32 Holes. Revised Weights	
BY L.M.C.			
CKD.			
S. C.			
DATE	II		
BY			
CKD.			
S. C.			
DATE	III		
BY			
CKD.			
S. C.			
DATE	IV		
BY			
CKD.			
S. C.			

	NAME	DATE
DSN.		
DRN.		
TR.		
CKD.		
APD.		
S. C.		

SUBJECT

JOB

PLACE COUNTRY OR STATE

STANDARD OIL DEVELOPMENT CO.
GENERAL ENGINEERING DEPT.
ELIZABETH, N. J.

SCALE		DATE 1/13/42
DRAWING 20907	SHEET OF	DRAWER 1

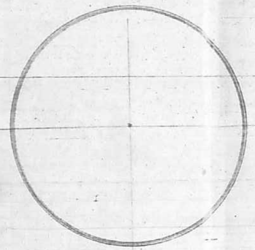
FIG. 10

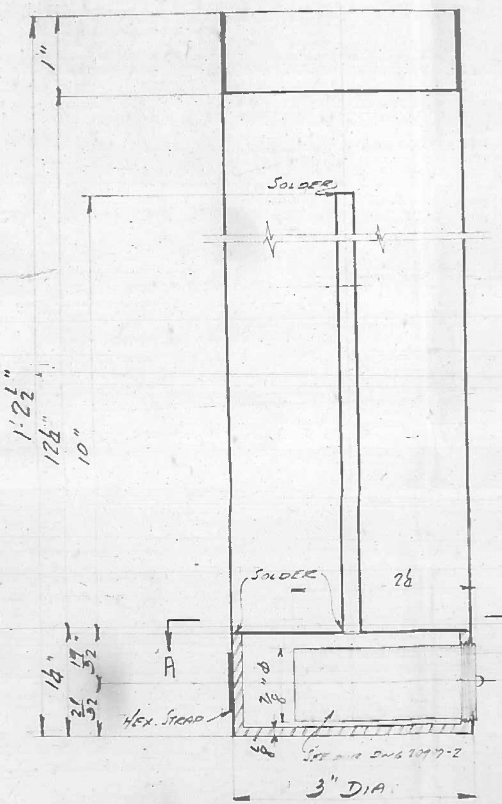
USING - .015" - ($\frac{27}{28}$ GA.) MATERIAL FOR BODY.

TOTAL WT. CONTAINER = 1.43 #
FUSE = .25 #
TOTAL WT. 1.68 #

CONTAINER + FUSE = 1.68 #
LIQUID CHARGE = 2.20 #
POWDER " = .12 #
TOTAL GROSS = 4.00 #

SECTIONAL DENSITY = .566

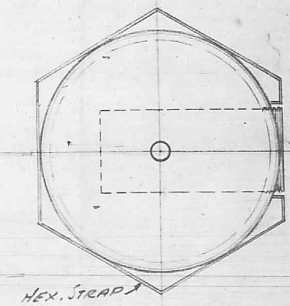




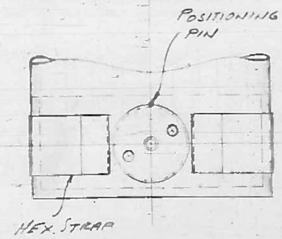
Appendix Figure D

PETROLEUM INCENDIARY BOMB

20 Gage Body
20 Gage Body and New Fuze



SECTION A-A



USING - .035" (20 GA.) MATERIAL FOR BODY

TOTAL WT. CONTAINER 2.105 #
" " FUSE = .250 #
TOTAL WEIGHT 2.355 #

CONTAINER + FUSE = 2.355 #
LIQUID CHARGE = 2.000 #
POWDER = .120 #
TOTAL GROSS = 4.475 #

APPROX.

SECTIONAL DENSITY = .633

REVISIONS I II III IV

DATE BY CKD. S.C.

NAME DATE DSN. DRN. TR. CKD. APD. S.C.

SUBJECT

JOB

PLACE COUNTRY OR STATE

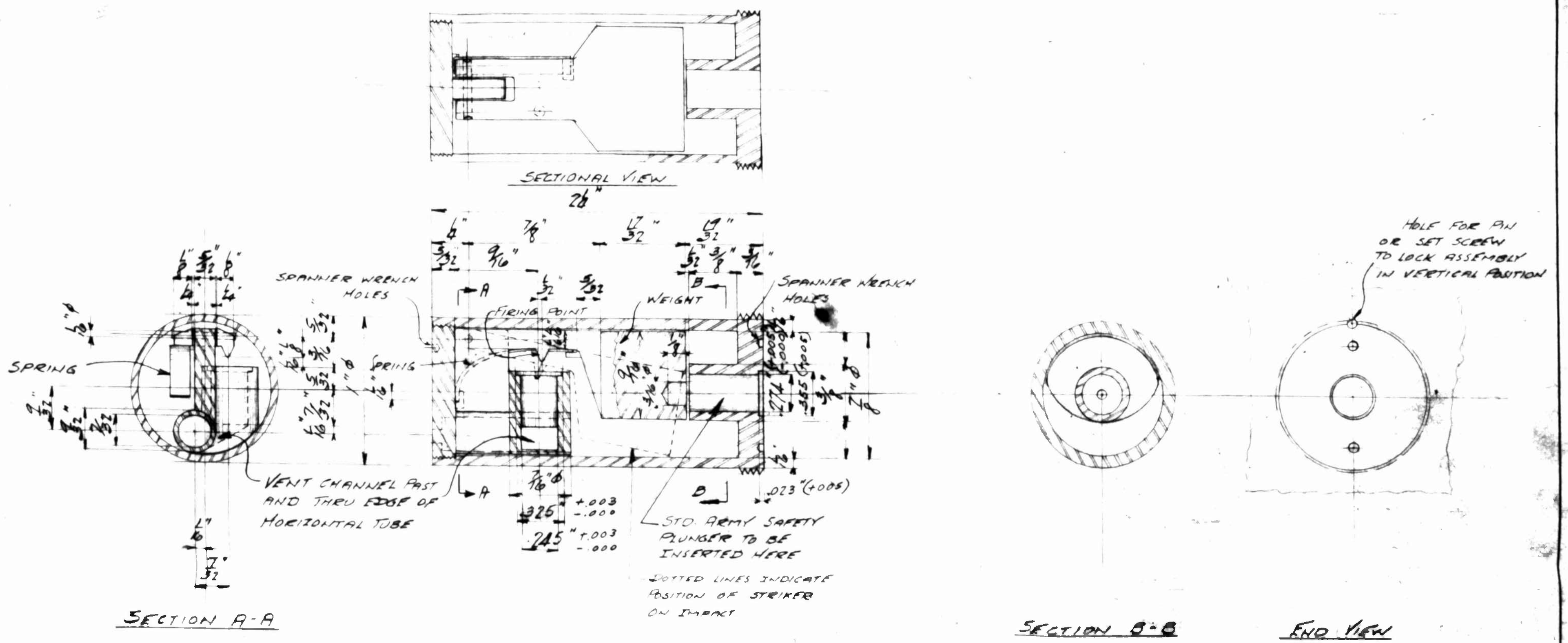
STANDARD OIL DEVELOPMENT CO.
GENERAL ENGINEERING DEPT.
ELIZABETH, N. J.

SCALE DATE

DRAWING 20907 SHEET OF DRAWER 7

FIG 11

NUMBER



APPROX TOTAL WT. 3 OZ.

SCALE 2=1

Appendix Figure E

DETAILS OF NEW FUZE

NAME	DATE
DRN	
DRN	
TR.	
CKD.	
APD.	
S. C.	

STANDARD OIL DEVELOPMENT CO.
GENERAL ENGINEERING DEPT.
ELIZABETH, N. J.

SUBJECT
JOB
PLACE — COUNTRY OR STATE
SCALE — DATE 1/7/42
DRAWING 20907 — SHEET OF — DRAWER 2

REVISIONS

I	II	III	IV
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31608

TITLE: The Development of Oil Incendiary Bombs

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REVISION

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AUTHOR(S): Russell, R. P.
ORIGINATING AGENCY: Standard Oil Development Co.

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Feb '42	Confd'l	U.S.	Eng.	59	drwgs, tables, graphs

ABSTRACT:

A quarterly report is given on the development of oil incendiary bombs. Burning tests have been carried out in several attic structures in which the destructiveness and completeness of any fire are taken as criteria, and special attention has been paid to developing mixtures and methods of application which would cause destructive attic fires. It has been found that attic structures can be destructively burned with the minimum amount of fuel if the incendiary is placed near or discharged into the eaves line where roof lath and rafters serve as kindling. Results show that with a given weight of fuel located at a given distance from the eaves, thickened gasoline is equal to magnesium and is distinctly superior to thermate. Gasoline-rubber gums and gasoline soaps are equally effective in non-explosive bombs.

DISTRIBUTION: Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

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