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TRAINING COURSE

FOR

INSPECTORS AND SUPERVISORS

PICATINNY ARSENAL, 1941

MANUAL OF FUZES—GENERAL LOADING

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TRAINING COURSE

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INSPECTORS AND SUPERVISORS

PICATINNY ARSENAL - 1941

MANUAL OF FUZES - GENERAL LOADING

PREPARATION OF TEXT

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INDEX

FUZE LOADING MANUAL

Section	Part	Subject	Page
		Table of Illustrations	
		Introduction	4
		Inspection	5
I		NOMENCLATURE	6
II		HIGH EXPLOSIVES	
	1.-	Chemical and Physical Properties of High Explosives	28
	2.-	Physical Testing of High Explosives-Laboratory Methods	32
	3.-	Physical Testing of High Explosives-Proving Ground Methods	56
III		FUZES	
	1.-	Design and Functioning	66
	2.-	Base Detonating Fuzes, M38A1 and M58	72
	3.-	Point Detonating Fuzes, M48, M51 & M57	74
	4.-	Point Detonating Mortar Fuzes, M52 & M53	90
	5.-	Point Detonating Fuze, M56	97
	6.-	Time Fuzes	106
	7.-	Primers, Detonators, Delays, Relays, Lead Cups	134
	8.-	Boosters	147
	9.-	Bomb Fuzes	164
IV		INSPECTION	
	1.-	Organization, Functions, Responsibilities	188
	2.-	Specifications	206
	3.-	Tests	213
	4.-	Notes	221
V		MISCELLANEOUS	
	1.-	Safety	224
	2.-	Packing	228
	3.-	Storing	247
	4.-	Shipping	253

TABLE OF ILLUSTRATIONS

FUZE LOADING MANUAL

SECTION	PART	FIG.	ILLUSTRATION	TO FOLLOW PAGE NO.
II	2	1 -	Ignition Temperature Curves of Standard Military High Explosives	34
		2 -	Ignition Temperature Apparatus	34
		3 -	Drop Test Accessories	35
		4 -	Drop Test Machine	35
		5 -	Bureau of Mines Drop Test Machine	36
		6 -	Large Sand Test Bomb	39
		7 -	Impulse Tester, General Arrangement	43
		8 -	Impulse Tester Firing Mechanism and Chamber	44
		9 -	Impulse Tester Accessories	44
		10 -	Impulse Tester, Various Set-ups	45
		11 -	Electric Firing Mechanism	48
		12 -	Revolving Drum Camera	49
		13 -	Disc Chronograph	49
II	3	1 -	Explosive Train Fixture	56
		2 -	Recorder, Schematic Set-up	56
		3 -	Explosive Train Assembly for Long Tetryl Leads	56
		4 -	Recorder Diagramatic Set-up	56
		5 -	Assembly Test Piece	57
		6 -	Primer Detonator Assembly	57
		7 -	Detonator Size Table	57
		8 -	Firing Record Table	57
		9 -	Firing Record Graph	57
		10-13 -	Effects of Detonator Explosions	58
		14-16 -	Types of Booster Casings	61
		17-18 -	Eccentric Tetryl Leads for Boosters	61
III	2	1 -	Base Detonating Fuze M-38	73
III	3	1 -	M-48 Fuze	76
		2 -	M-48 Fuze Head Assembly	76
		3 -	M-48 Fuze Body Assembly	76
		4 -	M-48 Fuze Delay Plunger Assembly	76
		5 -	M-51 Fuze Delay Plunger Assembly	77
III	4	1 -	M-52 Fuze, General Assembly	93
		2 -	M-52 Fuze Slider and Detonator Assembly	93
		3 -	M-52 Fuze Slider Detonator Staking Machine	93
		4 -	M-52 Fuze Slider Broaching Machine	93
		5 -	M-52 Fuze Lead Cup Assembly Operation	93
		6 -	M-52 Fuze Slider Spring Rack	93
		7 -	M-52 Fuze Assembly Tightening Machine	93
		8 -	M-52 Fuze Head Assembly Machine	93
		9 -	M-52 Fuze Head Assembly	93
		10 -	M-52 Fuze Packing	93

TABLE OF ILLUSTRATIONS -(Continued)

Fuze Loading Manual

SECTION	PART	FIG.	ILLUSTRATION	TO FOLLOW PAGE
III	5	1 -	M-56 Fuze Assembly	99
III	6	1 -	Static Burning Rate Chart	107
		2 -	Rate of Burning Curves	108
		3 -	Time of Burning Curves	110
		4 -	Curves Showing Effect of Different Riflings on Burning Time	110
		5 -	Curves Showing Effect of Angle of Elevation on Burning Time	110
		6 -	M-54 Fuze, Illustration Drawing	123
III	9	1 -	Nose Bomb Fuze M-103	168
		2 -	Demolition Bomb Assembly	169
		3 -	Tail Bomb Fuze M-106	170
		4 -	Nose Fuzes M110 and M111	184
IV	1	1 -	Plain Plug Gage, Work	192
		2 -	Plain Plug Gage, Inspection	192
		3 -	Combination Ring and Snap Gage, Work	192
		4 -	Combination Ring and Snap Gage, Inspection	192

INTRODUCTION

This Manual is made up of much new material as well as extracts considerably edited, revised and rewritten, taken from a number of sources. The material included is as accurate and as up-to-date as it is possible to make. For a few of the mistakes that have come to light, reference is made to the list of errata on page 257.

The object of this Manual is to furnish a convenient source of information for the Ordnance Inspector concerned with the manufacture of the metal components of, or the assembly and loading of artillery and bomb fuzes now being made on a production basis in this country.

It is necessary that the Inspector become thoroughly familiar with the action and functions of the various fuze components and assemblies. Proper functioning and accuracy depend largely on the care exercised in the manufacture and assembly of the fuzes. If all the allowable tolerances are held, the completed fuzes should meet all the tests and be acceptable.

It is to be understood that under no circumstances should this Manual be used as an official or final source of information. In cases of doubt, the final authority will be the contract under consideration, the pertinent drawings or specifications, or the General Inspection Manual, all of these being immediately available to the Ordnance Inspector on the job.

INSPECTION

Where the variations of machines and the uncertainty of the human element enters into the manufacture of fuzes on a production basis, it becomes necessary that a careful inspection be given to insure proper assembly and functioning of the completed fuze.

Because there are certain points that cannot be determined by the use of gages, the following list of suggestions are offered to help the Inspector to make a complete check of the component parts and completed fuze.

The Inspector should check the weights used in pressing powder, the scoops used in measuring powder and the dimensional requirements for height and diameter frequently to prevent the production of materials that do not conform with the drawings and specifications.

SECTION I

Nomenclature

Fuze and General Loading

ABC's of Inspection:

A. Alignment
B. Burrs
C. Concentricity
D. Distance of firing pin to detonator
E. Eccentricity
F. Finish

Adjustable Length Gage:

Used for acceptance or rejection of parts for length.

Adjustable Snap Gage

An adjustable gage in which the measuring surfaces or anvils may be set, within small limits to the proper dimensions. Mainly, outside diameters, length, thickness, etc.

A. I. E. E.

American Institute of Electrical Engineers.

Allowance

An intentional difference in the dimensions of mating parts, the clearance space which is intended for mating parts.

Amatol

Mixture of Ammonium Nitrate and T.N.T. used as a bursting charge for high explosive shell. Hygroscopic, insensitive to friction but can be detonated by severe impact.

American Gage Design Standard

Designates gages made to the design specification of a committee consisting of representatives of the leading gage manufacturers, commercial users, and the government departments.

Ammonium Picrate (explosive D)

Importance is due entirely to its marked insensitiveness to shock and friction which makes it well suited for a bursting charge in armor-piercing projectiles. Inferior to T.N.T. in explosive strength.

Angle of Thread

The angle included between the sides of the thread measured in an axial plane.

Annealing

Is a uniform heating above the usual hardening temperatures followed by cooling as desired. A process to make metal tougher and stronger.

A.P.G.

Aberdeen Proving Ground

Arm

The movement of fuze parts to predetermined positions such that the fuze will be able to function.

A.P. (armor piercing)

A projectile so designed to penetrate a given armored object.

Army Black Powder

Various grades of black powder specified by U.S. army specifications.

A. S. M.

American Society for Metals.

A.S.M.E.

American Society of Mechanical Engineers.

A.S.T.M.

American Society of Testing Materials.

Austempering

Uniformly heating the material to a temperature above the upper critical range followed by quenching into a liquid bath held at a predetermined temperature (not room temperature), below the critical range.

Axis of a Screw

The longitudinal central line through a screw.

Ball-Bearing

A bearing that turns on small steel balls.

Base of Thread

The bottom section of a thread, the greatest section between the two adjacent roots.

B.D.F.

Base detonating fuze.

Basic Size

The exact theoretical size from which all limiting variations are made.

Bevel Gear

Are gears having teeth cut so that they radiate from the apex of a cone and lie on the conical surface.

Bilaterial System

The basic size appears with a plus and minus tolerance.

Black Powder

Used as ignition charge, base charge or expelling charge for shrapnel shell, manufacture of primers and fuzes, saluting and blank fire charges, time train charges and combination fuzes.

Blending

The mixing of two or more powders into one mass.

Bore

The hole within the barrel of a gun through which the shell travels.

Bore Safe

A fuze so designed, that it will not explode in the barrel of the gun.

Brinell, Standard Method (hardness test)

By imposing a load upon a surface through the medium of a 10 m.m. diameter steel ball and measuring the diameter of the impression.

Brinell, Vickers (hardness test)

By imposing a load upon a surface through the medium of a diamond ground to the contour of a pyramid and measuring the distance across the diagonal.

Brisance

Shattering power.

Burrs

A rough edge of metal left at the intersection of two machined surfaces; metal left by the part breaking off from the bar before a complete cut-off is made.

Caliber

The bore size of a gun. Determined by multiplying the diameter of the shell by the length of the rifling in one turn.

Carburizing

A treatment by which carbon is added to iron base alloys by heating the metal below its melting point, but above the upper critical point (usually) 1650-1700 degrees F.) in contact with carbonaceous solids, liquids or gases.

Cartridge

Shell or case containing the charge for a gun.

Cash Discount

Discount in total cost due for payment in specified time.

Cavitation

Pockets formed in pouring bursting charge in projectile or bomb.

Centrifugal

Tending to move away from the center. Reaction due to rotation, as rotation of the projectile.

Centrifugal process

In this system the nitrating and the separation of the spent acid from the nitrated cotton are both carried on in a large nitrating centrifugal.

Chamfer

A bevel on the corner of a flange or on an edge of a diameter.

Charpy Tensile Impact

Energy absorbed in breaking a tensile test specimen by means of a suddenly applied load.

Charpy Transverse Impact Test

Is measured by the energy absorbed in suddenly breaking a standard impact bar fixed at each end, the load being applied at the center.

Check Gage

Used in the acceptance checking of certain gages and whether a gage has worn outside the permissible tolerance.

C. of O.

Chief of Ordnance.

C. O.

Commanding Officer.

Chisel

A metal tool or instrument with a cutting edge at the end of the blade, used in dressing, shaping, or cutting.

Chipping

Is the process of removing stock with a hammer and chisel.

Close Fit, (Class 4)

Includes screw-thread work requiring snug fit, somewhat closer than a medium fit. In this class of fit selective assembly of parts may be necessary.

Concentric

Having a common center.

Confidential

Ordnance subjects and items of ordnance material of such nature, which if disclosed, although not endangering the National security, might be prejudicial to the interest or prestige of the National government activity or be of advantage to a foreign nation.

Countersink

A conical depression. An enlargement of a hole, on a taper, to a larger diameter.

Creep Force

Retardation of projectile in flight.

Crest

The tap surface joining the two sides of a thread.

Crimping

The rolling over of a thin wall of metal to retain a mating part The wedging over of a ring of metal around a hole onto a mating part. Usually the crimping is 360 degrees, occasionally less because of interference.

Critical point

The critical point or critical temperatures are the temperatures at which some definite change takes place in the physical properties of the steel.

Critical Temperature

The temperature above which a piece of steel must be heated to effect a transformation in grain structure.

Dehydration

To remove water as from the nitrocellulose after shipment.

Delay

Fuze to burst shell after impact, for penetration of target or against personnel or recochet action. Actual time length of delay depends on length of Black Powder column.

Depth of Engagement

The depth of thread contact of two mating parts, measured radially.

Depth of Thread

The distance between the crest and the base of the thread measured normal to the axis.

Detonator

An instantaneous explosive.

Die

Is usually a flat piece of steel, internally threaded, with grooves or flutes intersecting the threads to form cutting edges. This type cuts the external threads on the screw.

Drilling

Term used when boring hole in any object.

Ductile

Capable of being drawn out into wire or threads.

Dud

Ammunition component that has had the opportunity to function and did not. However, may at any time.

E's of Safety (3)

1. Engineering
2. Education
3. Enforcement

Eccentric

Not having a common center.

Escutcheon

Stamp or stencil of the ordnance department (crossed cannons and flaming bomb) will be used by inspectors to identify and indicate final acceptance.

Explosion

When gas or vapor is released so suddenly as to cause a loud noise or concussion.

Explosive

May be defined in general as being a gaseous, liquid or solid substance, or mixture of substances, which upon application of a blow to a small portion of its mass, or by a rise in temperature is converted in a small space of time into other substances more stable which are mainly gases or vapors but may include solids. Thus,producing a sudden rise in pressure in the surrounding medium.

External Thread

Is a thread on the outside of a member (threaded plug).

Exudation

Dark colored oily liquid exuded from TNT or 50/50 Amatol loaded shell, caused by impurities of TNT, when stored in a tropical climate.

Fatigue Limit

The maximum stress that a rotating beam specimen will withstand for an infinite number of reversals.

Ferrous Metals

Include Carbon, Manganese, Sulphur, Phosphorus, and silicon elements.

F.F. Finish

A fine grade machine finish obtained with the usual cutting tools. Does not include lapping, honing, grinding, etc., processes.

Finish

The character of the surface of a component part.

Flaming Bomb

Official Ordnance Department insignia to signify provisional acceptance.

F.N.H.

Flashless, non-hydroscopic.

F.O.B. Destination

Final acceptance by the ordnance inspector at destination of shipment.

F.O.B. Origin

Final acceptance by the ordnance inspector at the origin of shipment.

Free Fit(Class 2)

Includes the great bulk of screw thread work of ordinary quality of finished and semi-finished bolts and nuts machine screws, etc.

Fuse

Rope-like in appearance usually loaded with black powder and functions as a delay.

Fuze

Is a mechanical fuze used as the initial build-up of a shell.

Gage

A device for determining whether or not one or more of the dimensions of a manufactured part are within specified limits.

Gagemaker's Tolerance

A tolerance which is allowed the gagemaker as he cannot produce perfect tools.

Gear

Is a toothed wheel used to transmit positive and uniform rotary motion from one shaft to another.

Go-Gage

Controls the extent of the tolerance in the direction of the limit of maximum metal, and represent the maximum limit of the internal member and minimum limit of the external member.

Grinding

Is the term given to the process of shaping or finishing metallic or other hard surfaces by abrasion.

Gun Cotton

Highly explosive substance produced by soaking cotton, or other vegetable fibre in nitric and sulphuric acids, and then leaving to dry. Used as the base for high explosives.

Hardening

Consists of uniformly heating the material to a temperature above the upper critical point for a sufficient time to insure uniform heating throughout followed by immersion in a suitable bath (liquid or gases) to produce a condition suitable for subsequent tempering.

Hardness Testing

Hardness testing figures are relative only. There are several methods for taking the reading, all of which depend upon making an impression upon the surface of the piece being tested.

Heat Treatment

Is a method by which the heat treater is able to change the physical properties of a metal.

Helical Gears

Are gears having teeth cut on a cylinder and at an angle with the axis of rotation of the gear body.

Helix Angle

The angle made by the helix of the thread at the pitch diameter with a plane perpendicular to the axis.

Herringbone Gears

Are gears having helical teeth which diverge from the center of the face toward the sides of the gear body.

High Explosives

Those substances whose rate of decomposition is so very high as to prelude their use as propellants but which on the other hand bring about very powerful disruptive action are known as detonating explosives or disruptives.

Homogeneous

Alike - being of the same nature.

Hopper

A temporary container for powder storage while in the machine.

Impact Force

Projectile striking force.

Indicating Gage

One that exhibits visually the variation in the uniformity of dimensions or contour, the amount of the variation being indicated by lever or graduated scale, flush-pin, plunger gages, etc.

Insignia

Ordnance department flaming bomb will be used when practicable to identify and indicate provisional acceptance.

Inspection Gage

Are all gages used by the inspector in the acceptance of the finished product. They are to insure that the product has been manufactured within the component limits specified on the drawing and that the part or unit assembly is acceptable to the Ordnance Department. Supply of these gages are a responsibility of the Ordnance Department. Inspection gage is the final gage.

Interchangeability

The process of machining components parts within certain size limits, which enable changing of parts without further machining.

Internal Thread

Is a thread on the inside of a member (threaded hole).

Izod Transverse Test

Izod transverse test is measured by the energy absorbed in suddenly breaking a standard impact bar fixed at one end, the load being applied at the other.

Jo-Blocks

Measure accurately in millionths of an inch.

Lapping

Is a refined abroding process generally employed for correcting errors in hardened and ground steel parts and securing a smooth finish, or for reducing the size a very small amount.

Lathe

Removes material from revolving work by using suitably formed cutting tools of hardened and tempered steel or of alloy metals such as carboloy, stellite, etc.

Lead

The distance a screw thread advances axially in one turn.

Lead Azide PbN_6

Is an initiating compound used for bringing about detonation of high explosive. Sensitive to flame but is too insensitive to be used alone where initiation is by impact or a firing pin. Insoluble in water is hygroscopic at 30 degrees.

Leave Time

Time built up at rate of 2 1/6 days per month which employees are entitled to for vacation.

Length of Engagement

The length of contact between two mating parts, measured axially.

Limits

The extreme permissible dimension of a part.

Linear Acceleration

Means setback.

Liquidated Damages

Penalty for delay in delivery by the manufacture to the government.

Loose Fit (Class 1)

Includes screw thread work of rough commercial quality, where the thread must assemble readily, and a certain amount of shake or play is not objectionable.

Machinability

Based upon the relative ease by which metal may be removed from a mass as compared with the removal from a standard material when carried out under identical conditions.

Major Diameter

Largest diameter of the thread of a screw or nut. Formerly known as the outside diameter and full diameter.

Malleable

That which may be beaten out or shaped by hammering.

Manufacturing Gage

Are all gages used by the contractor in the production of Ordnance material. Supply of these gages is a responsibility of the particular contractor for each item of Ordnance material.

M. C. F.

Maximum centrifugal force.

Medium fit (Class 3)

Includes the better grade of interchangeable screw-thread work.

Mercury Fulminate

Is one of the explosives used for bringing about detonation of high explosives. Great violence upon ignition by means of a flame such as a spit from a fuse.

Milling

The removal of metal from the work with a revolving milling cutter as the work is fed against it.

Milling Machine
: Is a machine that removes metal from the work with a revolving milling cutter as the work is fed against it.

Mine
: An encasing loaded with high explosives and buried in the ground with fuze assembled -- used in Anti-Tank warfare.

Minor Diameter
: Smallest diameter of the thread of a screw or nut. Also known as core diameter and inside diameter.

Miter Gears
: Are mating bevel gears having the same number of teeth and whose pitch core angle are 45 degrees.

Nitriding
: A treatment by which nitrogen is added to iron base alloys by heating the metal in contact with ammonia gas or other suitable nitrogenous material.

Nitrocellulose
: Used in the manufacture of F.N.H. powder is a blend of guncotton and pyrocotton.

Normalizing
: Consists in uniformly heating the material to a temperature sufficiently above the upper critical point for a length of time sufficient to produce a uniform structure after which shall be allowed to cool freely in still air to room temperature.

Nominal Size
: A designation given to the subdivision of the unit of length having no specified limits of accuracy but indicating a close approximation to a standard size.

Not Go
: Controls the extent of the tolerance in the direction of the limit of minimum metal, and represents the minimum limit of the internal member and the maximum limit of the external member.

Number of Threads
: Number of threads in one inch of length.

Obturation
: Escape of gas from burning black powder.

Ogive
French meaning rounded arch. Serves as a windshield on the M-48, M-51, M-57 P. D. Fuzes.

Half Blocks
Used as a safety feature on the M-56 to hold the firing pin away from the detonator.

P. A.
Picatinny Arsenal or Procurement Authority.

Parachute
A cloth arrangement used to support an object in the air— so as not to have the object descend too rapidly.

Percentage Elongation
The percentage elongation is the difference in the gage length before being subjected to any stress and after rupture expressed as a percentage of the original gage length.

Percentage Reduction of Area
The difference between the original cross-section and the least cross-sectional area after rupture, expressed as a percentage of the original cross-sectional area.

Per Diem
Latin Term meaning per day. Used in expense vouchers.

Photo Flash Bomb
A bomb suspended from a parachute, and is so designed to illuminate an area for bombing and photography.

Picric Acid
Trinitrophenal is a lemon-yellow, crystalline solid, only slightly soluble in cold water but soluble in alcohol, benzene and other organic solvents, absorbs no moisture-free air. Used originally in the dye industry. Now a high explosive.

Pivot
A pin on which anything turns, as the rotor of the M-20 Booster on the Rotor Pivot Pin.

Plain Snap Gage
A fixed gage arranged with inside measuring surfaces for verifying diameters, length, thickness, etc.

Poaching
A boiling treatment during the purification of nitrocellulose.

Pitch

The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis. Pitch in inches equals one over the number of threads per inch.

Pitch Diameter

The diameter of an imaginary cylinder the surface of which would pass through the threads at such points as to make equal the width of the thread and the width of the spaces cut by the surface of the cylinder.

Plain Cylindrical Plug Gages

Normally used when inspecting cylindrical holes in parts.

Plain Ring Gage

Normally used in acceptance or rejection of shafts or circular surfaces. They may be cylindrical or conical.

Planer

Is for producing flat surfaces on work that is too large or otherwise impracticable or impossible to machine on the milling machine or shaper.

Plug Gage

One whole outside measuring surface is arranged to verify the specified uniformity of holes. A plug gage may be straight or tapered and of any cross sectional shape.

P.D.F.

Point detonating fuze.

Primer

Non-disruptive flame to ignite the delay.

Proof Stress

The load per square inch of the original cross-section area which, when removed, will cause a permanent elongation of 0.0001 inch per inch of gage length.

Propellants

Those substances or mixtures whose rate of combustion is such as to permit their use for propelling projectiles from guns.

Propelling Charge

Pressure of propellent charges of gases.

Proportional Limit.

The greatest load per square inch of original cross-section area for which the elongation is proportional to the load.

P.S.I.

50,000 Psi means 50,000 pounds per square inch.

Pulping (beating)

A treatment to prescribe fineness in purification of nitrocellulose.

Pulping

A reduction of the pyrocotton fibers to a finer state of division in order to remove the last traces of acidity occluded by the fibers.

Pyrocotton

Used as the base in the manufacture of smokeless powder.

Pyroxylin

Used commercially as the base in the manufacture of lacquers.

Quenching

Is the operation of cooling rapidly in a suitable medium such as water, brine, oil or air.

Reamer

Is a tool for enlarging a hole round, straight, smooth and up to size.

Receiving Gage

Is one whose inside measuring surfaces are arranged to verify the specified uniformity of size and contour of manufactured material.

Rejection

Is the written notification given to the contractor by the inspector that material, parts, (finished or semi-finished), sub-assemblies or assemblies which have been inspected, do not comply in one or more respects with the requirements of the contracts, the specifications or the drawings.

Restricted

Ordnance subjects and items of Ordnance material not embraced in the above categories, but of sufficient importance to the National defense to warrant being withheld from the general public and of such nature that the related information is for official use only.

Ring Gage

One whose inside measuring surfaces are circular in form. The measuring surface may be cylindrical or conical.

Riser

Excess material used in pouring charge usually made by pouring funnel 2/3 full.

Rivet

Bolt or metal fastened by being hammered at both ends.

Rockwell (Hardness Test)

By imposing a load upon a surface through the medium of a ball or diamond cone and measuring the depth of the impression.

Rolled Threads

The part to be threaded is rolled between grooved dies in a special machine.

Root

The bottom surface joining the sides of two adjacent threads.

S.A.E.

Society of Automotive Engineering.

Screening (Nitrocellulose)

A water process after each boiling or washing operation in the purification of nitrocellulose.

Screw Thread

A ridge of uniform section in the form of a helix on the surface of a cylinder or cone.

Screw Thread Fits

Established by National Screw Thread Commission:

1. Loose Fit
2. Free Fit
3. Medium Fit
4. Close Fit
5. Wrench Fit.

Scleroscope (Hardness Test)

By dropping a known weight upon a surface to be tested from a given height and measuring the height of the rebound.

Set-Back Force

Force due to acceleration of the projectile.

Secret

Ordnance subjects and items of Ordnance material of such nature that their disclosure might endanger the National security or about which it is desired that no information whatsoever come into the possession of persons other than those directly concerned.

Shadowgraph

A precise method of measuring or weighing.

Shaper

A machine that has a ram that works with a reciprocating motion.

Side

The surface of the threads which connect the crest with the root.

Sine Bar

Used for measuring angles accurately or for locating work to a given angle within very close limits.

Snap Gage

Is a fixed gage arranged with inside measuring surfaces for calipering diameters, length, thickness, etc.

Soldering

The process of joining two metals by a third soft metal that is applied in the molten state.

Sour Boil

A treatment served to hydrolyze any "cellulose sulphate" (combined sulphuric acid) present, free sulphuric and soluble cellulose degradation products being formed.

Specifications

The inspectors guide as to the general and detailed requirements and characteristics that must be met by the material.

Spheroidizing

Consists of a prolonged heating of the material, in the neighborhood of, but generally slightly below the upper critical point, usually followed by relatively slow cooling.

Spiral Gears

Are gears with teeth cut on a conical surface so that they rotate continually toward or away from the apex of the cone upon which they are cut.

Spur Gears

Are gears having straight teeth cut parallel with the axis of rotation of the gear body.

Staking

The wedging over of several tabs of metal onto a mating part. Chisel pointed tools used on flat surfaces to bring up the required metal. Rounded tools can be used to depress a lug into a staking groove on the mating part.

Standard

A physical representation of a form, dimension or size established by law or by general usage and consent.

Standardization

A standard size or series of sizes so constructed that one may buy articles as incandescent light bulbs and the bases will be of the same size no matter what brand.

Standard Sizes

A series of recognized or accepted sizes corresponding to various sub-divisions of a recognized unit of length such as the yard or the meter. These are usually expressed in M/M sometimes by arbitrary numbers or letters.

Steel

Is an alloy of Fe and C. Among other elements found in steel are silicon, phosphorus, sulphur, manganese and chromium.

Strain draw

Is a low oil draw used on hardened steel immediately after it is quenched to relieve strain and reduce brittleness caused by the shock of sudden quenching.

Super Quick

Fuze to burst shell promptly on impact before penetration.

Super Sensitive

Fuze to burst shell promptly on impact against a light target.

Tachometer

A meter to check the R.P.M.

Taper

The gradual lessening or increasing of the diameter or thickness of a piece of work toward one end.

Tempering

Consists in reheating the quenched material to some temperature below the upper critical point and holding at heat for a sufficient time to insure uniform heating throughout.

Tensile Strength.

The greatest load per square inch of original cross-sectional area carried during a tension test.

Tetryl

Trinitrophenylmethylnitramine — is used as a high explosive found commonly throughout loading areas.

Thickness of Thread

The distance between the adjacent sides of the thread measured along or parallel to the pitch line.

Thread Plug Gage

Used in acceptance or rejection of threaded holes in parts.

Thread Ring Gage

Used in acceptance or rejection of threaded circular parts.

Time Fuze

Fuze to burst shell at some pre-determined time after projectile leaves the gun.

Time Rings

A component fuze part of a time fuze pressed with black powder and so designed to burn for a fixed time.

T.N.T.

Trinitrotoluene—importance is based upon its relative safety in manufacture, loading and transportation and storage. It is non hygroscopic. Lacks any tendency to form unstable compounds with metals. Has great brisance.

Tolerance

The amount of variation permitted in the size of a part.

Travel Order

Order issued for travel—and to designated point by an Executive Officer of the United States Government.

Trimonite

A substitute explosive for shell and bomb loading, composed of picric acid and mononitronaphtholine.

Unclassified

Ordnance subjects and items of ordnance material regarding which a "secret", "confidential", or "restricted" classification seems not to be warranted. Subjects in this category may be discussed freely.

Unilateral System

The basic size appears with a tolerance in one direction only. This system is used by the Ordnance Department.

Viscosity

The time of flow of a liquid as compared with that of water, from a pipette, or time for a steel ball to fall through a solution.

W. D.

War Department - Numbering system for steel, as carried out in the latest revision of U.S. Ordnance Spec. 57-107.

Worm Gear

Is a gear having the teeth cut angular with the axis of rotation of the gear body and radially in the gear face.

Wringing

To remove water from the pulp so that the subsequent operation of dehydrating by means of alcohol will be done with minimum amount of water present.

Yield Point

The load per square inch of original cross-sectional area, which causes a marked increase in extension without increase of the load as determined by drop of beam or divider method.

Yield Strength

The load per square inch of original cross sectional area which causes a specified set as measured by the offset method, or a specified extension under load.

COURSE OF STUDY

ORDNANCE SCHOOL OF INSPECTION

TRADE TERMS

Abrasive
: A substance used for abrading, as for grinding, polishing, etc. The principal abrasives now used are emery, tripoli, pumice, rouge, which are natural abrasives and silicon carbide and aluminum oxide, which are artificial abrasives, sold under various names such as Crystalon and Alundum, as sold by The Norton Company.

Alignment
: Laying out or regulating to a line. "Setting the lathe in alignment" means, that work rotating between centres will be parallel when cut by tool, which is controlled by carriage movement.

Backlash
: A slackness of movement between machine parts such as the slackness in the fitting of a screw and nut.

Blast
: Air under pressure.

Burr
: A thin, ragged edge of metal. Very essential to remove all burrs in Ordnance work.

Chip Pressure
: Is the pressure exerted on a cutting tool as the chip is removed from the material being cut.

Ferrous Metals
: Ferrous metals are metals containing Ferrite or Iron.

Finishing
: Machining to exact size with a fine cut and producing a smooth finish on the work.

Fillet
: A rounding of the inside corners of metal, noticeable in cast metals, to give strength.

Lead
: Is equal to "pitch" in a single thread, but twice the "pitch" in a double thread. It is the amount of progression or movement of a nut along a screw in one revolution.

Malleable

A malleable metal is a metal that is not brittle but can be bent slightly without breaking.

Mandrel or Arbor

A tapered piece of round steel used for mounting and driving work.

Parallels

A block of metal with parallel sides used for setting up work above a surface but parallel with it.

Periphery

Is the distance around a cylinder or the circumference of a circle.

Pinion

A small gear.

Pilot Hole

A small hole drilled previous to drilling a larger hole. It allows a free passage for the web or centre of the drill.

Pitch of Thread

Is the distance on a screw from one thread to the next thread. Expressed pitch 1/8"- 8 threads per inch.

100-Point Carbon Steel

Defines the carbon content or quality of the steel. 100-point equals one per cent carbon.

Roughing

An operation which removes the rough irregularities of metal and leaves it almost to size.

Scale or Oxide

Is rapidly produced when metal is heated and exposed to the air. Iron Oxide is a combination of Iron and the Oxygen from the air.

Serrated

A saw-like condition, or a series of scratches or grooves.

Snagging

Rough grinding to remove the hard skin or irregularities on Cast Iron.

Spotting

Making a small cone-like recess central with the rotating work to assist a drill in finding the correct location for drilling.

SECTION II

High Explosives

1. - Chemical and Physical Properties of High Explosives.

A knowledge of the chemical and physical properties of the high explosives used in ammunition is essential and all personnel dealing with this class of material should become thoroughly familiar with the characteristics of each explosive, so that proper safeguards may be used in handling.

High explosives are used as primer ingredients; in detonators, in boosters, and as shell and bomb charges. Such explosives must meet the requirements of the specification pertaining thereto and must be loaded in accordance with the pertinent specification in order to provide certainty of functioning at the time required. However, familiarity with such explosives should never operate so as to cause carelessness in handling. The chemical and physical properties of the high explosives used are listed as follows:

MERCURY FULMINATE. - Mercury fulminate is crystalline compound varying in color from white to a grayish tint. The purity of the material used is required to be not less than 98%. The material is soluble in water to the extent of only 0.01 percent at 15.5°C. and 0.77 percent at 100°C. It is readily soluble in pyridine and ammonium hydroxide, and can be precipitated from such solutions. It is decomposed by solutions of sodium thiosulphate, sodium sulphide, and potassium sulphide, such solutions being used where it is desired to destroy mercury fulminate. It reacts with aluminum and magnesium, the reaction being increased by the addition of water. Mercury fulminate is probably the most sensitive explosive used in ammunition. In the standard drop test apparatus using a 2 kilogram weight it explodes consistently with a 2 inch drop. The initiating value of mercury fulminate is shown by data that it requires .21 grams to initiate high order detonation in tetryl. These figures pertain when the test is conducted in a No. 8 blasting cap (2" length, inside diameter .220") with the loading pressure of 3000 lbs. per square inch on each explosive. The disadvantages in the use of mercury fulminate in ammunition are: first, relatively poor stability; second, it is made from semi-strategic material (mercury). In approximately five years storage under water the purity of the material decreases to a point somewhat below 98%. In elevated storage at 50°C., nine to ten months are sufficient to cause deterioration to the point where the material is of no further value as an explosive. At 80°C. it reaches the point in eight to ten days where it becomes worthless.

LEAD AZIDE. - Lead azide like mercury fulminate is an explosive used as a primer ingredient and in detonators. By the process of manufacture used in this country, this material is produced as granular aggregates of the extremely fine crystals of lead azide. It has a cream to light lemon color, and like mercury fulminate is only slightly soluble in water. It is less sensitive to impact and to heat than mercury fulminate, the drop test value being 3 - 4 inches, yet all precautions of handling apply to lead azide as well as they do to mercury fulminate. The initiating value of this material, determined under the same conditions of test as that specified for mercury fulminate, is .055 grams of lead azide required to initiate tetryl. The loading density of lead azide at 3000 lbs. per square inch is 2.56 compared with mercury fulminate of 3.03 under like conditions. The greatest advantage in the use of lead azide lies in its remarkable stability. Detonators loaded with this material have been subjected to one year's storage at 80°C. and at the end of that time have shown no evidence of deterioration. As lead azide reacts with copper, especially if moisture is present, all detonators, for ammunition in which lead azide is used, are made of aluminum. The high initiating value of lead azide permits a substantial reduction in the amount of material required in a detonator. It is estimated that in case of any emergency, the procurement of detonator explosives would be reduced by approximately one-third if azide is used in place of mercury fulminate.

TETRYL. - Tetryl is the only explosive which is now considered standard for boosters. This material has been improperly called tetranitromethylaniline; the correct terminology is trinitrophenylmethylnitramine. It is a fine crystalline powder, yellow in color, and practically insoluble in water but soluble in acetone, benzene, and other such solvents. It melts when pure between 129° and 130°C. All material meeting the requirements of the Army specification has a melting point of at least 128.5°C. The nitrogen content of this material is 24.4%, which is approximately 6% higher than that of trinitrotoluene. Tetryl is stable at all temperatures met with in storage but when heated to its melting point undergoes gradual decomposition. It is sensitive to shock and friction. In the standard drop test with a 2 kilogram weight, detonation is obtained with a drop of 7 to 9 inches. Pressed at a density of 1.5 it has a rate of detonation of approximately 7000-7500 meters per second.

TRINITROTOLUENE (TNT). - Trinitrotoluene known as TNT and Triton is a crystalline powder varying in color from a light yellow to a buff. There are two grades of this material now specified for use in ammunition; viz., Grade I and Grade II. The Grade I has a melting point of not less than 80.2°C., and Grade II has a melting point of not less than 76.0°C. Grade I is used either alone or in combination with ammonium nitrate as a bursting charge for shell and bombs. Grade II is reserved for 80/20 amatol only. TNT is quite insensitive to shock or friction. In the standard drop test apparatus using a 2 kilogram weight, a drop of 14 to 16 inches is required to cause detonation. When pressed to a density of 1.5 or as a cast explosive, it has a rate of detonation of approximately 6000-6500 meters per second. In the pressed form it can be detonated with a commercial No. 6 blasting cap, (length $1\frac{1}{2}$", inside diameter .220"), but in the cast form it requires a much stronger initiator. TNT is practically insoluble in water and non-hygroscopic and if reasonable care is exercised it is not necessary to dry the material after manufacture.

AMATOL. - Amatol is a mixture of ammonium nitrate and TNT. There are two compositions standardized for use in ammunition; namely 50/50 amatol and 80/20 amatol. The first figure given in the proportion is the percentage of ammonium nitrate by weight and the second the percentage of TNT. The 50/50 mixture is fluid at 80°C. and can be loaded by casting. The 80/20 mixture resembles brown sugar in consistency and must be loaded either by tamping or by means of a screw filling machine. The explosive characteristics; sensitivity to impact, etc., of the 50/50 mixture approximates that of TNT, while the 80/20 mixture is much more insensitive. The rate of detonation of these explosives is somewhat below that of TNT. Their value as bursting charges lies entirely in the fact that they offer a means of conserving the TNT supply without reducing the destructive effects of ammunition to any great extent.

TRIMONITE. Trimonite like the amatols is specified as a substitute explosive for shell and bomb loading. The explosive characteristics of this material are almost identical to the characteristics of 50/50 amatol, except that the density of cast trimonite is slightly higher, viz., 1.60 as compared with 1.55 for 50/50 amatol. Trimonite is composed of 88% picric acid and 12% mononitronaphthaline. This mixture melts above 90°C. but the same equipment used for the loading of TNT can be used in the loading of tridite. It has been adopted as a substitute in order to meet the requirements during the first months of an emergency. Both mononitronaphthaline and picric acid can be made in dye manufacturing plants. Provision must be made that it will not come in contact with either lead or zinc.

EXPLOSIVE D. (Ammonium Picrate). - Explosive D has a crystalline structure and varies in color from a lemon to an orange color. It is the least sensitive of all military explosives and is used exclusively as a bursting charge for armor piercing shell. Explosive D has a drop test of approximately 24" with a 2 Kilogram weight. It does not melt on heating but explodes when heated to a temperature of approximately 300°C. It is more soluble in water and more hygroscopic than any other of the standard explosives used, except amatol. It is loaded by means of a hydraulic press or by ramming to a density of 1.45 min.

BLACK POWDER. - There are two classes of black powder used in Army ammunition. Each class is divided into grades, the grading being according to the size of grain. The class using potassium nitrate in the composition is the more important from a military standpoint. It has the following composition:

Potassium Nitrate - 75.0% plus or minus 1%
Charcoal - 15.6% plus or minus 1%
Sulphur - 10.4% plus or minus 1%

Certain percentages of potassium nitrate may be replaced by barium nitrate, in order to make the powder slower burning. In the second of powder sodium nitrate is used. It has the composition of -

Sodium Nitrate - 71.0% plus or minus 1.5%
Sulphur - 12.5% plus or minus 1.5%
Charcoal - 16.5% plus or minus 1%

The powders containing potassium nitrate are, in the main, used in time fuzes, delay elements and as powder charges for artillery primer. Black powder is sensitive to friction, ignites easily by flame, and is hygroscopic. After drying the material should be kept in sealed containers, in order to avoid moisture absorption.

GRENADE POWDER.- The explosive now standard for fragmentation hand grenades is E.C. Blank fire which is a smokeless powder of the following composition:

80% Nitrocellulose
16% Barium and Potassium Nitrate
2% Starch or agar-agar
Balance coloring material and anti-acids.

E.C. Blank fire may be colored yellow or pink, consists of small granules, can be ignited by flame and has sufficient explosive power to fracture the grenade into 40-60 pieces, 50% of which will penetrate one inch pine at a distance of 30 ft.

SECTION II

HIGH EXPLOSIVES

2 - Physical Testing of High Explosives - Laboratory Methods.

The present high explosives standard for military purposes have been tested out by actual use over a long period of time and their points of superiority, and their weaknesses are a matter of record.

When a new high explosive is proposed to meet a particular use, the question then arises as to how it is to be compared with the explosive it is intended to replace. It is obviously impossible to obtain a satisfactory comparison by subjecting the new high explosive to the test of actual use, for the period of time in which the old high explosive has been so tested comprises many years.

A new high explosive is therefore, compared with the old or accepted high explosive by subjecting both to certain more or less arbitrary tests and in the interests of economy, rapidity of examination, and safety, the preliminary comparison tests are made on a small scale in the laboratory. If the laboratory results seem promising, further tests are conducted on a larger scale.

Practically all tests, both small and large scale, upon high explosives are more or less empirical because the very nature of high explosives prevents the use of highly refined or delicate apparatus. A high explosive is a material in which there has been intentionally stored a large amount of available energy and this energy exists in the explosive in a somewhat unstable condition. To use a mechanical analogy, but not mechanical explanation, the center of gravity of the system is high and as a result its equilibrium is easily disturbed.

As a result then of the inherent limitations imposed by the nature of the high explosive material itself, it is almost impossible to devise tests of a rigidly scientific type, and the results obtained by standard tests on high explosives consist usually of the measurement of that specific characteristic f r which the test was developed, but so encumbered with partial measurements of several other characteristics that it is difficult to estimate or separate their relative magnitudes. For this reason it is necessary to consider the results of the entire series of tests before rendering a verdict as to the relative merits of two different high explosives.

There are nine laboratory tests applied to high explosives. These are:

1. Ignition Temperature.
2. Sensitivity to Impact.
   a. Standard Drop Test Apparatus.
   b. Bureau of Mines Type Drop Test Apparatus.
3. Sand Test for Brisance.
4. Initiating Value.
5. Sensitivity to Initiation, or Minimum Detonating Charge.
6. Impulse Tester, measuring:
   a. Impulse.
   b. Volume of Gas Produced.
   c. Uniformity of Functioning.
   d. Solids Carried in the Explosion Flame.
   e. Sensitivity to Percussion.
   f. Minimum Charge Required to Ignite Black Powder.
7. Duration of Primer Flames.
8. Form and Volume of Flame Produced.
9. Duration of Flame Produced.

These nine laboratory tests for high explosives will be discussed in the foregoing order.

1. Ignition Temperature. (Ref. 1,2).

The determination of the temperature of ignition of explosives illustrates the difficulties attendant to the physical testing of high explosives due to the fact that they are by intention more or less thermally unstable and for this reason tend to undergo some slow decomposition before explosion. Each explosive material possesses a certain heat conductivity and this governs the time required for heat to flow into it. Each high explosive also possesses a certain heat capacity which must be satisfied by influx of heat before its temperature can rise and this also involves time of heat ingress.

When a high explosive is exposed to a given temperature, below its approximate ignition temperature, a time interval of several seconds is required for the heat influx to overcome the thermal conductivity and heat capacity characteristics and thereby raise the temperature of the explosive to a point where it flashes or explodes. Now, if this time of exposure to heat interval is plotted against the temperature of ignition, a curve is obtained which tends to approximate a hyperbola in the case of explosives with low ignition temperatures, and a straight line in the case of explosives with high ignition temperatures. With certain high explosives, explosive D or ammonium picrate for example, the ignition temperature curve shows some signs of discontinuity as the longer heating periods are approached; this is probably due to incipient decomposition occasioned by the prolonged exposure to temperatures somewhat below its true or ideal ignition temperature- its ignition temperature requiring zero exposure time, if this were possible.

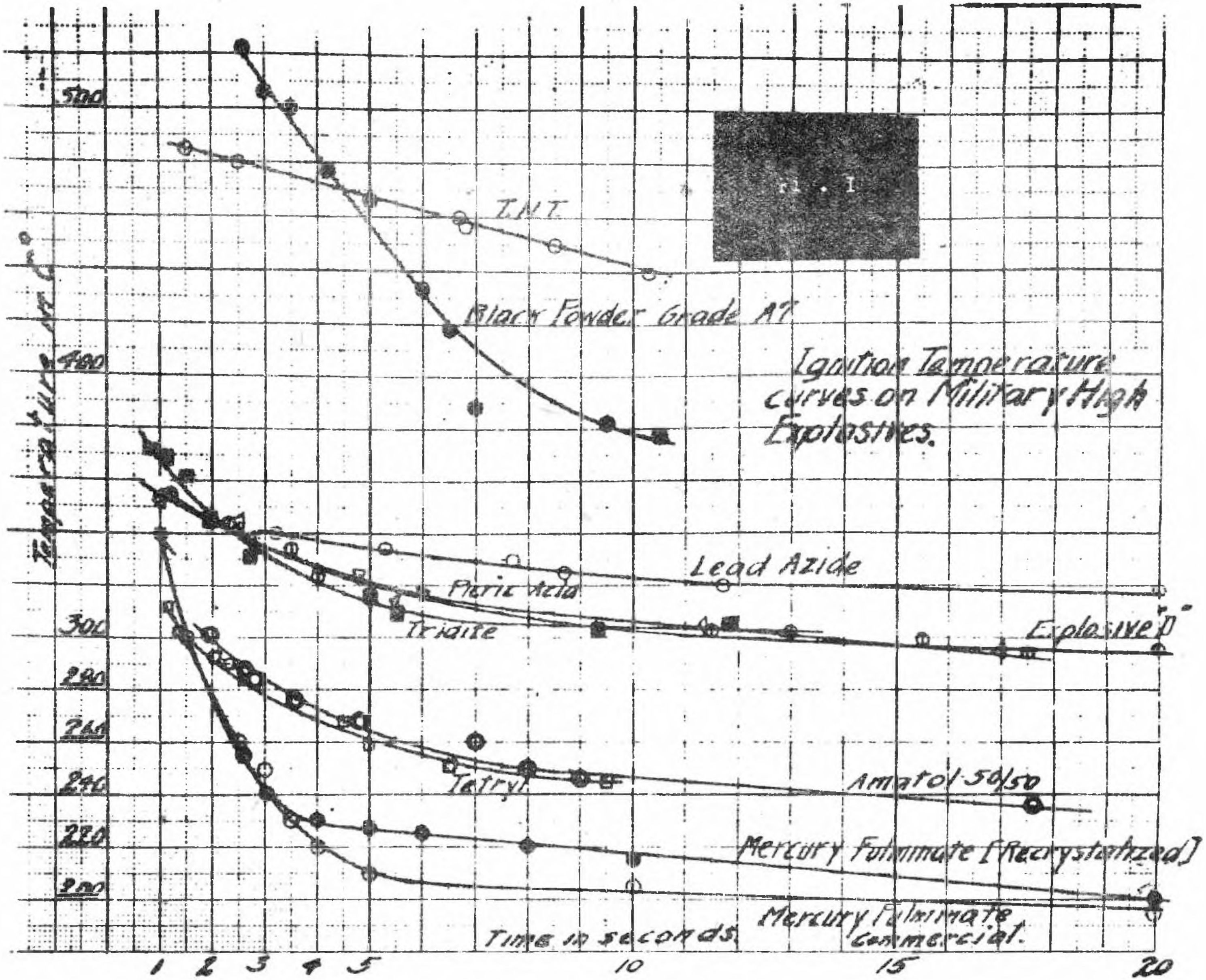
Strictly speaking, the relative ignitibility of a high explosive is proportional to the area included under the time-temperature curve but it has been found satisfactory in practice to accept as the ignition temperature of an explosive that temperature where the explosive requires an exposure time of five (5) seconds to flash or explode.

Most high explosives are obtainable in the form of a crystalline powder of 60-mesh size but propellent powders should first be reduced to such a size as will pass a 14-mesh, but be retained upon a 28-mesh sieve.

Fig. 1 shows the ignition temperatures of military high explosives.

The ignition temperature apparatus is shown in Fig.2. It consists of a multiple unit electric furnace A with a rheostat B to control the temperature. In the electric furnace is an iron crucible containing a bath of Wood's metal; an alloy composed of 50 percent bismuth, 25 percent lead, 12.5 percent tin, 12.5 percent cadmium and melting at 65.5° C. For temperatures above 500°C. an alumel-chromel thermocouple C immersed in the Wood's metal and connected to an indicating pyrometer D gives the temperature of the metal bath. For temperatures under 500°C. a calibrated thermometer is used, correction being made for the emergent stem.

The time interval during which the high explosive is exposed to the temperature is measured on a stop clock. The operator is protected by the wire glass barricade E. The copper blasting cap is fastened in a clamp F, free to rotate about a point G and provided with a fixed stop to to insure a fixed depth of immersion in the moltem metal bath. The clamp F is connected to a counterweight H by means of a string and the two pulleys I so that the loaded copper blasting cap can be rapidly immersed in the molten metal bath.



Ignition Temperature curves on Military High Explosives.
Temperature in °C
500
400
300
280
260
240
220
200
T.N.T.
Black Powder Grade A7
Lead Azide
Picric Acid
Triazine
Explosive "D"
Tetryl
Amatol 50/50
Mercury Fulminate [Recrystallized]
Mercury Fulminate Commercial.
Time in seconds
1
2
3
4
5
10
15
20

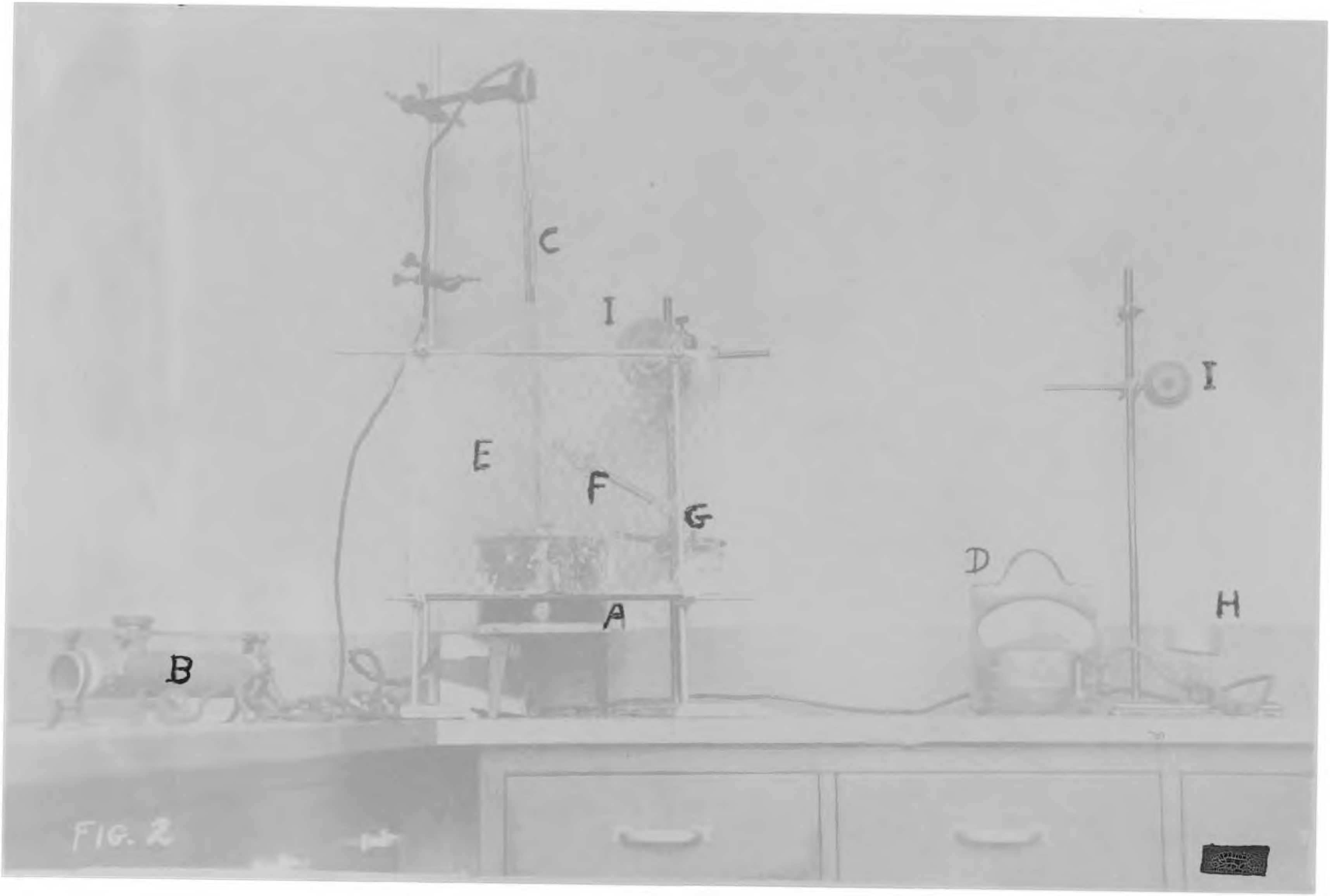


FIG. 2

Detailed procedure for determining the ignition temperature of a high explosive is as follows:

Load each of ten (10) No. 8 copper blasting caps with approximately 0.03 grams of the explosive under test. Immerse the loaded caps in succession in the metal bath, and determine the bath temperature and the time of immersion required to cause each to flash or explode. The temperature of the metal bath is varied between determinations in such a way as to have the ten (10) flashes or explosions occur over a time interval range of approximately two (2) to ten (10) seconds. Plot the resulting temperature time curve and select from this curve the temperature necessary to cause the high explosive to flash or explode after immersion in the molten bath for five (5) seconds. This temperature is taken as the ignition temperature of the high explosive under test. With certain difficult ignitible explosives it is necessary to plot the average of from two (2) to five (5) explosions at ten (10) intervals over the range from two (2) to ten (10) seconds, to obtain a valid temperature-time curve. Ignition temperatures of military high explosives are given in Table 1.

2a. Sensivity to Impact. (Ref. 3)

It was necessary to develop some means of determining the sensitivity to impact of high explosives and in this way gain some knowledge of the relative danger involved in handling them. The Standard Drop Test utilizes a machine (Fig. 4) and equipment (Fig. 3) which at first sight appears to be cumbersome and to involve a needlessly complicated procedure. But it must be remembered that certain of these high explosives are quite sensitive to impact and that this standard drop test is the result of long experience in developing such a test.

The object of this test is to find the minimum height that a two kilogram hammer may fall on a cup, arranged as hereafter described, and give at least one detonation in ten trials;while at one inch lower no detonations are obtained.

The die cups are made of tool steel,hardened, and the vented plugs are constructed of high carbon drill rod, drawn and hardened. The hardness of the die cups and vented plugs is adjusted by trial and error until carefully prepared samples of standard military high explosives give the following drop tests;

Explosive	Weight of Hammer	Drop Test. Inches
Tetryl	2 Kilograms	7 or 8
TNT	2 "	14 or 15

The brass covers used in the die cup assembly are annealed.

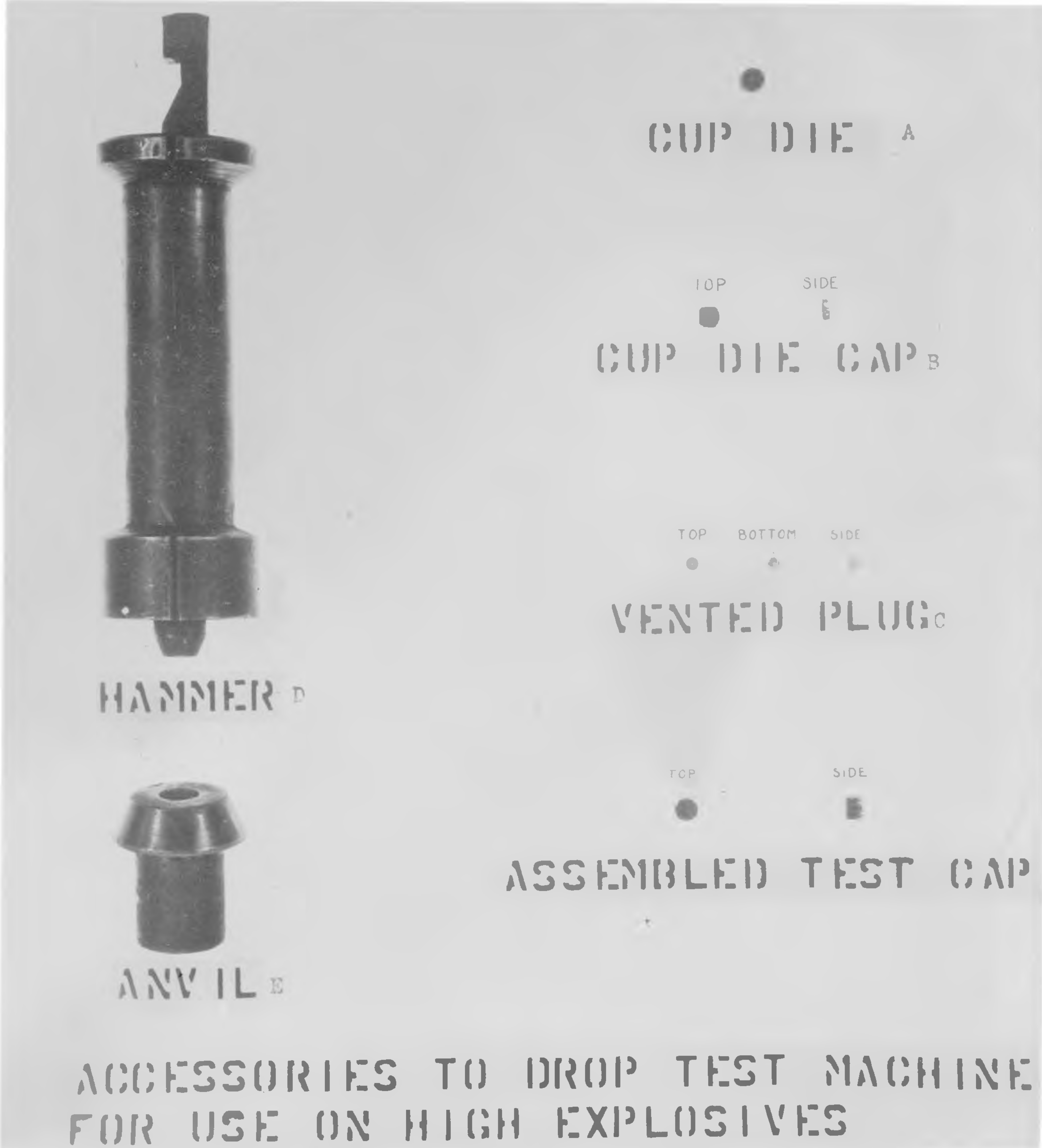

CUP DIE A
TOP
SIDE
CUP DIE CAP B
TOP
BOTTOM
SIDE
VENTED PLUG C
HAMMER D
TOP
SIDE
ASSEMBLED TEST CAP
ANVIL E
ACCESSORIES TO DROP TEST MACHINE FOR USE ON HIGH EXPLOSIVES

FIG. 3

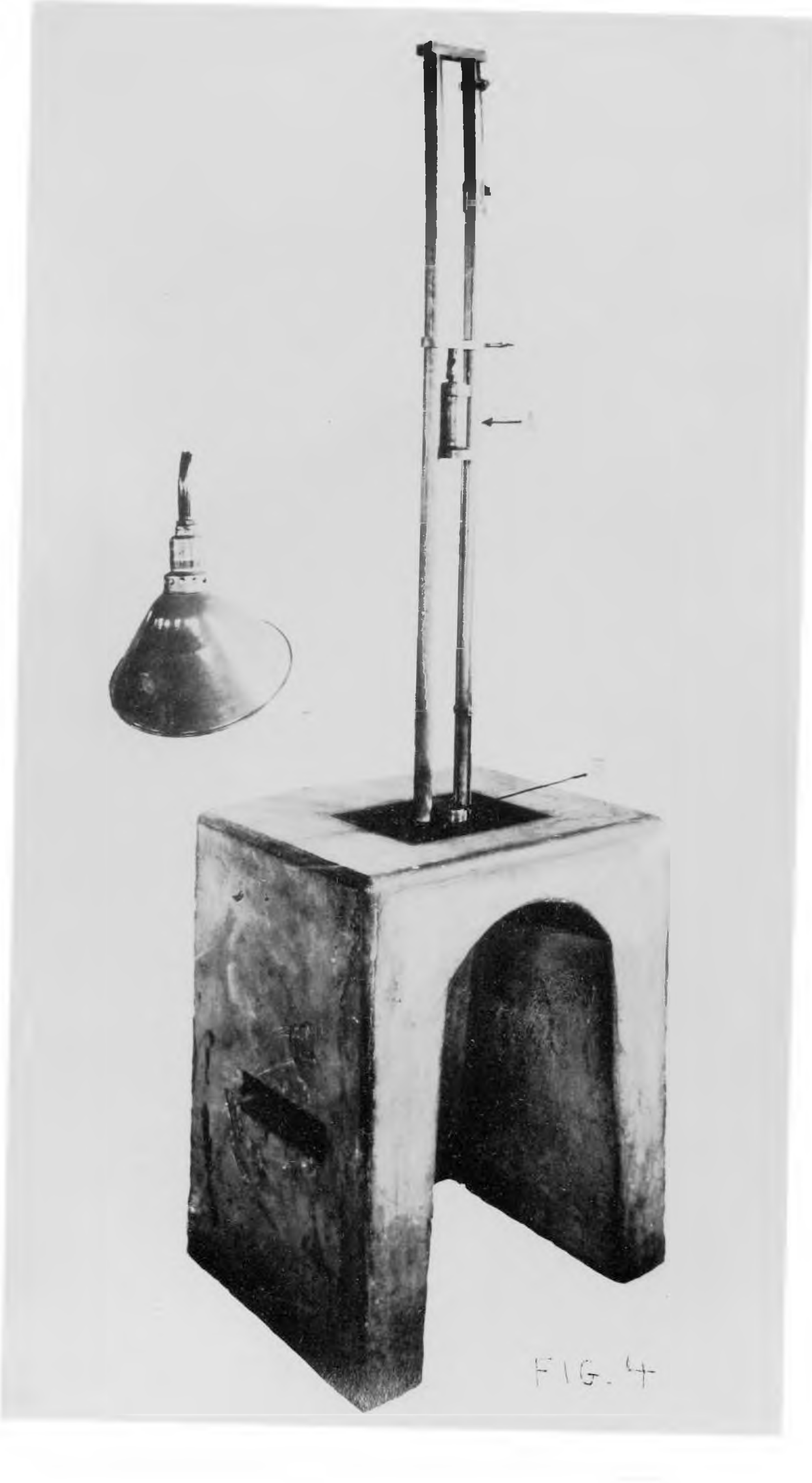


FIG. 4

Detailed procedure for the Standard Drop Test on High Explosives:

Fill the die cup A with the explosive to be tested, pressing it firmly into place with a horn spatula. Carefully remove any excess explosive from the rim of the cup, place the brass cover B on the die over the explosive and press it down uniformly. At least thirty cups will probably be needed for this test. Place the assembled cup in the anvil E (Fig. 3) with the brass cover upward. Place the vented plug C on top and in the exact center of the brass cover, with the grooved side of the plug downward.

Adjust the yoke (Fig. 4) so that the hammer will fall about twelve inches for the first fall. If explosion occurs, lower the hammer about two inches for the next trial and continue the adjustment for different trials until the desired height of drop, as explained above, is secured. If no explosion is obtained on the first trial at twelve inches, the hammer is raised about four inches for the next trial and so on until the desired height of drop is found. These preliminary tests are for the purpose of securing an idea of about what the "drop test" on the explosive will be, and until such an idea is obtained it is not worth while to make more than one trial at a given height. Use a fresh assembled cup for each trial, even though no detonation was obtained in the preceding trial. When the maximum height has been found at which ten trials give no detonation, a height of one inch higher, where at least one detonation occured in ten trials, is taken as the "drop test" on that high explosive.

The Standard drop test machine (Fig. 4) is also provided with a one pound hammer and an eight ounce hammer for use in determining the "drop test" on initiators such as mercury fulminate, which are more sensitive to impact. Drop tests for military explosives are given in Table I.

2b. Bureau of Mines Direct Impact Test for Explosives (Ref. 4,5).

The principle of the Bureau of Mines drop test is the same as that of the standard drop test in use at this Arsenal. The object of this test is to find the maximum height that a hammer of known weight can be permitted to fall in the modified small impact machine, described on page 74 of Bureau of Mines Bullentin 346, and fail to produce a detonation in ten successive trials.

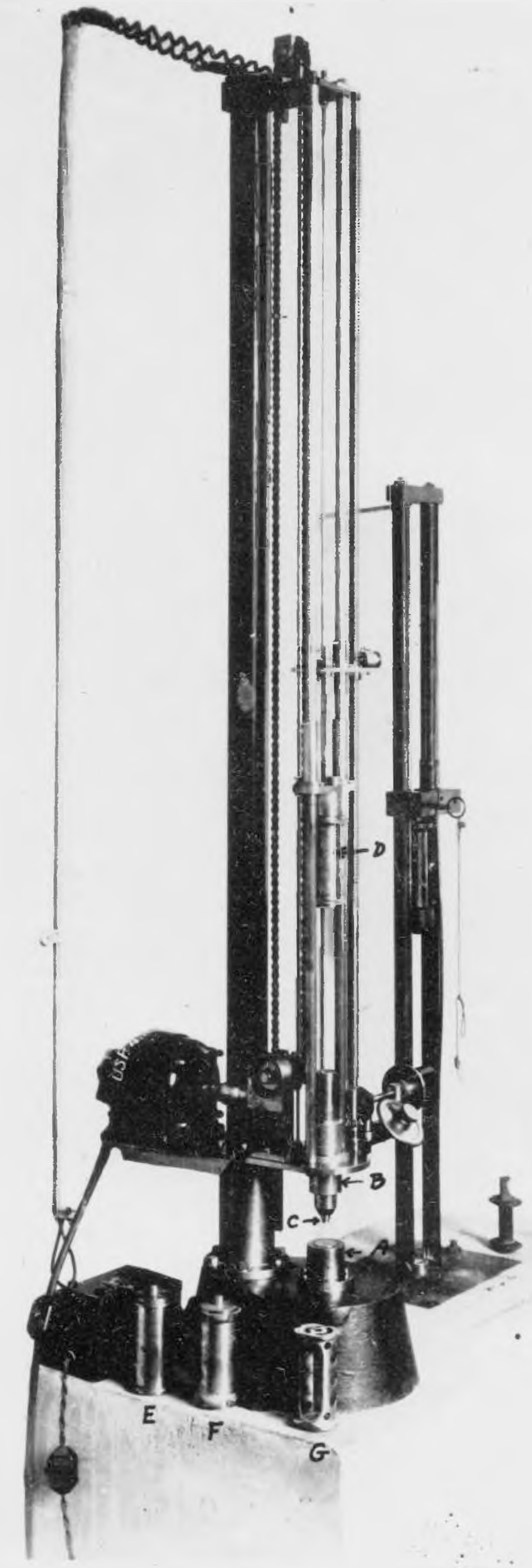


FIG. 5
BUREAU OF MINES
DROP TEST MACHINE
A-5119

Procedure:

A weighed sample of 0.02 gram of the explosive to be tested is placed in the center of the impact block A (Fig. 5). The plunger B is lowered so that the plunger tip C covers the entire layer of explosive and compresses it to a compact mass; the plunger is sufficiently heavy to tend to spread out the sample and in this way produce a more or less uniform layer thickness for the various high explosives. The hammer D is then allowed to fall from a measured height and strike the plunger, communicating its impact through the plunger tip to the layer of high explosive resting on the impact block. Elevation and release of the hammer is accomplished by means of a combination of electrical and mechanical devices which operate semi-automatically. If no explosion takes place, the residue of the sample is removed from the plunger tip and impact block and the hammer then dropped from a greater height on a new sample. When explosion results, the height of fall of the hammer is decreased until there is no explosion in ten trials with a fall of 1 centimeter less than the least height causing an explosion. After each explosion the impact block and plunger tip are cleaned and inspected. If either is dented, cracked, spread or deformed in any way, it is replaced before making further tests. Hammers of differing weights are shown at E, F and G (Fig. 5). The face of the impact block is easily seen in the center of A.

Sand Tests:

3. Brisance, or Sand Test. (Ref. 6,7,8,9,10,13).

4. Initiating Value.

5. Sensitivity to Initiation, or Minimum Detonating Charge.

The sand test may be used in several ways. It may be used to show the relative shattering force or brisance of an explosive, the ability of an explosive to initiate detonation in another explosive or the minimum detonating charge of a standard initiator, such as mercury fulminate, required to detonate an explosive. In any case the thing measured is the amount of standard 20-mesh Ottawa Silica Sand which is crushed to 30-mesh fineness by the explosion of a blasting cap loaded with the explosive under test and fired under standard conditions.

Here again is encountered the difficulty, seemingly inherent in high explosives, that tests can not be devised to measure only a single characteristic of the explosive. The term "Brisance" is probably better interpreted as the "explosive violence" or "shattering ability", rather than the "strength" of an explosive ,and appears to be proportional to the velocity of the detonation wave. The explosion pressure as well as the velocity of the detonation wave depend upon the density of the explosive, among other things involved, and an attempt is therefore made to minimize density differences by using a fixed loading pressure applied for a fixed time.

Force displacing a mass thru a distance is work but when a force acts over the very short time interval characteristic of the duration in anyone spot of a detonation wave from a high explosive, no displacement occurs and the body occupying that particular spot is merely shattered. Therefore in the brisance test it is the explosive force that is measured and not the explosive work performed. While no precise demonstration of this peculiar action of high explosives has so far been made, it can be shown as a rough approximation that the grams of sand crushed or brisance, B, and the rate of travel of the detonation wave in meters per second, R, are related as,

$$\text{Log } B = 3.53 \text{ Log } \frac{R}{2500}$$

The following calculated values were obtained by means of this equation. The average values of both cast and pressed high explosive for rate of detonation, and the brisance values, are taken from Table I.

High Explosive	Brisance Grams of Sand Crushed by 0.40 gram of High Explosive Actual	Calculated
Mercury Fulminate	17.6	15.2
Lead Azide	13.9	14.4
Tetryl	46.4	43.2
Amatol 50/50	33.6	38.3
Tridite	36.1	28.2
T.N.T.	35.7	35.4
Amatol 80/20	16.9	21.0
Picric Acid	40.0	44.6
Explosive D	32.1	32.5
Black Powder	8.5	---

The above calculated values show that the brisance value of a military high explosive can be obtained from the rate of detonation value alone within an error of $\pm$ 3.1 grams of sand crushed; using the standard sand test in the large bomb.

Conversely, the rate of detonation can be calculated from the brisance value alone within an error of $\pm$ 190 meters per second.

However, when the black powder value is inserted in the foregoing equation it is found that black powder should possess a rate of detonation of 4600 meters per second to correspond with its brisance value of 8.5 grams of sand crushed. This may possibly be near the true rate of detonation of black powder for it has been suspected that the value of 400 meters per second for black powder given in Marshall, Vol. III, 1932, pp.148-153, represents the determination of the speed of travel of the explosion wave and not the detonation wave. There are reasons for believing that the rate of travel of the true detonation wave of black powder would be extraordinarily difficult to determine. It is an incorporated mixture, rather than a melt mixture, and requires 0.3 gram of tetryl booster to get its brisance value of 8.5 grams of sand crushed.

The apparatus used in these sand tests at this Arsenal is a cylindrical bomb. Two sizes are now in use, a large one (Fig.6) which is charged with two hundred grams of sand, and a small one in which only one hundred grams of sand is placed.

The sand used is a pure ,clean grade of quartz sand designated as "Ottawa standard sand",furnished by the Ottawa Silica Co., of Ottawa, Illinois. This sand is practically free from particles finer than 30-mesh and is entirely passed through a 20-mesh sieve. It is almost pure quartz, containing about 99,9 percent SiO_2.

In making the test with the large bomb, 80 grams of sand is poured into the cavity of the bomb A (Fig. 6) and compacted by striking the outside of the bomb two or three times with a copper hammer B. The loaded blasting cap G into which an 8-inch length of miner's fuse H has been inserted and crimped, or the electric detonator with its firing wires, is then placed in the bomb so that it rests on top of the sand in a vertical position and centered as nearly as possible in the cylindrical cavity. One hundred and twenty grams of sand is then poured over and around the cap and the fuse or firing wires then threaded through a hole in the bomb cover C. The cover is then clamped to the bomb by means of a bottom plate D and two vertical bolts E extending from the bottom plate D to the shackle F. The bomb is then struck vigorously several times with the copper hammer to pack the sand around the blasting cap. The blasting cap is then fired by igniting the miner's fuse or by sending an electric current thru the firing wires. After the explosion has occurred, the bomb cover is removed, and the sand is sifted thru a standard 30-mesh sieve

FIG. 6

by shaking on a mechanical shaker for three minutes. Care is taken to remove all the sand from the bomb. The sand crushed by the detonation of the high explosive passes through this sieve and is weighed on a small trip balance, as was also the original sand charge.

While the sand test is used for determining the brisance or relative shattering effect and uniformity of commercial detonators and also of detonators manufactured for service by the Government, it is more frequently used in the laboratory in connection with the study of the stability of explosives, the initiating power of compounds used to initiate detonation of high explosives, and the relative shattering effect or brisance of new explosives. This necessitates the loading of blasting caps in the laboratory.

The procedure that is followed in this loading operation depends upon the result desired and the nature of the explosive. Two sizes of caps are in general use, numbers 6 and 8, the difference being in length only, and the size chosen depending on the bulk of the explosive material to be loaded. The empty cap is placed in a brass block I (Fig. 6) of appropriate length, and a weighed charge of the explosive to be tested is brushed into the cap through the ram hole in the upper end of the brass block. Block and loaded cap are placed in a barricaded press, the initial action of the press inserts a steel ram into the loaded cap and the explosive is then held under a known pressure for a time interval of either one or three minutes, depending upon the particular test being conducted.

For the purpose of this test high explosives may be considered under three heads:

(1) Explosives which are caused to detonate by the spit of flame from a black powder fuse. This type includes most of the initiators such as mercury fulminate and lead azide. These are weighed and loaded as described above, but before they are pressed a shell-like cover with a small hole in the closed end is slipped open end down over the explosive inside the cap, and the ram then forces this reinforcement cap down over the explosive, thus providing greater confinement for the charge, which in most cases results in increased brisance.

(2) Explosives that are not caused to detonate by the flame spit from a miner's fuse, but will give a high order detonation when initiated by a suitable amount of mercury fulminate. This class includes Tetryl and pressed TNT. Any detonation of a less degree of violence than the maximum brisance

of an explosive is called a low order detonation. Most explosives, when initiated with a suitable series of initiators, will yield a range of brisance values from a detonation of very low order at the lower end to a very high order detonation, noticeably higher tha the formerly accepted values, at the upper end of the range. The formerly accepted values were so high that they were thought to be at the maximum values but recent work at this Arsenal has shown that the use of extremely intense sources of initiation, largely specific to each explosive, results in an increased brisance, greater than the formerly accepted maximum value, for practically all military explosives.

(3) Explosives which will yield high order detonation only when used in combination with an auxiliary explosive called a booster. The booster is initiated by mercury fulminate and the detonation of the booster detonates the explosive of this class 3. Explosive D, or ammonium picrate, and cast TNT are such. The explosive usually used as a booster is tetryl.

The amount of sand crushed by the first type of explosives is readily determined by loading a group of five caps with carefully weighed charges, pressing at 3,000 pounds per square inch for one minute, and proceeding with the test as descri ed above. The weight of sand crushed is a measure of the shattering ability or brisance of the initiator and by comparing it with the amount of sand crushed by equal weights of the other initiators, its relative brisance can be obtained. Within the limits of 0.2 gram and 1.5 grams of charge, for most initiators, the amount of sand crushed is a straight line function of the weight of the charge. Beyond these limits the design of the appatatus is thought to be responsible for deviation from this straight line relationship.

The relative shattering effect or brisance of the second type of explosives, those requiring detonation by a primary initiator (a primary initiator is a high explosive which detonates on contact with a spit of flame), may be determined by causing a weighed charge of the explosive to be detonated completely by the use of a sufficient charge of mercury fulminate. In the usual tests of tetryl, for example, 0.40 gram of tetryl is brushed into a number 6 blasting cap and pressed at 3,000 pounds per square inch for three minutes. Then 0.23 gram of mercury fulminate is poured into the cap on top of the pressed tetryl, a reinforcing cap is inserted and the detonator again pressed for one minute at 3,000 pounds per square inch. The amount of sand that 0.23 gram of fulminate alone would crush is then deducted from the total sand crushed by the compound detonator to obtain the sand crushed by the tetryl.

The third type of explosives requires a compound detonator of three increments, the weighed charge of explosive to be tested, the weighed charge of the booster, and the weighed charge of the initiator. In testing ammonium picrate

(Explosive D) for its brisance or relative shattering effect, for example, 0.4 gram of ammonium picrate is used as the first increment, about 0.15 gram (accurately weighed) of tetryl as the second or booster, and 0.23 gram of mercury fulminate as the third increment, or initiator. Each increment is pressed at 3000 pounds per square inch, the first two for three minutes each, and the last one for one minute. The total amount of sand crushed is corrected for sand crushed by the fulminate and tetryl used, to find the sand crushed by the picrate.

An average of the amount of sand crushed in five tests is taken as the measure of the brisance or relative shattering effect of a high explosive.

When the relative sensitiveness of a high explosive is to be determined, a fixed amount of the explosive (usually 0.40 gram) and varying amounts of initiator, or initiator and booster, are loaded into the test cap. The relative sensitiveness or ease of detonation is shown by a comparison of the amount of initial detonating material, i.e mercury fulminate for the second type mentioned above and tetryl for the third type, which is required to insure complete detonation of the explosive under test, with the amount required to completely detonate the same amount of a standard high explosive, usually TNT. Completeness of detonation can readily be judged by an inspection of the cap after firing, incomplete detonation being accompanied by incomplete destruction of the blasting cap, or by a large change in the amount 30-mesh sand obtained from the tests.

Relative initiating value may be determined:

For initiators, by ascertaining the minimum charge of initiator necessary to completely detonate 0.4 gram of a standard tetryl sample pressed in a number 6 blasting cap at 3000lbs. per square inch for three minutes.

Brisance or shattering effect of military high explosives appears in Table I.

Priming compositions

Primer compositions are generally friction-sensitive or flame-sensitive mixtures of high explosives, with or without the admixture of inert ingredients, and are used to initiate the functioning of the explosive train in military ammunition. The primer may be followed in the explosive train by an igniter system, as in the case of smokeless powder charges, or some form of delay element designed to give a fixed delay interval between the action of the primer and the detonation of the high explosive end of the explosive train. This fixed delay interval may be arranged so that it can be varied as, for example, in the time fuze which can be set at any point up to their maximum delay.

Much difficulty has been encountered in the past in determining the primer domposition which will be satisfactory for use in new designs of ammunition. Much of this difficulty has been due to the fact that the essential characteristics of the various available compositions were unknown in that the effects of the several variables involved in percussion elements were undetermined and specific methods of evaluating these had to be developed. It is generally considered that the factors involved in the ignition efficiency of a charge of priming composition include:

a. Weight of charge.
b. Volume of gas liberated by primer explosion.
c, Impulse, or shock effect, of the explosion.
d. Incandescent solids carried by the flame.
e. Sensitivity of the primer composition to percussion.
f. Duration of the flame produced by the primer.
g. Temperature of the primer flame.
h. Form of the flame produced by the primer.

Methods have been developed to measure all of the above characteristics except (g.), which is now under investigation. The Characteristics, b,c,d, and e, are determined by means of the Impulse Tester.

6. Impulse Tester. (Ref.11)

The Impulse Tester and equipement is shown in Figs. 7,8,9, and 10.

The Impulse Tester as set up for use appears in Fig. 7. Essentially it consists of an open mercury manometer E which is connected at one end to a firing chamber B in which the primer is held and fired. A is an open sided rectangular box which serves as a base to support the manometer and firing mechanism. B is the cylindrical firing chamber into which an adapter C is set. This adapter into which the primer fits is held in place by the firing pin holder D. The lower end of the firing chamber B is connected through a brass pipe to the mercury manometer E which is used to indicate the impulse and gas volume. In the connecting pipe is a petcock F to relieve pressure in the system before or after firing a primer. The two upright brass rods on the right support the magnet G, which is a regular Boulenge Chronograph magnet, and holds it centered above the firing pin H.

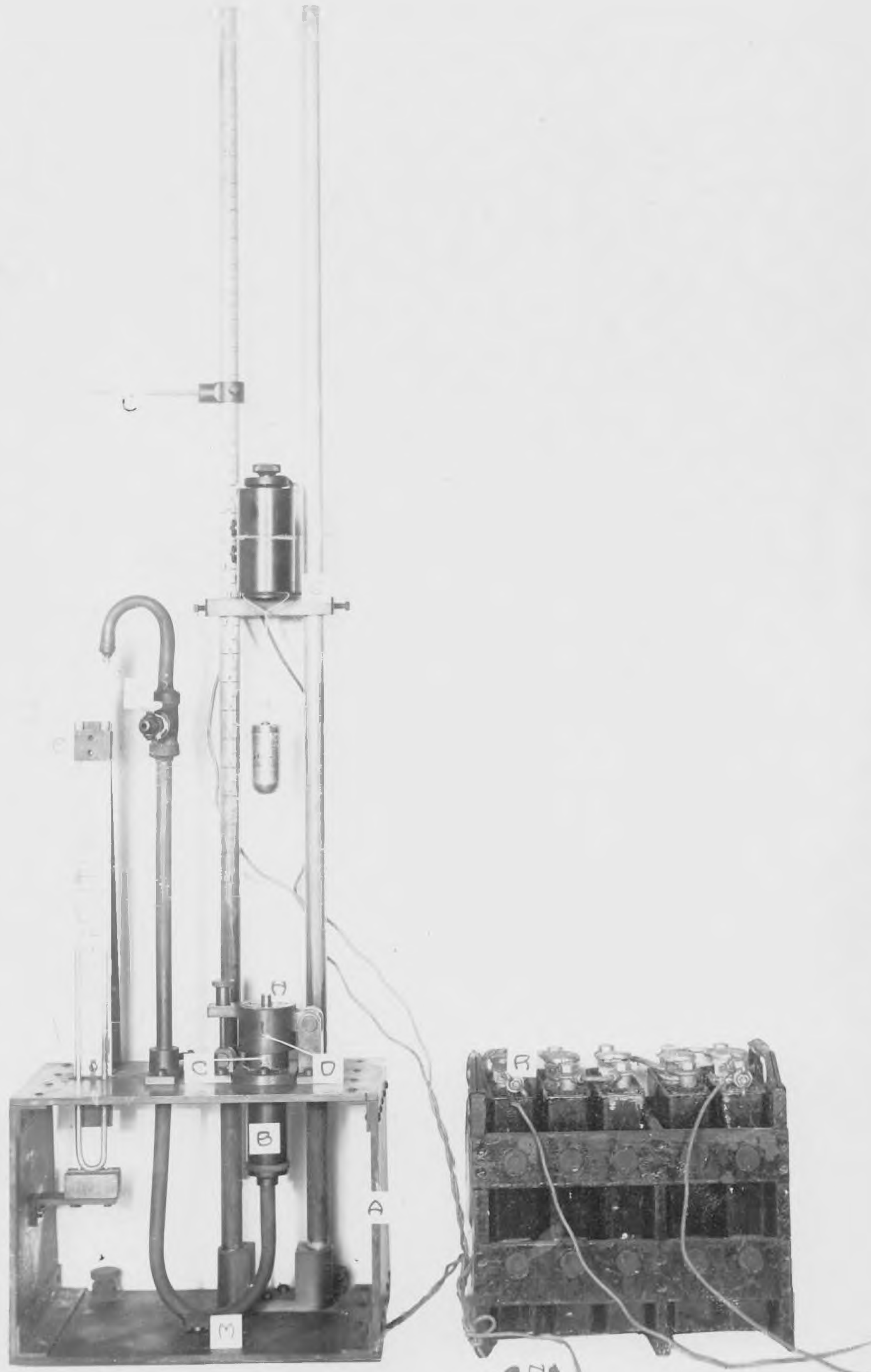


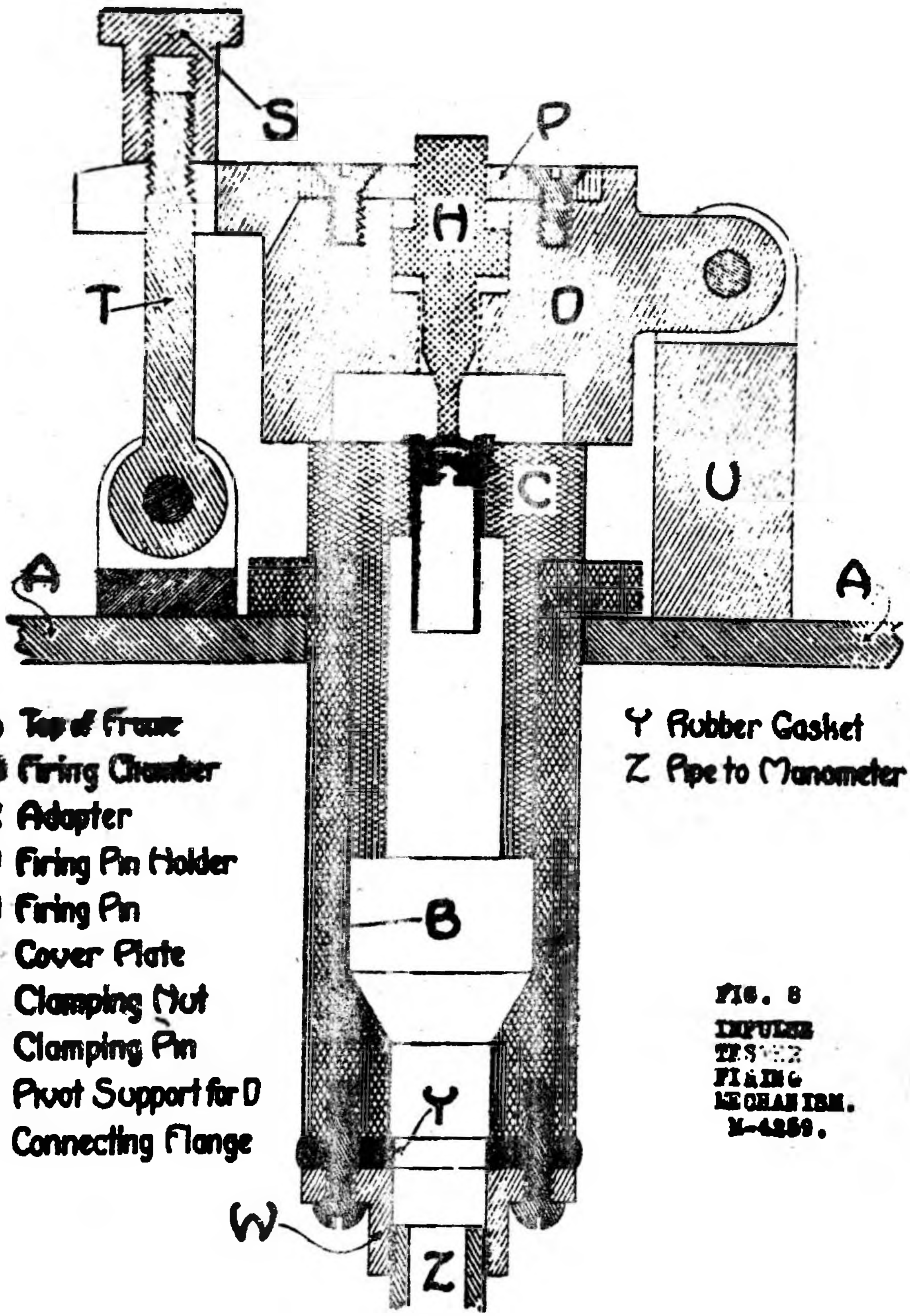
FIG. 7

(A third upright brass rod, to the rear and forming a triangle with the two just mentioned, has since been added to obtain rigidity in centering the magnet above the firing pin.) When the magnet is energized, a drop weight K is hung from the point of the magnet core and, on being released, drops squarely on the firing pin. The left upright, which is graduated in inches, also carries the arm L which supports a silk thread on one end of which is very small cork float and on the other end a counterweight. However, it was later found that the mercury rise could be observed visually within the limits of precision of the method. The magnet G is energized by the storage battery R. The whole aparatus rests on three leveling screws, one of which is shown at M.

In Fig. 8 is shown a detailed cross-section through the center of the firing mechanism and chamber which will make the construction of this part more clear. The same letters have been used in all figures to indicate the same part. A is the upper side of the supporting frame. B is the firing chamber which is screwed in place in A. At the lower end of B is the flange W which connects B with the pipe Z leading to the manometer. Y is a rubber gasket to make a tight seal between B and W. C is one of the large adapters made to fit very closely into B and hold the primer. A twenty-grain primer is shown in place in this adapter. Above the adapter C is the firing pin holder D. On the right this is supported by a vertical hinge U, which is fastened to the base A. At the left side D is held by a ve rtical hinged rod T which swings into a slotted lug on D, and is clamped by the thumb-nut S. The under side of D is hollowed out over the primer and then drilled through for the firing pin H. The firing pin H is held by the plate P which may be removed for changing firing pins.

The various accessories and supplementary parts used with the Impulse Tester and shown in Fig. 9.

In the upper left hand corner are grouped the four DROP WEIGHTS for firing the primer. The three largest are made hollow so that by adding weight in the form of lead shot the weight of each may be varied. This enables any desired weight from sixteen ounces to four ounces to be obtained. The bottom of each weight is rounded off to a hemisphere and then at the top is a small central projection having a flat conical point. The magnet core also has a conical point so that the weight hangs vertically from the magnet and drops squarely on the firing pin.



A Top of Frame
B Firing Chamber
C Adapter
D Firing Pin Holder
H Firing Pin
P Cover Plate
S Clamping Nut
T Clamping Pin
U Pivot Support for D
W Connecting Flange
Y Rubber Gasket
Z Pipe to Manometer

FIG. 8
IMPULSE
TESTER
FIRING
MECHANISM.
M-4259.

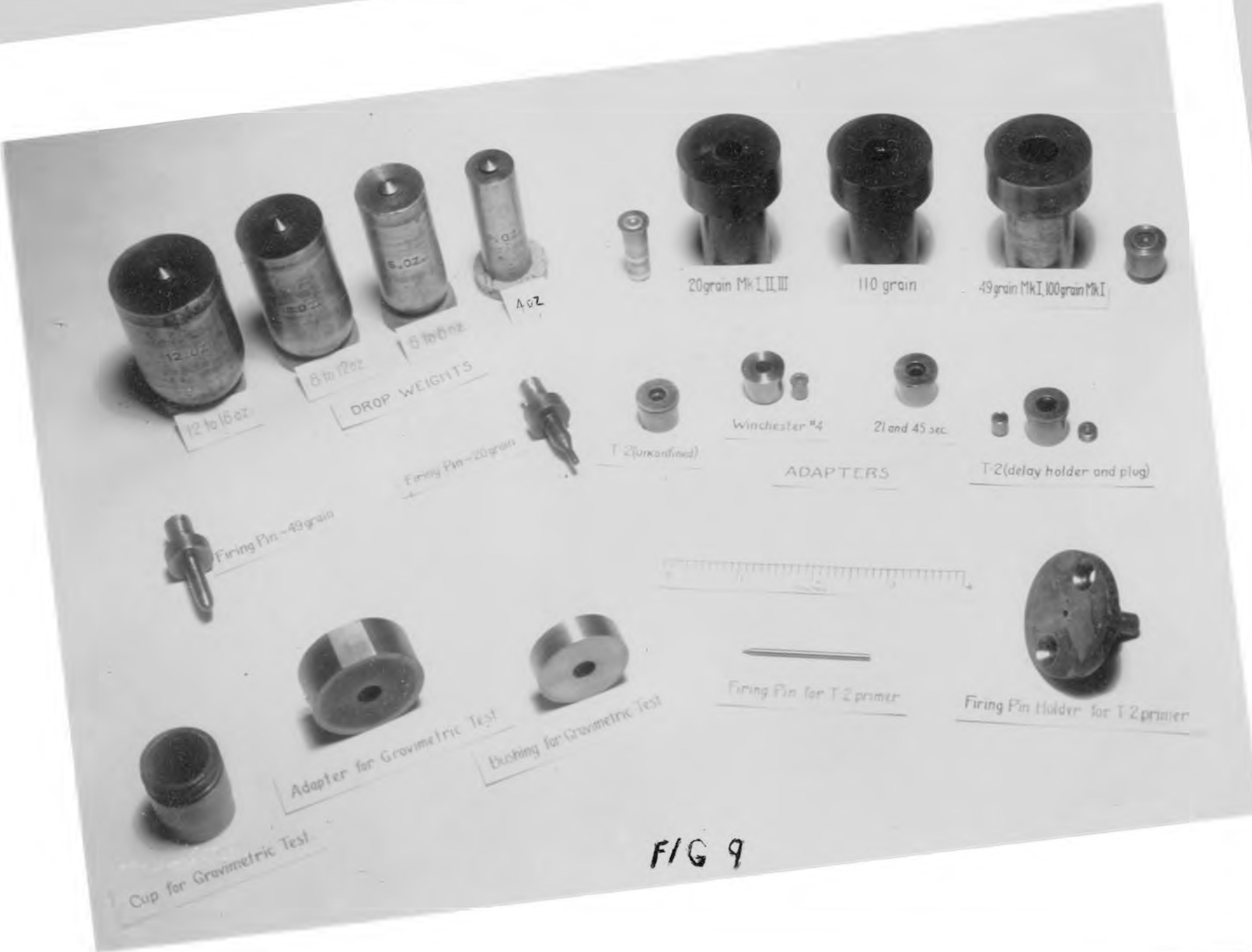

12 to 16 oz
8 to 12 oz
6 to 8 oz
4 oz
DROP WEIGHTS
20 grain Mk I, II, III
110 grain
49 grain Mk I, 100 grain Mk I
T-2 (unconfined)
Winchester #4
21 and 45 sec.
T-2 (delay holder and plug)
ADAPTERS
Firing Pin - 20 grain
Firing Pin - 49 grain
Firing Pin for T-2 primer
Firing Pin Holder for T-2 primer
Adapter for Gravimetric Test
Bushing for Gravimetric Test
Cup for Gravimetric Test

FIG 9

Just below the drop weights are shown the two large FIRING-PINS, one for use with 20-grain primers and the other for 49-grain primers. These may be interchanged by unscrewing the plate P shown in Fig. 8.

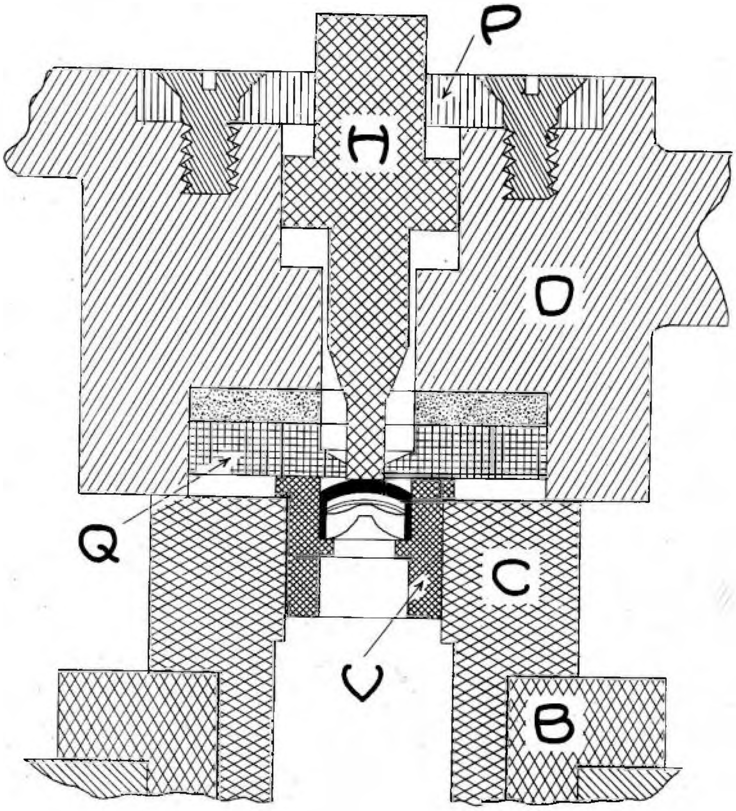
In the upper right corner of Fig. 9 are shown the three large ADAPTERS. These fit the firing chamber B as shown at C in Fig. 8. On the left side is the adapter for the 20-grain Mk. I, II and III, one of which is shown beside the adapter. In the center is the adapter for the 110 grain primer and on the right the adapter for the 49-grain Mk. I and 100-grain Mk. I. Beside it is shown the head of a 100-grain primer. To supplement these large adapters and make the instrument available for testing small primers for control work, there is a set of adapters, shown in front of the large ones, which fit into the 100-grain adapter. These take the Winchester #4 primer and the T-2 or M-39 primer with the delay holder and plug. The other adapters shown are no longer used.

The dimensions of the glass tubing in the manometer, as well as the weight of mercury used therein, are on record for duplication if necessary.

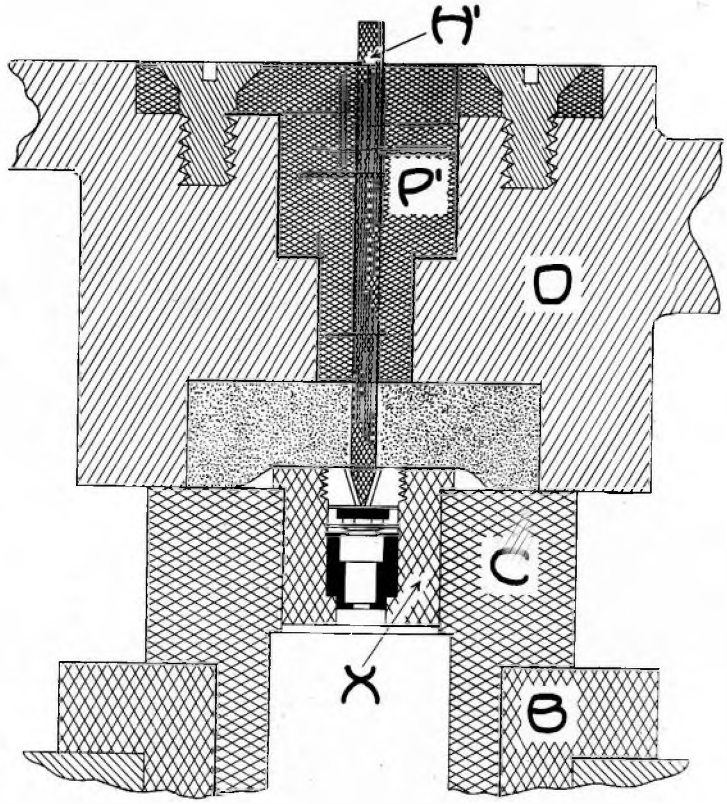
The volume of the manometer, connecting tube and firing chamber, up to the six and one-half inch mark on the scale (used as a convenient reference point) is equivalent to 349.9 grams of mercury at room temperature.

6a and 6b. Impulse and Gas Volume

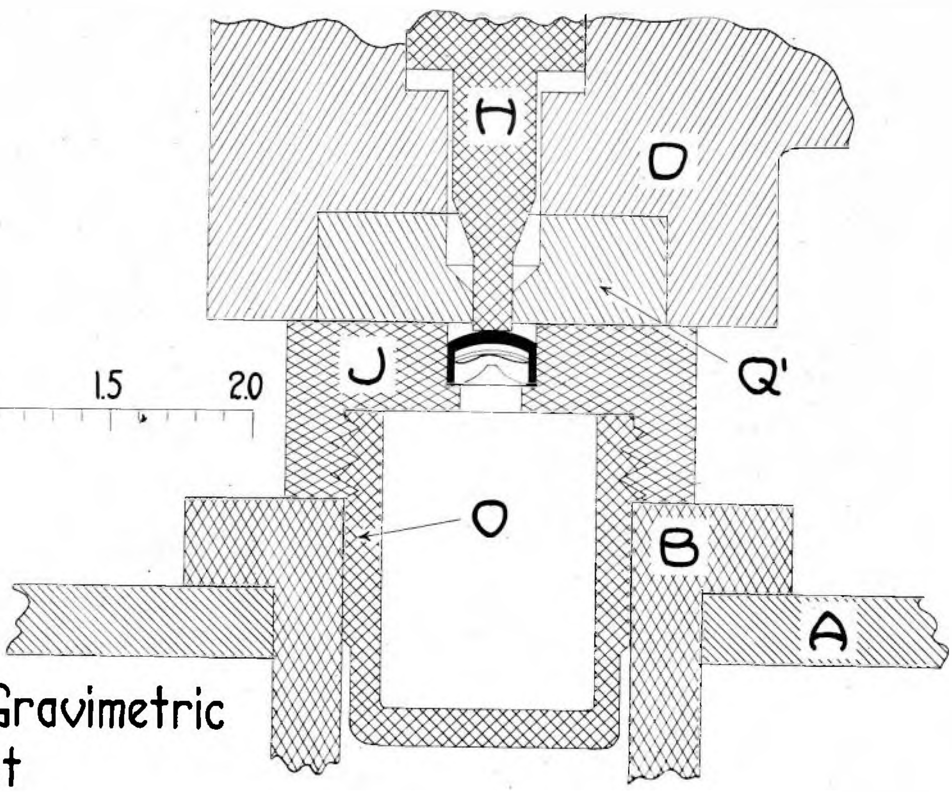
The instrument must be leveled before starting the test. A plumb-bob is suspended from the tip of the magnet core and the three leveling screws adjusted until the bob hangs just over the center of the firing pin. By referring again to Fig. 8 the set-up will be more clear. This is shown with a 20-grain primer in place. The adapter C is well smeared with heavy graase or vaseline on the lower portion and set into the firing chamber B, twisting it around to get a good seal. Into the adapter the primer, also slightly greased, is pressed. The firing pin holder D is closed over and clamped down in the adapter by means of the clamping rod T and the thumb-nut S. To relieve the pressure created by forcing the primer into the adapter, the petcock F, Fig. 7 , is opened for a few seconds until the mercury in the manometer has come to rest. The desired drop-weight is held against the tip of the magnet core and the switch closed. As soon as the weight hangs motionless,



Set-up for 20gr. Percussion Elements



Set-up for T-2 Percussion Elements



Scale of Inches

FIG. 10

Set up for Gravimetric Test

it is dropped on the firing pin by opening the switch and the primer is thus fired.

The firing of the primer gives two readings simultaneously. First, the explosion wave, transmitted through the closed system, throws the mercury to a certain height above its initial point of rest and this point is observed visually. This indicates the IMPULSE. The mercury then drops back to a lower level, but still above its initial position, where it holds steady for a short time. This is proportional to the Gas Volume.

The IMPULSE is reported as the difference in inches between the maximum height reached by the mercury column and its initial point of rest. This IMPULSE, like BRISANCE, probably includes the effect of rate of travel of the explosion wave as well as the pressure developed by the explosion . The GAS VOLUME is recorded as the inches difference in height between the point where the mercury temporarily holds steady and its starting level. For purposes of comparison this is left in terms of inches of tubing, but for absolute measure of gas volume this is converted to cubic centimeters and then corrected to standard temperature and pressure conditions.

6c. <u>Uniformity of Functioning</u>.

After ascertaining the minimum height that the chosen weight must fall to fire the primers, a batch of considerable size, from 25 to 100, according to the nature of the priming composition, is fired to determine uniformity of functioning.

6d. <u>Solids in Explosion Flame</u>.

This determination is made using weighed primers in a special adapter in the Impulse Tester. The parts used in these tests are shown in the lower left corner of Fig. 9 and the lower sketch in Fig. 10 shows it set up for use. The adapter J has in it a cavity just large enough to take the 20-grain percussion cup. The cavity communicates through a hole with the underside into which is screwed the cup O. The primer cup, anvil and paper disc are weighed empty and again after loading, the difference being the weight of the charge. After placing the loaded primer in the adapter and screwing up the cup, the whold assembley is weighed and placed in the Impulse Tester. Over the adapter is placed the bushing Q which just fits the cavity in D and is provided with a hole for the firing pin to work through. The primer is fired and after a few moments to allow the explosion gases to cool the adapter is removed, the cup being unscrewed just enough to allow excess gases to escape.

The whole adapter assembly is next weighed again. The difference between the weight before and after firing gives the weight of gaseous products and the difference between the weight of the original charge and the weight of gaseous products gives the weight of solids in the flame.

A sample calculation follows:

Wt. of dried primer = 1.2430	Wt. of assembly before = 154. 0865
Wt. of empty primer = 1.1512	Wt. of assembly after = 154. 0638
Wt of dry charge = 0.0918	Wt. of gaseous products = 0. 0227

Wt. of dry charge = 0.0918
Wt. of gaseous products = 0.0227
Wt. of solids = 0.0691

$$\% \text{ Solids} = \frac{0.0691 \times 100}{0.0918} \quad \text{or } 75.2\%$$

6e. Sensitivity to Percussion.

This is determined on the Impulse Tester. It may be done separately or coupled with the determination of the impulse and gas volume. Except when running tests on plant lots this work is done with weighed charges in the primer. The supporting magnet is raised to such a height that the desired weight will fire the primer. From there it is lowered an inch or even a half inch at a time until the point is reached at which ten successive primers fail to fire. The sensitivity is then reported as one inch above the point at which ten misfires are obtained.

6f. Minimum Charge to Ingite Black Powder.

This is determined in an electric firing mechanism (Fig. 11) using loaded igniters. Several groups of primers are made up using a decreasing weight of charge and put into the igniters, having the black powder charge loaded in them. These groups are fired and in this way the minimum charge required to set off the black powder is determindd visually.

7. Duration of Primer Flames. (Ref. 14)

Although the primer flame is easily visible to the eye, efforts to determine its duration by means of a rotating drum camera were unsuccessful due to the lack of actinic light in the flame. Later it was found possible to obtain fairly satisfactory still pictures of these flames by the use of superspeed film, but the images obtained on this film were too thin to offer any hope of using the rotating drum to measure the duration of the primer flame.

The duration of the primer flame is measured by firing the primer into a paper disc rotating at any known and constant speed between 3,000 and 13,160 R.P.M., and controlled by a micrometer governor. The mechanism for firing the primers is a modified breedh portion of a Springfield rifle, supplied with adapters to take the various primer components. This rifle is mounted as shown on a bracket which is bolted to the stationary part of the motor mounting, and is arranged to permit shifting the axis of the firing pin closer or farther from the dege of the rotating disc. The firing mechanism of this is equipped with several firing pins and springs of different strengths appropriate to the several primers.

8. Form and Volume of Flame.

The effect of the primer upon the form and volume of the resulting black powder flame is determined in the 20-grain primer. The camera used in this work is the rotating drum camera. This camera will be described later. For the present purpose, however, the driving mechanism of the camera is disconnected and the film drum is turned a little after each exposure so that five shots may be recorded on one strip of film. The film used is Eastman Commercial Panchromatic in strips 3-7/8 inches by 20 inches. The primers are fired in the electric firing mechanism (Fig. 11) built according to Drawing CP-10907. The loaded primers are held in this mechanism at a convenient distance form the camera in a dark tunnel and, after opening the camera shutter, the primer is fired. In order to measure the extent of the flash a screen ruled in inches and tenths is photographed in the same position as the primer.

After developement of the exposed film the dimensions and form of each flash in the series are taken from the film and plotted full size on cross-section paper. This gives a series of outlines representing the individual flashes superimposed and from this a single outlire may be drawn which approximates the average of the group of five which are fired. The line represenping the center line of the primer is drawn and prolonged through the outline. The right and left section of each composite is marked. The whold pattern is then cut out and also cut apart along the center line previously drawn. Each piece is weighed and the weight noted, as well as the weight of

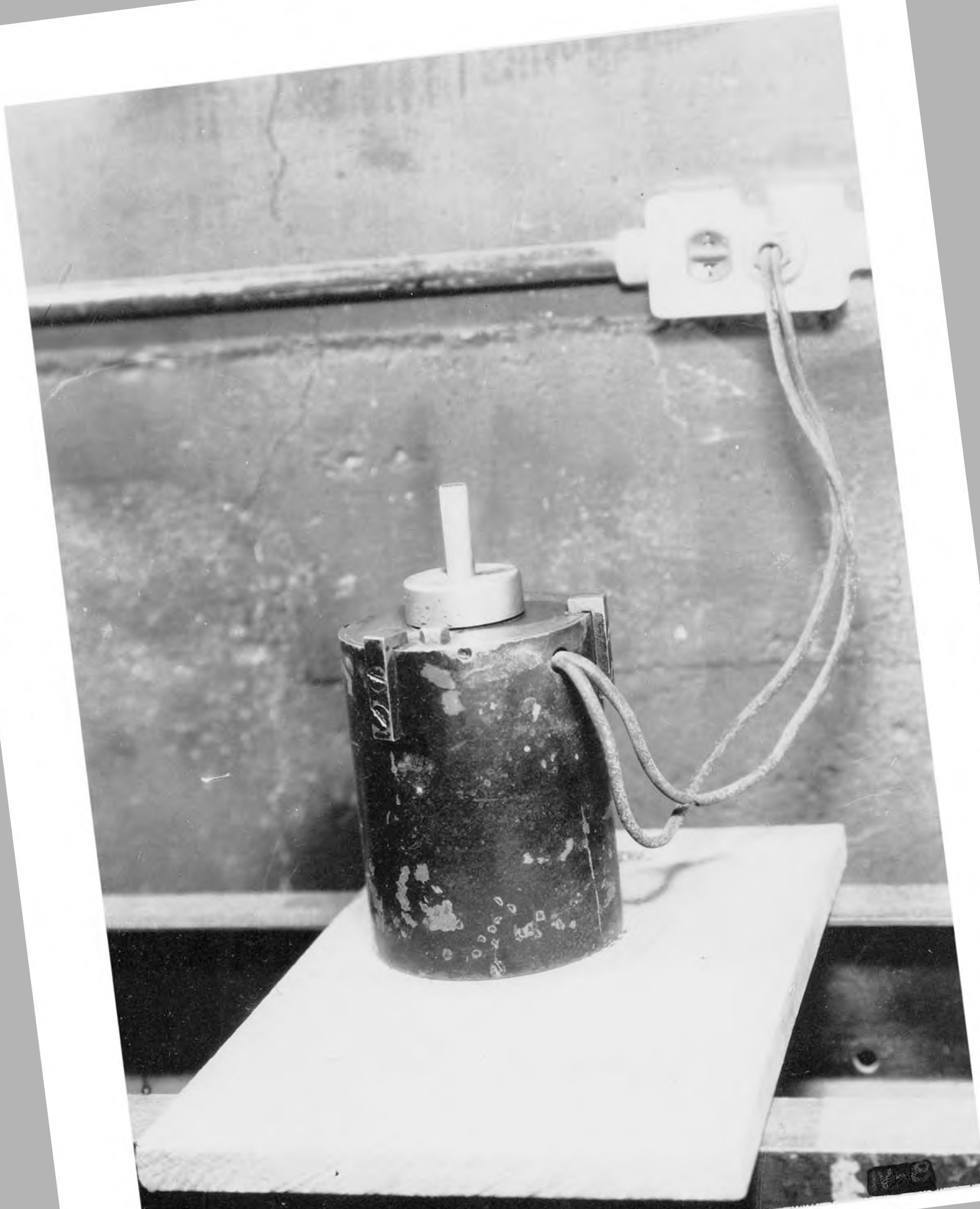


FIG. 11

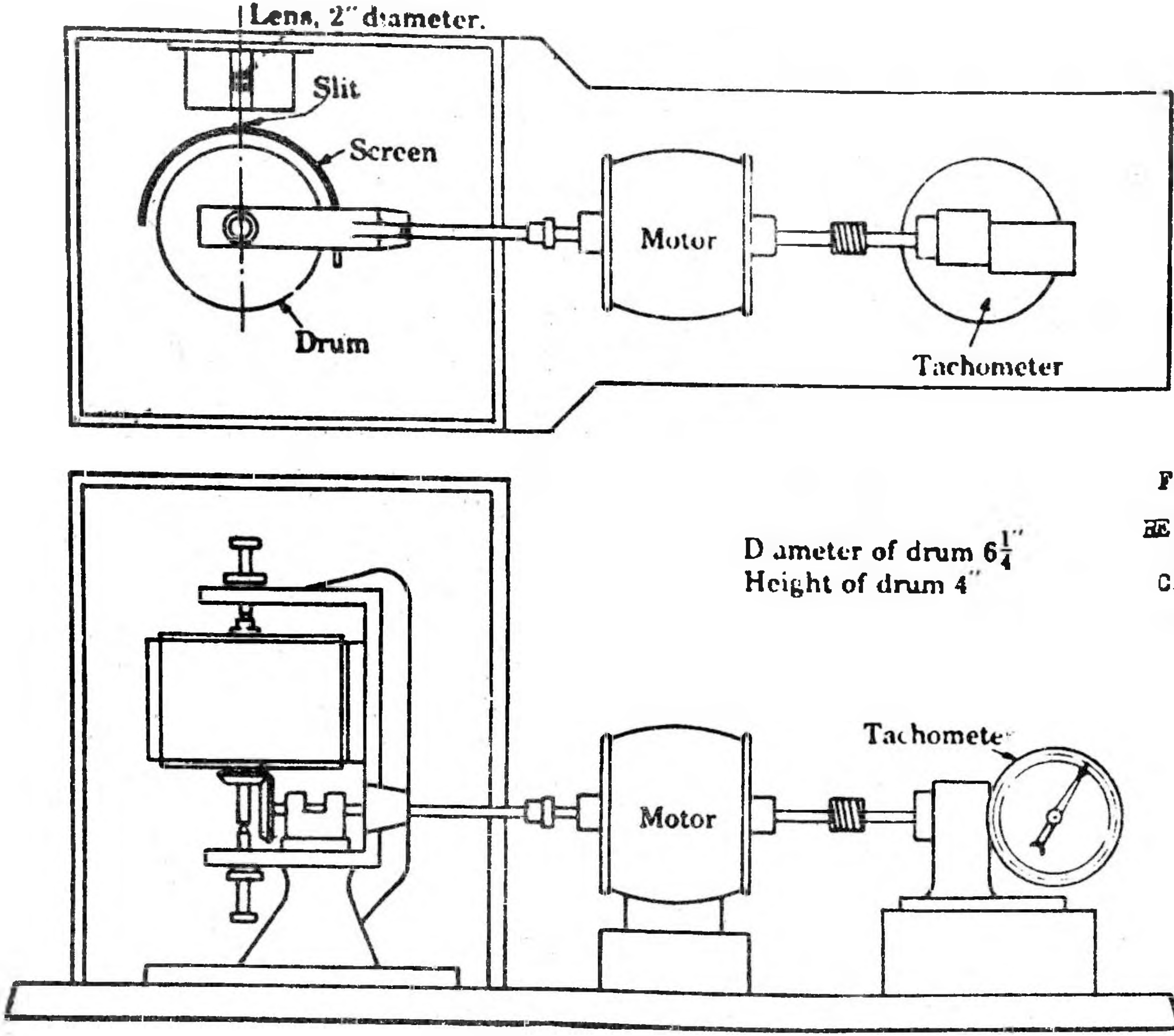
a piece of the same paper of known area. By comparing the weight of each section of the flame drawings with the weight of the known area, the area of the sections is easily obtained. By hanging the sections from a pin at several points and drawing the vertical line from the point of suspension each time, the center of gravity of each section is located at the intersection of these lines. The distance of this center of gravity from the edge of the section which represents the center line is also determined. Now treating each section as a plane revolving about the center-line as an axis, the volume of the solid of revolution thus obtained may be calculated by application of Pappus' second theorem, stated on page 125 of "Applied Mechanics" by Fuller and Johnson, Vol. I. "If a plane surface, lying wholly on the same side of a straight line in its plane, revolves about that line, and thereby generates a solid of revolution, the volume of the solid, thus generated, is equal to the product of the revolving area, and of the path described by its center of gravity. This calculation gives one volume for the right hand section and another for the left hand, so the average of the two is taken and converted into cubic centimeters.

9. Duration of Flames Produced by Primer Igniters. (Ref. 12).

The effect of the primer upon the duration of the resulting black powder flame may be determined in the 20-grain primer. The revolving drum camera (Fig. 12) is used in this work. Eastman Transparent Non-curling film or Commercial Panchromatic film may be used in this work. The 20-grain primer is placed in the electric firing mechanism located at a convenient distance from the camera in the light-proof tunnel and after the film drum has been brought up to the speed desired, the camera shutter is opened and the primer fired. After development of the film, the length of the flame image in the direction of drum rotation is measured and the duration of the flame is then easily calculated from the diameter and rate of rotation of the drum or screen.

With the drum geared for the fast speed, 1200 R.P.M., the film has a linear velocity of 20 meters per second; when geared for low speed, the linear velocity of the film is 31.25 centimeters per second. Linear velocities for other values between 20 meters and 31.25 centimeters per second are readily calculated by simple proportion.

On account of the high centrifugal force at the fast speed it was necessary to hold the film in place on the drum



Photographic apparatus.

FIG. 12

REVOLVING DRUM CAMERA.

M-3915

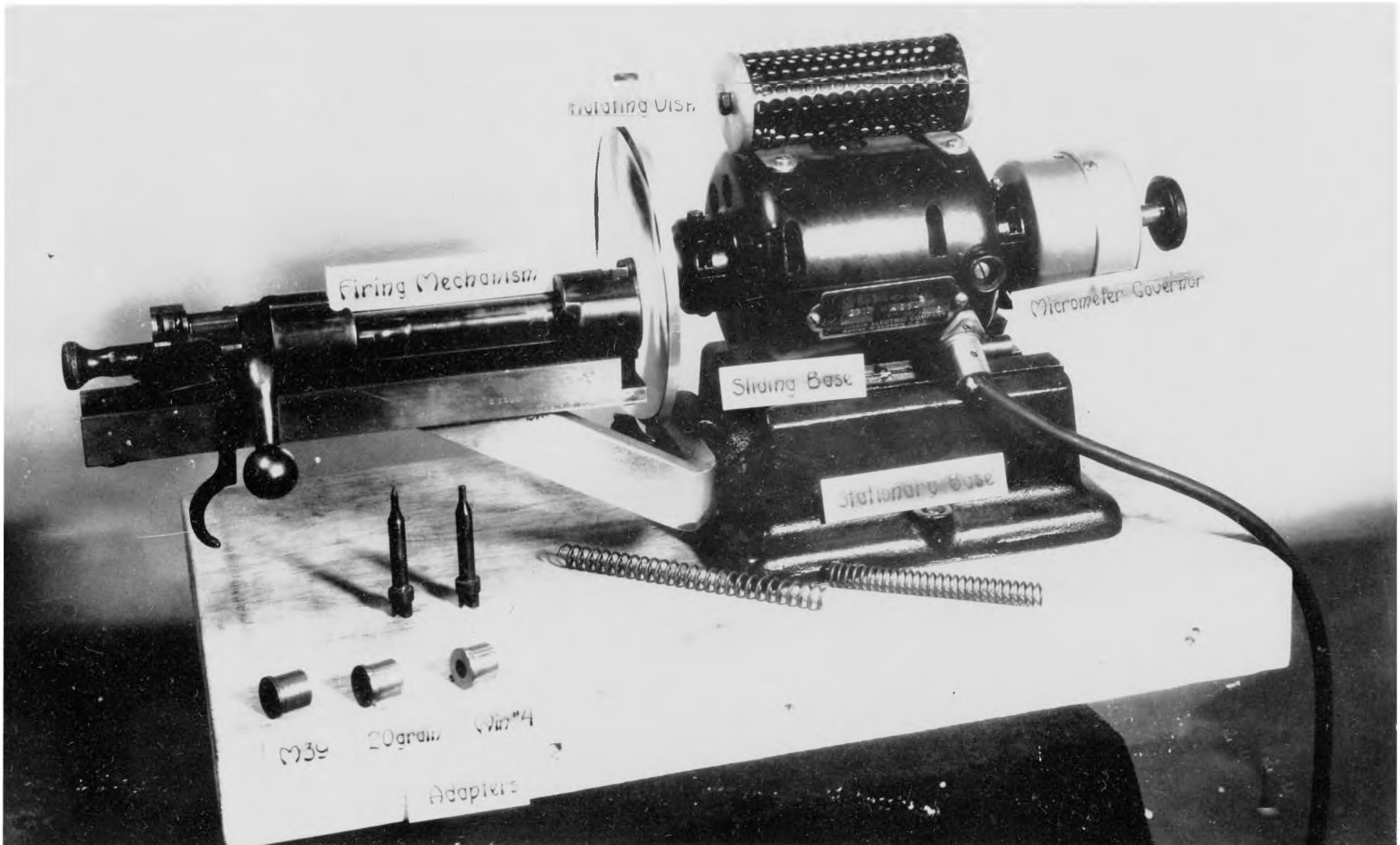

Rotating Disk
Firing Mechanism
Micrometer Governor
Sliding Base
Stationary Base
M39
20grain
Win#4
Adapters

FIG. 13

with a rubber band around it at each edge and a strip of adhesive over the free end. The characteristics of military primer compositions now is in use appear in Table II.

----- Note -----

If a new explosive successfully passes the small tests conducted in the laboratory, it is tested on a larger scale. These larger scale tests, on account of their danger, are conducted only on special areas designated for that use, such as the Testing Station at this Arsenal.

TABLES

Table I. Some Physical Characteristics of Military High Explosives.

Table II. Some Physical Characteristics of Military Primer Compositions Now In Use.

TABLE I

EXPLOSIVE CHARACTERISTICS OF MILITARY HIGH EXPLOSIVES

HIGH EXPLOSIVE	To Impact Inches Fall of 2 Kg. Hammer	To Heat Ignition Temperature °C	Rate of Detonation, Meters per Second	Brisance Grams Sand Crushed in Sand Test by .4 gram Explosive	Stability cc of Gas Evolved in 40 hours in vacuum at 120° C.
Mercury Fulminate D = 4.2 a	2 g	210 g 225 Recryst. g	5400 a	17.6 g	—
Lead Azide D = 4.6 a	6 g	335 g	5300 a	13.9 g	—
Tetryl Pressed / Cast D = 1.65a	8 g	260 g	7300 a / 7230 a	46.4 g	2.98 c
Amatol 50/50 D = 1.56a	12 g	265 g	7020 a Steel Tube	33.6 g	4.53 c
Tridite Cast D = 1.64c	13 g	315 g	6440 c	36.1 i f	.99 g
T.N.T. Pressed / Cast D = 1.59a	14 g	470 g	6700 a / 7030 a	35.7 g	.44 c
Amatol 80/20 D = 1.40a	15 g	290(approx) g i	5920 a Steel Tube	16.9 g	3.65 c
Picric Acid Pressed D = 1.70a / Cast D = 1.69a	16 g	322 g	7400 b / 7260 b	40.0 g	.42 c
Black Powder A-7, Meal War Reserve	16 g	457 g	400 a D = 1.20	8.5 g h	
Explosive D D = 1.52b	17 g	320 g	6700 b	32.1 g d	.52 c

References
to Table I

a. Explosives, Arthur Marshall, Vol. III, 1932, pp. 148-153.

b. L.R. Carl. Unpublished work done in initiating the Bureau of Mines program on Rate of Detonation. Quoted in Technical Division Lecture "Combustion; Explosion: Detonation", by V. C. Allison.

c. Average values from surveillance Records of accepted samples.

d. Technical Report R-106; O.O. 471.861/157; P.A. 471. 863/97.

e. Work by L.R. Carl. Information Memorandum to Aberdeen from C.J. Bain under Proj. 515.6-2. (Possibly 515.6-2/41 is the source of the information) in October 1928.

f. Laboratory Report No. 26495, Tridite from 155 mm. Shell.

g. Laboratory Report No. 36965, Miscellaneous. Physical Characteristics of Military High Explosives.

h. 0.3 gram of tetryl required.

i. Flash was obtained at 340°C. for 1 second and 331°C. for 1.5 seconds. Further exposure at lower temperatures resulted in decomposition rather than explosion or flash.

TABLE II

SOME PHYSICAL CHARACTERISTICS OF MILITARY PRIMER COMPOSITIONS

Composition Designation	No. 70	No. 1894	No. 74
Duration, Seconds, M-39	.00055	.00054	.00041
Impulse (0.08 g. Charge) Inches	6.5	4.1	5.3
Gas Volume (0.06 g. Charge) Cubic centimeters, Std. Press. and Temp.	2.02	1.49	2.16
Solids in Flame, (0.05 g. Charge) Percent	57.9	72.6	70.0
Sensitivity to Impact (0.03 g. Charge) 8 ounce weight	13.5	14.5	21.0
Relative Ability to Ignite Black Powder	High	Low	Medium
Flame Volume (0.06 g. Charge Yielded by 20-grain Igniter, Cubic centimeters	816	415	1200

Reference: P.A. Technical Report No. 64 and subsequent work on Problem 502.1-12 - Development of Methods of Testing Artillery Primer Caps.

List of References

1. Problem No. 502.12-12/1, Re: Study of Ignition Temperatures of Propellent Powders, Dec. 20, 1926.

2. Miscellaneous Laboratory Report No. 19895, Jan. 5, 1926.

3. Picatinny Arsenal Standard Methods of Analysis and Testing, Standard Drop Test on High Explosives, pp. 80, 81, 160; AP 2926 and AP 2924.

4. United States Bureau of Mines Bulletin 346, pp. 71-75.

5. Sensitivities of Detonating Compounds to Frictional Impact, Impact, and Heat. Taylor and Rinkenbach, Jour. Frank. Inst., 204, 369-376 (1927).

6. Explosives, Arthur Marshall, Vol.II, 1917, pp. 476-530.

7. Picatinny Arsenal Standard Methods of Analysis and Testing, pp. 142-144.

8. The Sand Test. Storm and Cope., Bureau of Mines Technical Paper 125, 1916.

9. U.S. 50-13-4, Specification for Tetryl.

10. U.S. 50-13-6, Specification for Mercury Fulminate.

11. Technical Report No. 64; O.O. 471.83/2305; P.A. 471.5/960-3-1.

12. Technical Report No. R-73; O.O. 471.5/5067; P.A. 471.5/788-28.

13. 505.0-4, Ammunition Explosive for Fuze, Booster and Shell, General - Standardization of Sand Test for Determination of the Sensitivity and Brisance of Booster and Shell Filling Explosives, May 22, 1923.

14. Technical Report No. 580, Development of Methods of Testing Artillery Primer Caps, Third Progress Report, 502.1-12/1.

SECTION II

HIGH EXPLOSIVES

3. Physical Testing of High Explosives-Proving Ground Methods.

Introduction:

In a previous lecture on the laboratory tests of high explosives the necessity for such tests has been explained. The tests which will now be considered are all on a larger scale and serve to confirm former tests as well as to determine some other qualities. The fragmentation test, setback tower and explosive train fixture, test the explosive more definitely for the special qualities required for military use. Since the explosive train fixture is used for a variety of purposes some of the studies involving its use will be discussed in detail.

Explosive Train Fixture - Ref. No. 1.

In designing ammunition, the aim is to produce a complete round which will function consistently. It may not be possible to produce, ammunition which will give 100% functioning, on account of factors which are beyond control, yet the number of failures can be reduced, by making sure that each of the explosive components are of sufficient strength to initiate detonation in the next succeeding explosive element of the train. Also each component must have a factor of safety so that dependable functioning will be assured even though deterioration of the explosive has taken place in storage.

The explosive train testing fixture has been designed to simulate a round of ammunition with provision of means for determining the effectiveness and the factor of safety of each component. With this equipment discs of metal, or an air gap may be interposed between the components. The amount of either which is required to prevent detonation of the explosive charge is taken as a measure of the effectiveness of the component. Provision is also made to determine the rate of detonation of the main charge. The determination of the rate may be used merely to determine whether or not a high order detonation occurred or to determine the characteristic of the explosive.

In almost all tests; up to the present, half hard brass has been used as the interposed material. In all cases where the discs are mentioned, one half disc will mean .017 inch and one disc will mean .034 inch of half hard brass.

History.

The explosive train fixture as now used was not produced at one stroke, but has been a gradual development of a general

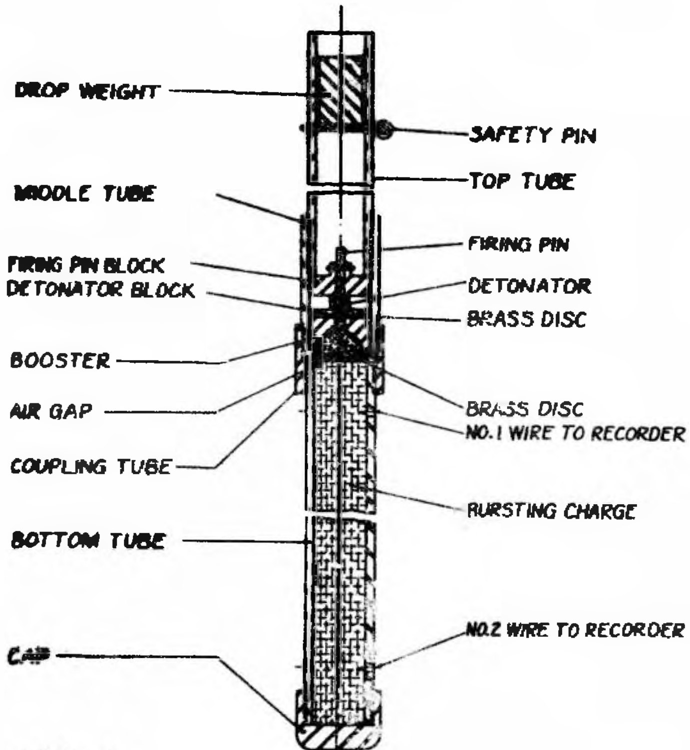


FIG. 1

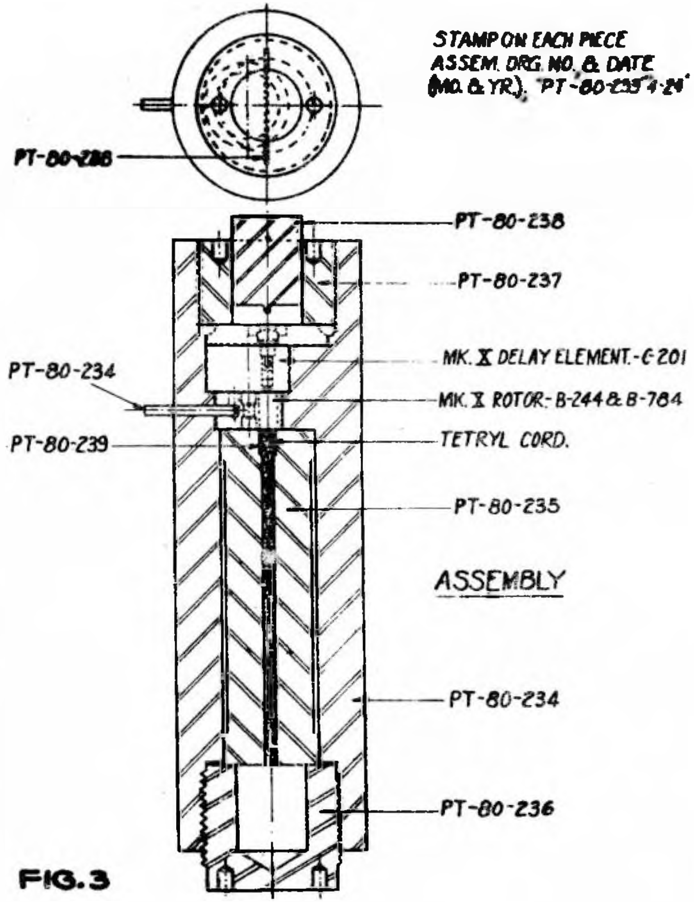


FIG. 3

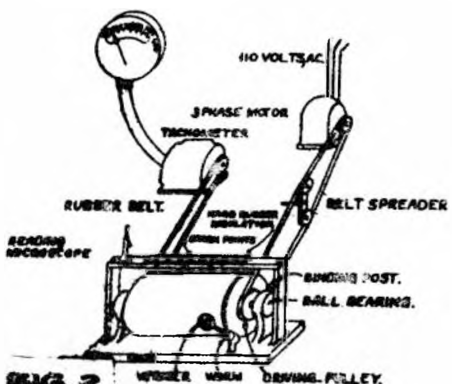


FIG. 2

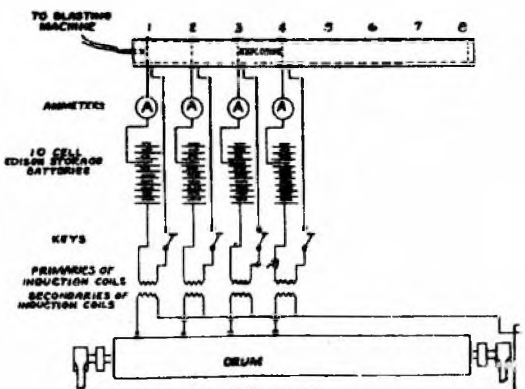


FIG. 4

idea. It will not be necessary to follow each minor change but it may be interesting to show the problem which was first studied by this means. The subject of this problem was, "The Effect of Density and Diameter of File on the Transmission of Wave of Detonation of Tetryl".

This work was performed because it was thought possible that failures secured with the Mk. X Base Detonating Fuze might be due to the small diameter of the tetryl lead from the detonator to the main body of the booster.

This equipment was built to take the mechanism of initiation of the Mk. X Fuze and contain a very long tetryl lead, $3\frac{1}{2}$ inches in length. Blocks were produced with several sizes of holes, but only that one having the smallest, i.e. .077 inches which is less than 2 mm. was used. With this size hole loaded with tetryl either of a very pure lot or with tetryl which failed to pass specifications, and containing 2% stearic acid, complete detonation was obtained even up to densities of 1.70. With the pure grade of tetryl plus 5% stearic acid at a density of 1.70 in two trials detonation was not complete. Five trials were then made in the same way except with 4% stearic acid and resulted in completed detonation. Tests were then made with tetryl at a density of 1.40 using percentages of stearic acid up to 15%. At 10% complete detonation was secured. At 15% slight reduction of violence and a large volume of flame was noted probably indicating a low order of detonation. An idea of the violence of the explosion of such materials as tetryl is gained by noting that the cylinder of steel which weighed over 300 grams was cracked radially in several places by a charge of approximately .45 gm. or less, and having a diameter of .077 inches or less than 2 mm.

As a result of this investigation any doubts which existed as to the ability of tetryl to transmit detonation through the lead of the Mk. X fuze were considered unfounded, as the tetryl lead in this fuze is 0.123 inches in diameter.

The study of the possible cause of malfunctioning in one particular type of ammunition was extended to make it applicable to the study of the explosive train in general, and to secure more or less fundamental data in regard to the functioning of all the parts which make up a high explosive round.
The effectiveness or sensitiveness of the components is measured by the amount of space or metal through which the detonation is transmitted. This should also give a good indication of the factor of safety possessed by the explosive. We will consider the tests of components in the order of their function in the round starting with the detonator, then the boosters and finally the main charge. All of the detonators studied up to the present are the type adapted for the newly designed fuzes. The

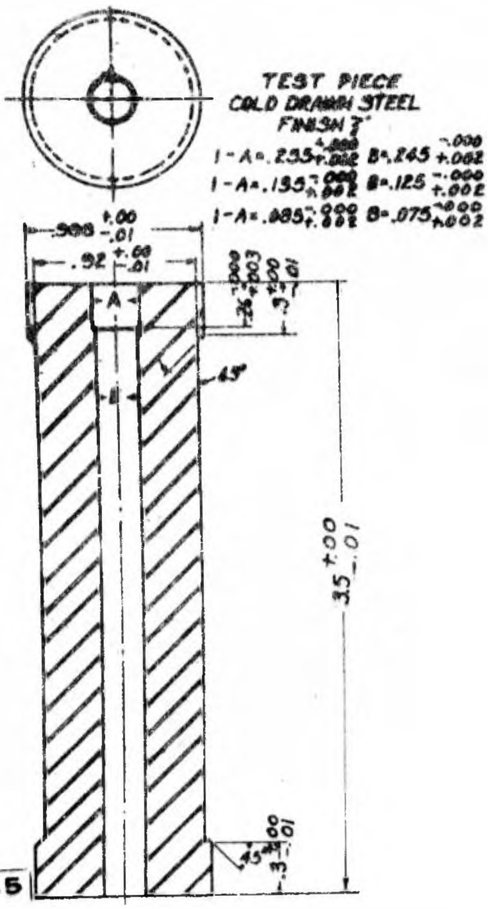
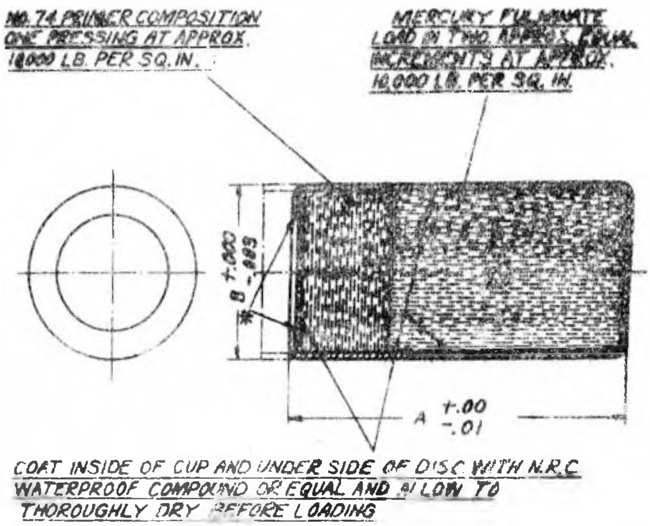


FIG.5

COL.	SIZE OF TUBE	DETONATOR			
		METAL	A	B	
1	.5 I.D.				
2	.75 I.D.				
3	1. I.D.	.008	.998	.194	B9177
4	1.5 I.D.				



* SEAL WITH WATERPROOFING WAX.

PRIMER DETONATOR ASSEMBLY

FIG.6

FOR E-13 FUZE PRIMER DETONATOR SEE DRG B-9177

FIRING RECORD

FUNDAMENTAL DATA ON DETONATORS
EFFECT OF HEIGHT AND DIAMETER OF CHARGE

DET. NO	WEIGHT OF CHARGE GRAMS	SIZE OF CUP INCHES DIAM.	SIZE OF CUP INCHES HEIGHT	HEIGHT OF CHARGE INCHES	KIND OF CHARGE	LOADING PRESSURE LBS PER SQ. IN	NO. OF PLATES INTERPOSED WITH 2.0 CONSECUTIVE NO DETONATIONS	RATE OF DETONATION M.P.S.	NO. OF PLATES WITH WHICH FAILURES OCCURRED	NO. OF ON WHICH FAILURE OCCURRED
1	3	.155	.215	.182	FUL.	10,000	½	5840	1	6
2	5	.155	320	.280	FUL.	10,000	½	6690	1	13
3	6 ½	.155	.415	.377	FUL.	10,000	1 ½	5720	2	6
4	7 ¾	.155	520	.475	FUL	10,000	1 ½	3335	2	1
5	9 ½	.155	620	.575	FUL	10,000	1 ½	6475	2	3
6	4 ¾	.190	215	.182	FUL.	10,000	½	5755	1	9
7	7 ½	.190	320	.280	FUL.	10,000	1 ½	6500	2	4
*8	8 ¼	.190	.415	.377	74 MIX FUL	10,000	2	6100	2 ½	5
9	9	.190	.415	.377	FUL.	10,000	1 ½	6795	2	7
10	9 ¾	.190	.415	.377	FUL.	20,000	1 ¼	6165	2	5
11	10 ¾	.190	.415	.377	FUL.	30,000	0	FAILED SHOT NO 5	½	7
ϕ12	9	190	.415	.377	74 MIX FUL	10,000	2 ½	5875	3	4
13	11 ½	.190	.520	.475	FUL.	10,000	2	6005	2 ½	4
14	14	190	.620	.575	FUL.	10,000	2	5990	2 ½	5
15	6 ¾	.225	215	182	FUL.	10 000	½	6030	1	4
16	10 ¼	.225	320	280	FUL	10,000	2	5695	2 ½	4
17	13 ½	.225	.415	.377	FUL	10,000	2	5825	2 ½	7
18	16 ½	225	520	475	FUL	10,000	3	6355	3 ½	3
19	20 ½	225	.620	.575	FUL.	10,000	3	5690	3 ½	4
⊙20	9	.190	.415	377	FUL.	10,000	2 ½	5780	3	1

* FORMERLY THE E13
ϕ THE MK X DETONATOR
⊙ DETONATOR NO 9 FIRED IN REVERSED POSITION

FIG.8

PLATES BRASS, HALF HARD
THICKNESS .034

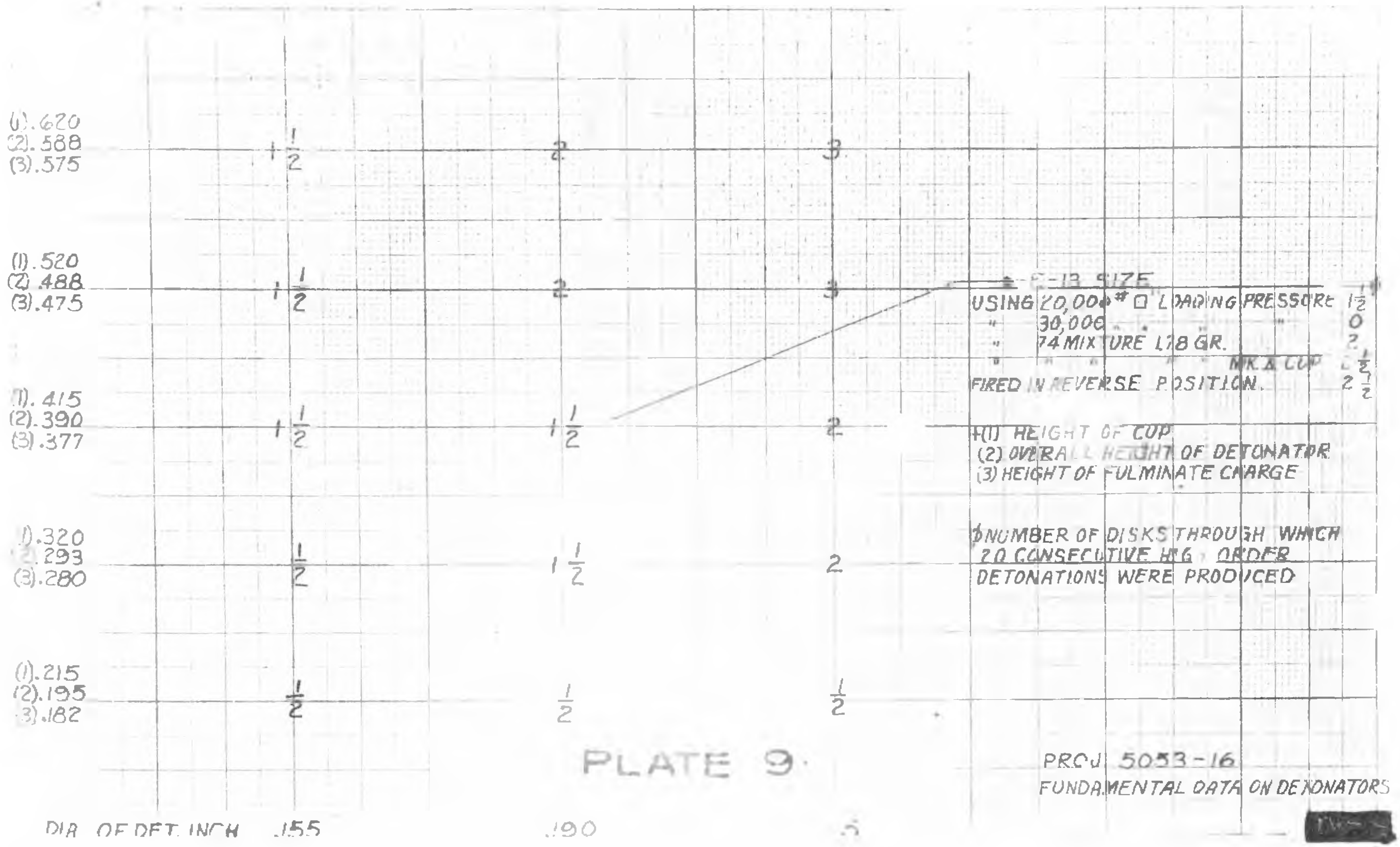

(1).620
(2).588
(3).575
(1).520
(2).488
(3).475
(1).415
(2).390
(3).377
(1).320
(2).293
(3).280
(1).215
(2).195
(3).182
1 1/2
2
3
1 1/2
2
3
1 1/2
1 1/2
2
1/2
1 1/2
2
1/2
1/2
1/2
E-13 SIZE
USING 20,000# □ LOADING PRESSURE 1 1/2
" 30,000 " " " 0
" 74 MIXTURE 1.78 GR. 2
" " " " " MK. & CUP 2 1/2
FIRED IN REVERSE POSITION. 2 1/2
(1) HEIGHT OF CUP
(2) OVERALL HEIGHT OF DETONATOR
(3) HEIGHT OF FULMINATE CHARGE
NUMBER OF DISKS THROUGH WHICH 20 CONSECUTIVE HIGH ORDER DETONATIONS WERE PRODUCED
PROJ. 5053-16
FUNDAMENTAL DATA ON DETONATORS
DIA. OF DET. INCH .155
.190
.5

PLATE 9

following indicates the wide application of the fixture for testing the different components.

<u>Fundamental Data on Detonators - The Effect of Height and Diameter - Ref. No. 2.</u> In this series detonators having diameters of .155, 190 and .225 and heights of .215, .320, .415, .520 and .620 were used making a series of 15 sizes. These detonators had a charge capacity for fulminate, varying from 3 grains to 20½ grains. The smallest containing approx-mately the minimum amount of fulminate capable of causing detonation of tetryl and the largest, so large that it would be impractical to secure bore safety when used in a fuze.

The detonators were all loaded with straight fulminate in two increments at a pressure of 10,000 lbs. per square inch. Each of these detonators was shot in the explosive train fixture with varying amounts of metal interposed until the point was found where twenty consecutive high order functionings were secured and also the point at which failure occurred. The results of these firings are shown on Plate Nos. 8 and 9.

The E-13 size of detonator (No. 9) fulminate loaded, has sufficient strength to initiate high order detonation in the booster when six times the amount of metal used in the fuze is interposed between the base of the detonator and the tetryl load.

The use of 1-3/4 grains of No. 74 mixture over the fulminate increased the factor of safety about 25% according to this method of testing. Although the 74 mixture apparently assisted the fulminate in puncturing brass, later works showed it to be useless in detonating tetryl.

It will be noted that detonator No. 12 the Mk. X having an indentation in the base is more effective than a detonator similarly loaded with a flat base. The shortest detonator containing only 3 grains of fulminate was as effective as the detonator containing 6¼ grains with increased diameter.

On Slide Nos. 10, 11, 12 and 13 is shown the effect of the explosion of the detonator alone on the metal parts surrounding them. It will be noted that those containing more than 11 grains ruptured the middle tube of the explosive train fixture. This would indicate that in case of the selection of a detonator of this size or larger that the bore safety factor of the fuze would be endangered. In the trials made with detonators loaded at higher pressures than 10,000 lbs. per square inch it is shown that this is not good practice, as higher pressure tends to rupture the

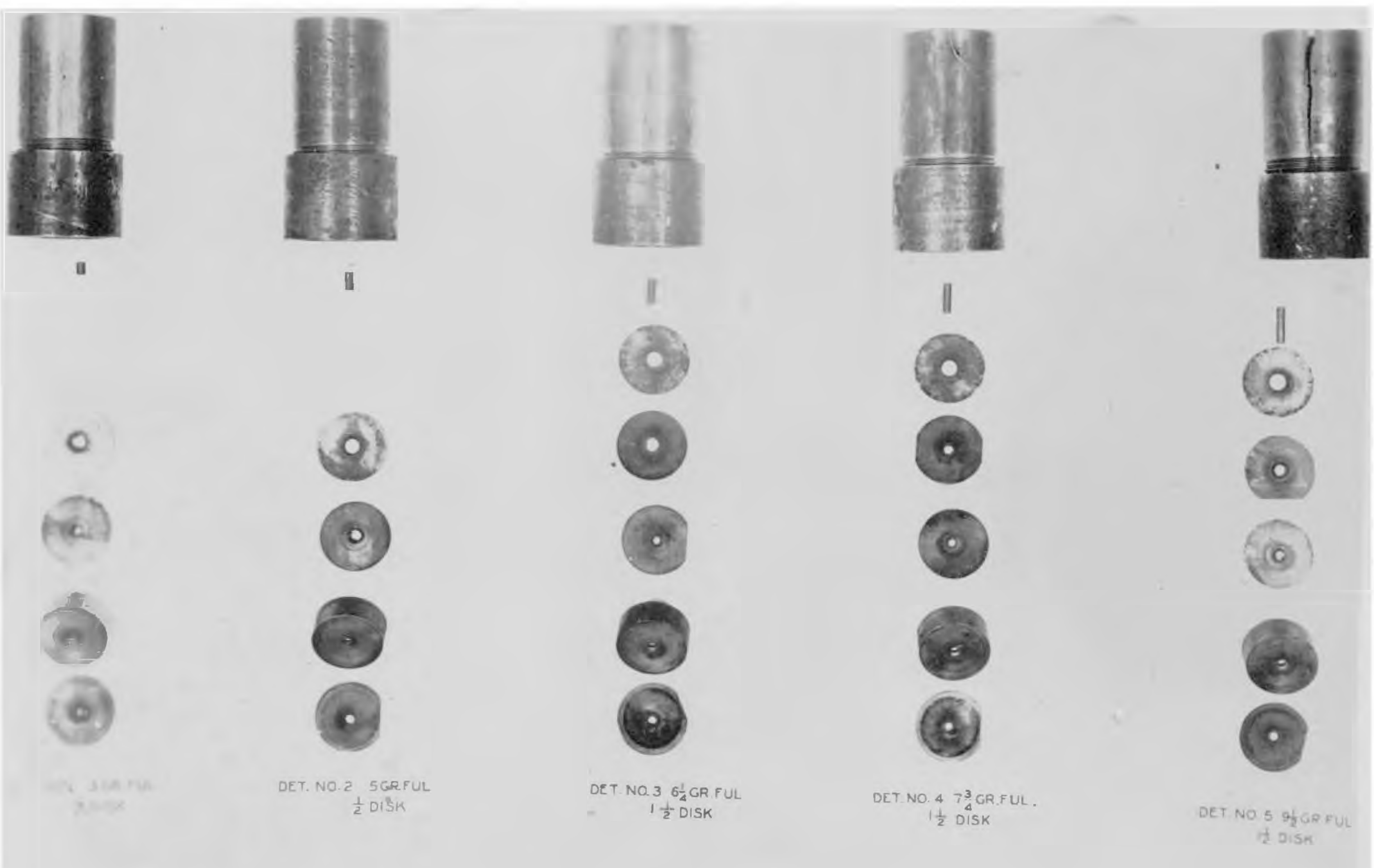
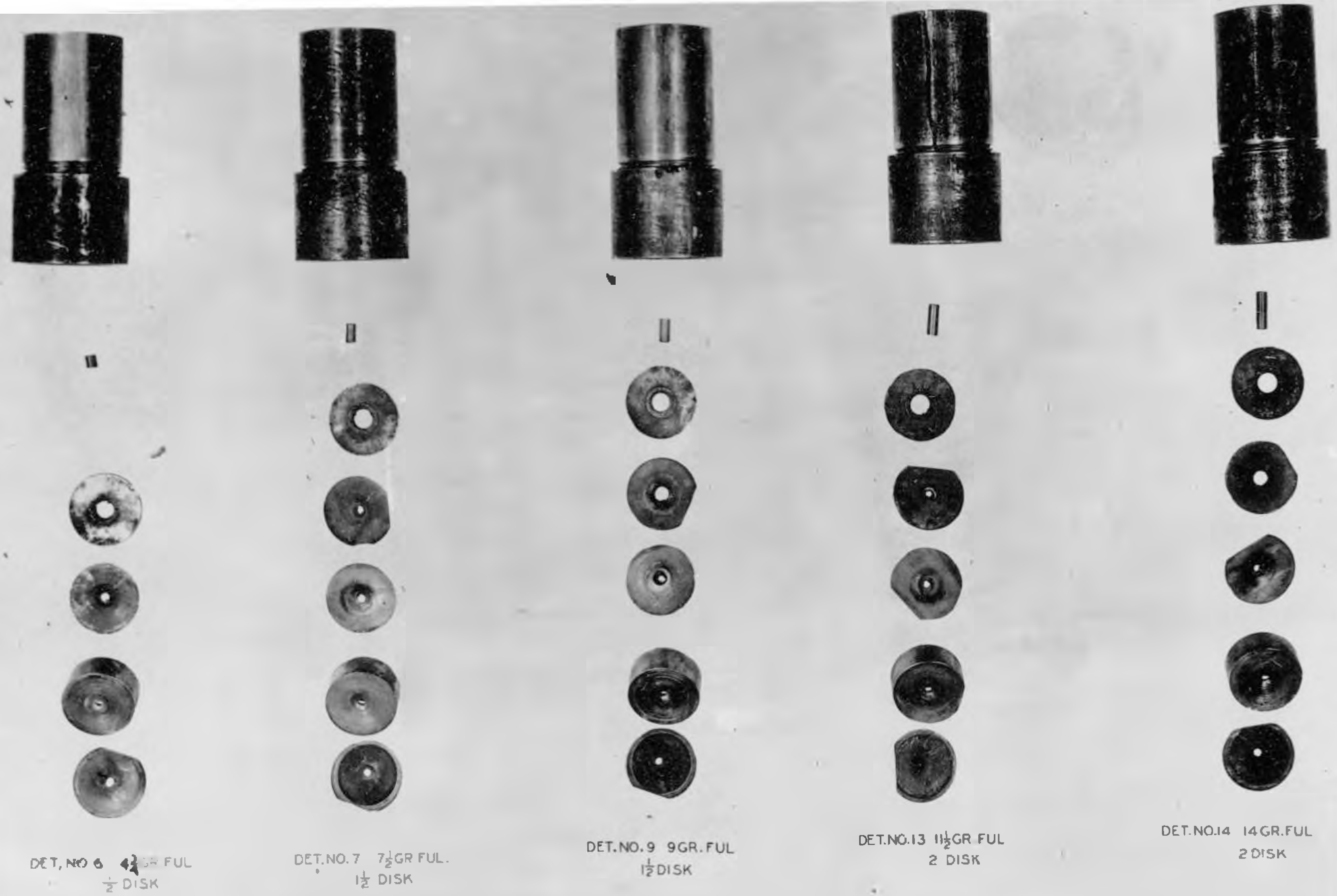


PLATE 10

PROJ. 505.3–16/1

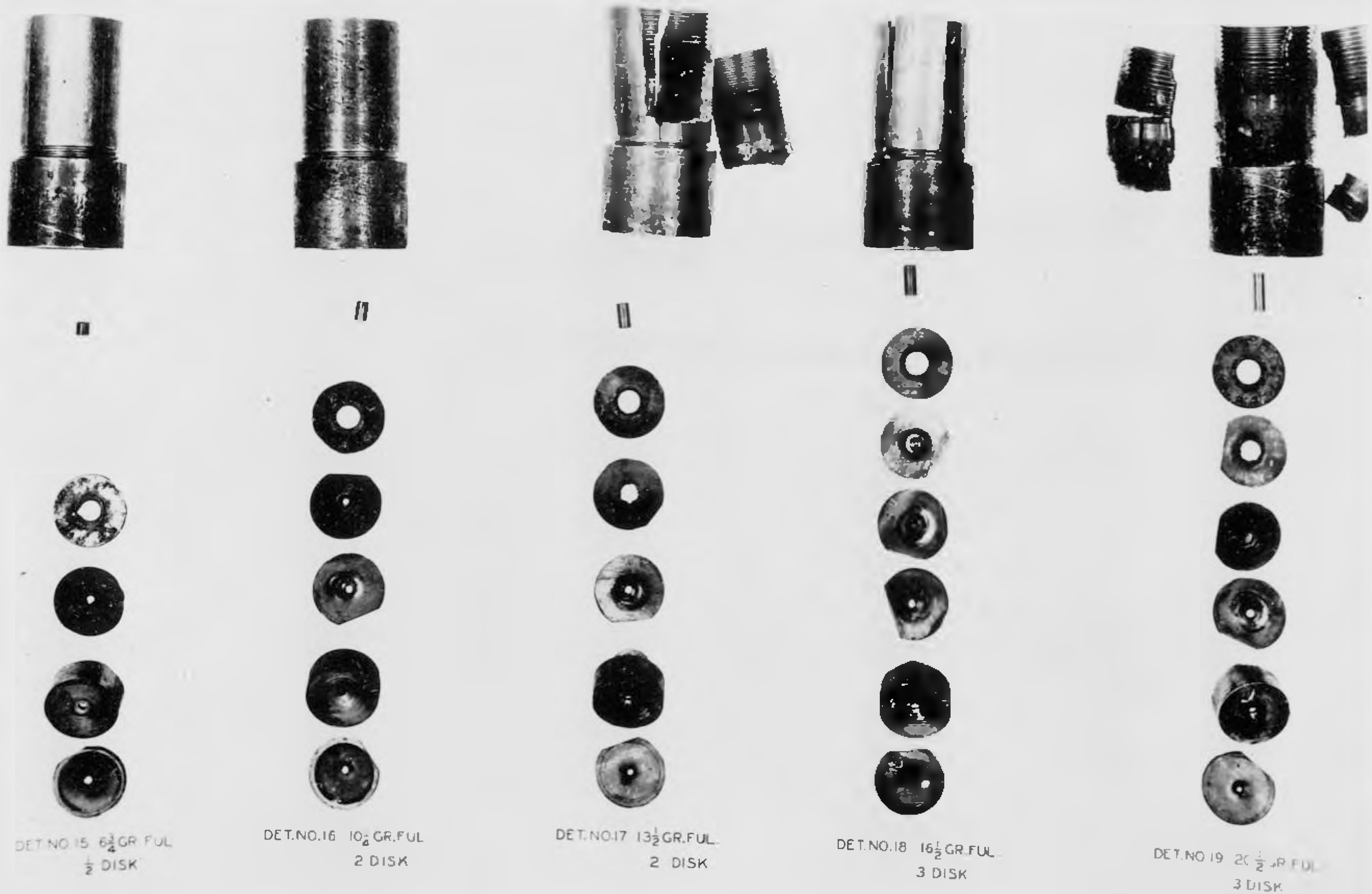
DETONATOR BLOCKS, INTERPOSED METAL, AND EMPTY BOOSTERS, AFTER FIRING DETONATORS. THE [illegible]RPOSED METAL IN EACH INSTANCE IS THAT THROUGH WHICH THE RESPECTIVE DETONATORS PRODUCED TWENTY CONSECUTIVE [illegible] ORDER DETONATIONS. EMPTY DETONATOR [illegible] ARE SHOWN TO ILLUSTRATE SIZE OF CHARGE.



PROJ. 5.05.3—16/1

DETONATOR BLOCKS, INTERPOSED METAL, AND EMPTY BOOSTERS, AFTER FIRING DETONATORS. THE INTERPOSED METAL IN EACH INSTANCE IS THAT THROUGH WHICH THE RESPECTIVE DETONATORS PRODUCED TWENTY CONSECUTIVE HIGH ORDER DETONATIONS. EMPTY DETONATOR CUPS ARE SHOWN TO ILLUSTRATE SIZE OF CHARGE

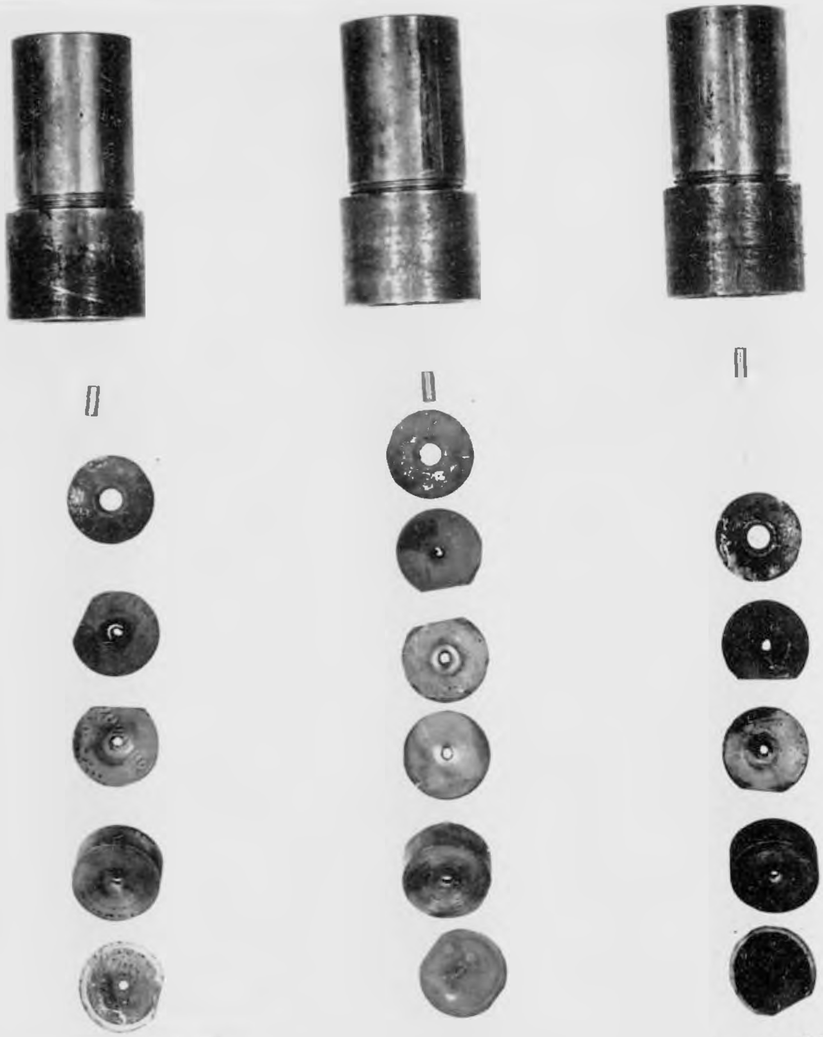
PLATE 11



PROJ.505.3-16/1

DETONATOR BLOCKS, INTERPOSED METAL AND EMPTY BOOSTERS, AFTER FIRING DETONATORS. THE INTERPOSED METAL IN EACH INSTANCE IS THAT THROUGH WHICH THE RESPECTIVE DETONATORS PRODUCED TWENTY CONSECUTIVE HIGH ORDER DETONATIONS. EMPTY DETONATOR CUPS ARE SHOWN TO ILLUSTRATE SIZE OF CHARGE.

PLATE 12



DET. NO 8 E-13 1.78 NO. 74 MIX 6.34 FUL.
2 DISK.

DET. NO.12, E-13 MK.-10 CUP
$2\frac{1}{2}$ DISK

DET. NO.21 5 GR. FUL 1.75 GR. TETRYL
2 DISK

PROJ. 5.05.3 – 16/1

DETONATOR BLOCKS, INTERPOSED METAL, AND EMPTY BOOSTERS, AFTER FIRING DETONATORS. THE INTERPOSED METAL IN EACH INSTANCE IS THAT THROUGH WHICH THE RESPECTIVE DETONATORS PRODUCED TWENTY CONSECUTIVE HIGH ORDER DETONATIONS. EMPTY DETONATOR CUPS ARE SHOWN TO ILLUSTRATE SIZE OF CHARGE

PLATE 13

detonator cup. The detonator loaded at 30,000 lbs. pressure failed to produce high order detonation when no metal was interposed. Pressed at 20,000 lbs. the detonator functioned satisfactorily but after storage at 50°C. for 6 months it showed greater deterioration than the same detonator loaded at 10,000. Analysis of the fulminate from the detonators pressed at 10,000 and 20,000 lbs. per square inch and after storage at 50°C. for 9 months showed that the one pressed at the higher pressure contained 93.8% of fulminate or 1% less than the detonator pressed at 10,000 per square inch.

In detonators having a diameter of 0.190 inch it was found that a height of charge of 0.28 inch (No. 7) was as effective as a height of charge of 0.377 (No. 9) and only a slight increase was obtained by increasing to a height of charge to 0.575 inch (No. 14). By such an increase in height the weight of the charge was increased from 7½ grains to 14 grains while the added effectiveness was only 1/2 disc.

Fulminate-Chlorate Mixtures:- Sand test results seem to indicate a greater effectiveness of the 80/20 mixture of fulminate and potassium chlorate than for straight fulminate. In order to definitely settle the point from the ammunition point of view trials were made with the E-13 size loaded with the 80/20 mixture. The results showed this mixture to be only two-thirds as effective as the straight fulminate. This detonator only penetrated one disc as compared to 1½ for the straight fulminate. When 1.75 gr. of No. 74 mixture was added to the 80/20 fulminate, failures were secured even on 1/2 disc.

Compound Detonators:- Compound detonators were made in cups of the same size as the No. 9 (E-13) and loaded with 1 gr. of tetryl plus 3¾ gr. of fulminate plus 1.78 gr. of No. 74 mixture. Similar detonators were loaded with PETN and cyclonite substituted for the tetryl. All of these detonators either failed or passed on only 1 disc. In later tests a cup of the same size was loaded with 1¾ gr. of tetryl plus 5 gr. of fulminate. This detonator gave 20 consecutive high order detonations with 2 discs over the tetryl lead. Later when the height of the fulminate charge was being studied it was found that the height of the fulminate charge weighing 3¾ grains was below the minimum, of .155 inches which is necessary to obtain the maximum rate of detonation or brisance of mercury fulminate. It is interesting to note that this height of fulminate charge was not effective when No. 74 mixture was loaded above it. The total height of the combined charge of fulminate and primer mixture being .3 inches, or nearly twice the height required for fulminate. It is indicated that the Number Seventy-Four (74) mixture has no effect as an initiator and does not affect the height of fulminate required to initiate tetryl. In a further study of the compound detonator of the E-13 size a comparison was made with the straight fulminate detonator as to their ability to jump an air gap. The strai ht fulminate was able to jump a gap of 0.1 inches compared to a gap of o.29 inches for the compound detonator.

The Method of Ignition of a Detonator:- Trails were made with the E-13 sizedetonator using the spit from black powder as a means of ignition to determine if any difference in the effectiveness of the detonator would result. Twenty consecutive high orders on $1\frac{1}{2}$ disks with failure on 2 disks resulted which is the same as was secured when the detonator was fired by stabbing. It would, therefore, appear that the effectiveness of a detonator is independent of its method of initiation.

The Effect of the Diameter of the Tetryl Lead on the Effectiveness of the Detonator:- It was found by making trials with detonators of three diameters and using tetryl leads of four different diameters, that to secure the maximum efficiency the diameter of the lead must bear a relation to the diameter of the detonator. Lowered efficiency was shown when the lead was greater in diameter by more than .025 inch or smaller by .025 inch than the detonator.

Boosters. Ref. No. 5.:- Three types of booster casings were tried. Slide Nos. 14, 15 and 16 show the three designs. The long cylindrical type was found to be least effective, giving high order detonation through three disks. The ellipsoidal booster gave high orders through 5 disks, and the short cylindrical proved slightly more effective giving high orders through 6 disks, in every case using tetryl as the booster explosive.

Comparison of Booster Explosives:- Four booster explosives were tested using the cylindrical and ellipsoidal booster cavities. The explosives selected were tetryl, picric acid, cyclonite and T.N.A.

The tetryl and cyclonite were equally effective both passing with 6 disks withthe cylindrical cavity and on 5 with the ellipsoidal. The T.N.A. was less effective with both types cavity, passing with 5 and 4 respectively. The picric acid passed on only 1 disk with the cylindrical cavity. With the ellipsoidal cavity it gave high orders with 5 disks. This result excited some curiosity due to the fact that in every other test the cylindrical was slightly superior in its functioning to the ellipsoidal cavity. The only possible explanation seemed to be the fact that the ellipsoidal booster cavity had been zinc plated. A number of these metal parts were therefore dezinced and loaded in the same way with picric acid. When tested in this condition the booster passed on only 3 disks or 2 disks less than when the zinc plated part was used.

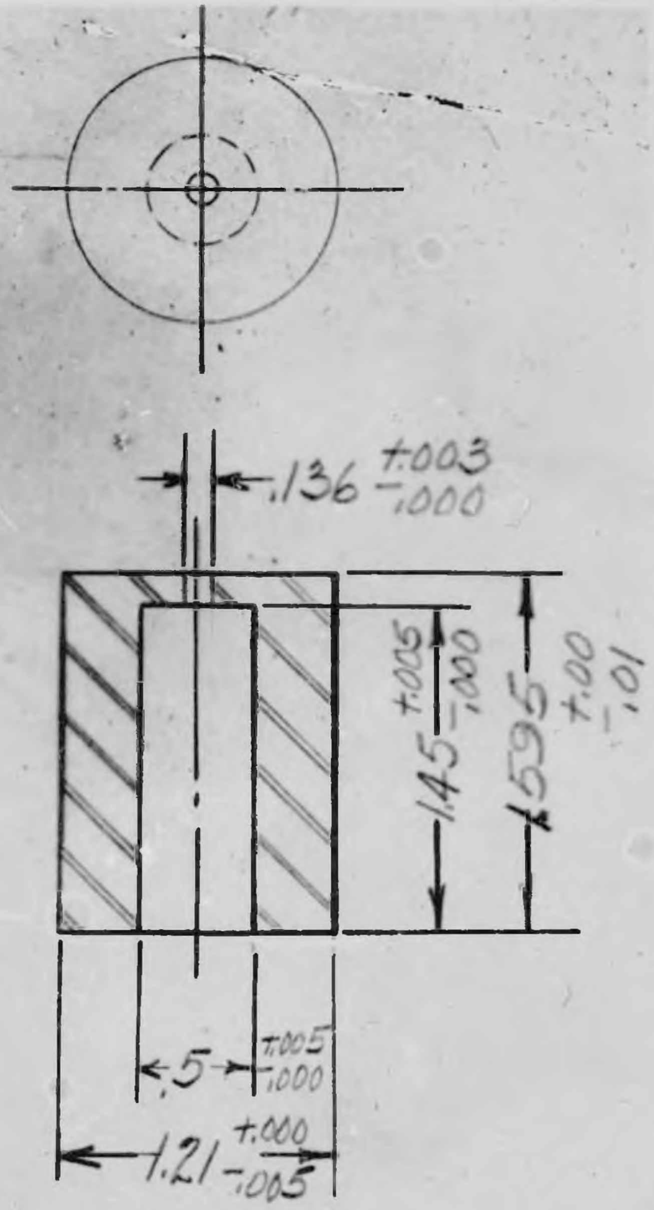
Position of the Tetryl Lead, Ref. No. 3:- There might arise a case in fuze design where it would be advantageous to place the tetryl lead in some other position than in the center of the booster. In order to settle this point a booster was manufactured having tha lead as close as practicable to the circumference. This position was selected because it was considered the most unsatisfactory of any position. Tests with this type of booster proved them to be just as effective as when the tetryl lead was in the center. Slide Nos 17 and 18.

Main Charge:- Tests were run to determine the rate of detonation of tridite, 80/20 picric acid-dinitrophenol. The tridite was loaded by the casting method into steel tubes, one inch inside diameter. The density, loaded in this way is approximately 1.64. The results of ten trials gave an average rate of 6440 m/sec. The sensitiveness of this explosive to detonation by a booster was found to be less than that of TNT. Four disks were required to prevent detonation as compared to six required for TNT. A further indication of the effect of zinc on picric acid was found when tridite was fired for sensitiveness to detonation in steel tubes some of which were zinc plated. Both sets of tubes had been stored for 3 months at 50° C. The tubes which had been zinc plated gave 5 high orders with 5 disks under the booster. The tubes which were not zinc plated gave 1 high order and 4 low orders.

Rate of Detonation of Amatols, Ref. No. 4:- It might become advantageous to load amatol by the pellet method the pellet consisting of lumps of ammonium nitrate. There was, however, some question of the effect of large granulations on the rate of detonation of amatol made up in this way. Charges of amatol were loaded for the explosive train using six granulations of ammonium nitrate. The granulations and the rates of detonation are given in the table below:

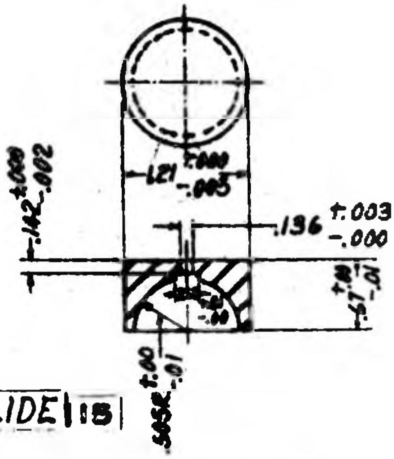
Granulation	Rate M/sec.
Thru 2 on 4 mesh	4905
Thru 4 on 8 mesh	5720
Thru 10 on 20 mesh	5695
Thru 20, on 40 mesh	5645
Thru 40 on 60 mesh	5650
Thru 60 on	5530

The rate of detonation of cast TNT was found to be 6705 M/sec. This compares with a rate of 6640 secured by the Bureau of Mines, using the Mettagang recorder. Four series of tests were made to determine how far the first wire should be placed from the booster. The results follow:



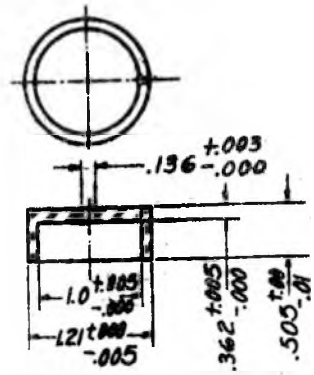
CAVITY, BOOSTER
STEEL, WD 1112
FINISH "f"

SLIDE 14

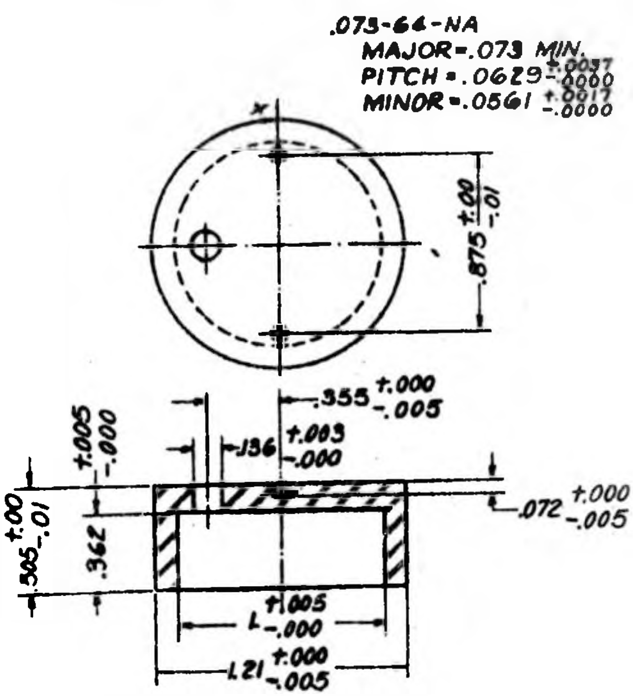


SLIDE 15

CAVITY, BOOSTER
STEEL WD1112
FINISH J
ZINC PLATED .001 THICK.

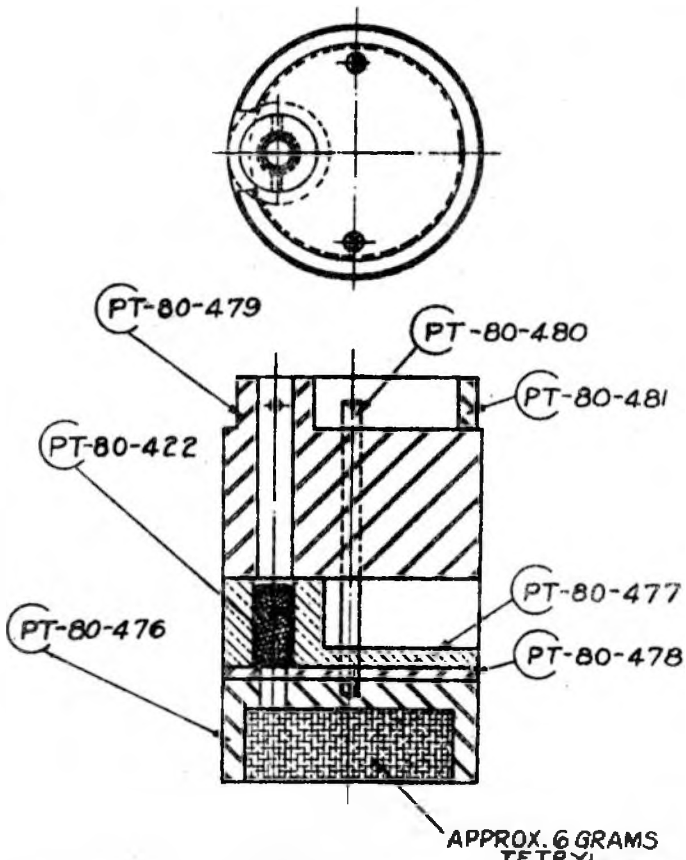


BOOSTER CUP SLIDE 16



CAVITY, BOOSTER
STEEL, WD1112
FINISH J

SLIDE 17



SLIDE 18 ASSEMBLY

[redacted]

2.5 cm.	7860 M/sec.
5.0 cm.	6760 " "
7.5 cm.	6715 " "
12.5 cm.	6625 " "

These results were secured using fiber tubes as confinement and indicate that on this diameter of column the confinement has little effect on the rate.

Pendulum Friction Machine:- Ref. B of M Bulletin #186.

The pendulum friction machine is used for testing the sensitiveness of explosives when subjected to frictional impact or a glancing blow. The details of the construction and method of operation of the machine are described in the Bulletin cited above. In brief, the shoe of the pendulum is first adjusted square with the plate so that it slides across the plate 18 ± 1 times when there is no explosive on the plate. The charge of explosive is 7 ± 0.1 grams. The charge is packed into the grooves in the center of the plate and the remainder heaped above the center.

The drop of the Shoe is 1½ meters. The weight added is 20 kilograms. The temperature of the Shoe is maintained between 14° and 30°C. The Steel Shoe is tried first being the most severe test. If the explosive fails to withstand 10 trials with the Steel Shoe, the fiber Shoe is substituted and 10 trials made or until failure occurs.

An explosive, to be used for bursting charge, must not give any unfavorable results with the fiber Shoe: that is, it should show no explosion or ignition.

While this machine is not capable of indicating slight differences in the sensitivity of explosives it is of value in determining the group or class in which a new explosive falls as regards friction sensitivity.

Trauzl Lead Blocks:-

The Trauzl lead-block test measures the comparative disruptive effect of an explosive when fired under moderate confinement in a small bore hole in a large lead block. The charge of 10 ± 0.01 grams is wrapped in tin foil to make a cartridge 25 m/m in diameter. The tin foil is cut in the shape of a trapezoid with sides 150 and 130 m/m and a width of 70 m/m.

A number 6 or larger detonator is used to initiate the explosive. The charge is tamped with a 50 c.c. of dry sand. The temperature at the time of firing is maintained at 15 ∤ 2° C.. The volume of the bore hole is measured before and after the shot and the expansion caused by the explosion is computed to the nearest cubic centimeter. Since this test is not considered to measure very accurately the power of an explosive, it is not widely used in testing military explosives; it has been more generally used for testing blasting explosives.

Large Impact Test Ref. No. 7:-

The large impact machine is similar to the small impact machine but gives results which do not entirely parallel it. The weight of the charge is 20 ± 0.5 grams. The charge may be tested in the confined or unconfined condition. The unconfined charges are placed between two steel discs, each 0.75 inch thick and having a diameter of 5 inches. The confined charges are placed between two steel discs, each .375 inch thick. The two discs with the explosive are then fitted into a section of Shelby tube 5/8 inches in height, outside diameter 4½ inches and inside diameter 3.86 inches. The Shelby tube is lined with one thickness of paper. The weight used with this test is 200 kg. The height of fall is measured in feet.

The results are recorded as "no explosion", "partial explosion" or " complete Explosion".

The maximum height at which no explosion occurs is determined by three trials. The height of drop is decreased by 1 ft. whenever an explosion occurs at a given height until the point reached at which no explosion occurs.

A representative result secured by this equipment is a comparison between T.N.T. and tridite. Both explosives fired at 10 ft. and failed at 8 ft. indicating the sensitivity to impact to be very nearly the same.

The Ballistic Mortar, Ref. No.8.:-

The ballistic mortar was first used by dynamite manufacturers to test the strength of their products. This instrument gives a comparison between any explosive being tested and a standard explosive. The standard explosive generally used is T.N.T. The pendulum is suspended on knife edges and supports a steel mortar, which weighs 642 pounds. The outer chamber in the mortar has a diameter of 4-7/8 in. and a depth of 5 in. The inner explosion chamber, is 2 in. in diameter and 5½ in. deep. The Steel Shot which fits into the outer chamber of the mortar weighs 36.6 pounds. The Shot has an axial hole entirely through it, large enough to accommodate a piece of Bickford fuze or electric detonator wires. A quadrant, graduated in degrees, is arranged so that the deflection or swing of the pendulum may be measured.

The explosive to be tested is formed into a cartridge by wrapping it in a piece of tin foil 3½ in. x 7 in. x .0007 in.

This foil should weigh about 2 grams. A No. 6 electric detonator is located centrally in the charge and retained in position by twisting the open end of the cartridge around the detonator wires.

Several samples of 10 grams each of T.N.T. are first fired and the average deflection measured in degrees and the values averaged. By trial, determination is made of the number of grams of the explosive under test that will cause a deflection of the pendulum equal to within $\frac{1}{2}$ degree of the average deflection caused by the T.N.T. Using this weight of explosive each time, several more shots are made alternately with shots of 10 grams of T.N.T. A charge of blasting gelatin of approximately 5 grams is fired after every other shot to consume any remaining combustible material which might be left in the bore of the mortar.

Calculation of Results

The Ballistic Mortar value for the explosive under test is calculated as follows:

A = the deflection of the pendulum given by the 10 grams of standard T.N.T.

B = charge in grams of the test explosive which gives a deflection approximating A.

C = deflection given by B.

X = T.N.T. value of the test explosive.

$$B:X = C:A$$
$$XC = BA$$
$$X = \frac{BA}{C}$$

Example:

Deflection obtained with 10 g. T.N.T.	=	16.61°
Wt. of Explosive under test required to give approx. same deflection as T.N.T.	=	14.3g
Actual deflection given by Test Explosive	=	16.41°
Then T.N.T. Value of Explosive	=	$\frac{14.3 \times 16.61}{16.41} = 14.4$

Simulation of Setback Tower: Ref. No. 9.

The development of high explosives for both shell and bomb fillers, requires that the explosive when loaded in the shell or bomb, retain its initial condition after undergoing either setback in the gun or setforward upon impact so that satisfactory detonation may be assured and that no prematures will result. Other parts which enter into ammunition are also required to withstand the shock of setback or impact.

The setback tower was constructed to test such resistance. This tower is an arrangement whereby a shell or bomb may be raised to a predetermined distance and dropped on an anvil. The shell or bomb to be dropped is clamped in a fixture with guides on two sides which engage two guide wires. The shell is lifted by means of a motor driven windlass and released at the proper height by an adjustable tripping mechanism. The maximum drop with this tower is 55 feet. After the component is subjected to the test, it is carefully examined for any evidence of deformation if no explosion occurs.

Fragmentation Test:-

This test may be used to determine the degree of fragmentation produced by a new explosive when loaded in a standard component or the effect produced by a standard explosive in a new component which is under test. For this purpose there is provided a fragmentation tub in which a shell may be buried in sand to sufficient depth that none of the fragments can escape when the shell is detonated.

The shell which is to be fragmented is fuzed in the same way as when used in Service except that the detonator of the fuze is initiated by means of an electric detonator instead of a firing pin or an excitor. The shell when placed in the sand should stand in a vertical position enclosed in a wooden bow of such size that there will be an air space of approximately the diameter of the shell on all sides of the shell. After the shell has been detonated the fragments are collected by putting the sand through a screen. The collected fragments are classified by screens. The number caught on No. 1, 2, 3, and 4 mesh are counted and weighed. The percentage of the total weight of the shell recovered is calculated, and also percentage of effective fragments obtained. The fragments which pass through the No. 4 mesh screen are considered as too small to be effective and are not considered in the calculation for effective fragments.

Approximate number of fragments for 75 m/m Shell 500
Approximate number of fragments for 155 m/m Shell 2200

Boosters are embedded in a sufficient quantity of sand in a container so that on detonation there will be no fragments lost and no refragmentation caused by the fragments hitting the side of the container.

SECTION III

FUZES

1. Design and Functioning of Artillery Fuzes

A fuze is a mechanism or device by which the explosion of a projectile is governed so as to cause the explosion at a certain time or only under certain conditions.

Fuzes as originally used in spherical projectiles were "time" or "concussion" fuzes.

The oldest form of time fuze was a piece of "fuse" or "slow match". This was followed by a wooden fuze forced into the opening in the shot, containing a compressed black powder charge, which was ignited by the blast of the gun and when burned down to the end spit through an opening into the burster charge and exploded the projectile. The wooden fuze was cut off or pierced along its length to fix the time of burning. In later developments, metal cases were substituted but the principles involved were the same. In a concussion fuze, an inflammable composition was ignited on discharge of the gun and, on impact, by some contrivance, the flame was admitted to the burster charge. The contrivances used were glass tubes, zinc tubes which when heated by the burning powder inside would break off on impact, or plaster of paris tubes. Due to the fact that a spherical projectile would strike on any point of its surface, percussion fuzes did not operate satisfactorily, though tried in many forms. In one type three distinct double-ended plungers were used with their axis perpendicular to each other. The plunger, whose axis was in line on impact, was arranged to strike a fulminate composition. The plungers were held in place during flight by copper shear wires.

On the introduction of rifled guns and elongated projectiles a great deal of the troubles with percussion fuzes were eliminated. As the projectile then struck point first, the use of a plunger striking a cap on impact was made possible. The use of the rotation of the projectile to function additional safety features marked the further advancement in the design of fuzes. With the modern use of high explosives a further change was required in providing a detonating element and producing a delay feature.

Fuzes are grouped according to the assembled position in the projectile and action at the time of impact. Following are types now in use.

Point

Time
Powder
Mechanical

Impact
Superquick
Supersensative
Delay-non,short
(combination of
above)

Base

Impact
Delay-non,short

Combination

"Point" fuzes are assembled into the nose of shell and "Base" fuzes into the base.

(a) "Superquick" fuzes are designed to burst the shell promptly on impact and before it has penetrated. Very little crater effect will be obtained from this type. It is used where the target to be demolished is above the ground, such as wire and personnel.

(b) "Supersensative" fuzes are designed to burst the shell promptly on impact against a light target, such as an airplane wing.

(c) "Delay" fuzes are designed to burst the shell shortly after impact. Delay fuzes are manufactured with various times of delay such as non-delay and short-delay. They are used where it is desired to obtain penetration and against personnel. When used against personnel the round is fired so that a ricochet action is obtained.

(d) "Time" fuzes are designed to burst the projectile at some pre-determined time after the projectile leaves the cannon. They are used against personnel, aircraft, and in barrages.

(e) "combination" fuzes combine two or more of the features such as "time and superquick", "time and non-delay" etc.

Fuzé Design in General:- a. During the World War the application of science and engineering to the art of warfare reached such proportions that the system employed in fuzing our projectiles proved entirely inadequate to meet the requirements imposed on ammunition components. The history of fuze developement shows a more or less regular progress, but much progress seems to have been made at the time the problems and new situations demanded improvements in functioning of the fuze. The development of fuzes has, since the World War, resolved itself into a problem requiring extensive study in order that our Ordnance program be complete.

(b) Ammunition is of no value unless the projectile can be made to function at the time and place desired; hence a fuze must function with extreme exactness, efficiently. A fuze is but a small part of a complete round of ammunition yet it requires a high degree of technical skill in its perfection and offers much difficulty in design.

(c) Fuzes can be standardized only to the point where their efficiency is not impaired. The more action a fuze is required to perform, the greater its cost and delay in production. Since the actual life of a fuze in service is but a few seconds, a multi-purpose fuze would be required to perform more that required for an individual shot and would represent wasted effort. The standardization of fuze design must meet the requirements of supply, use and manufacture.

Technical Requirements in Fuze Design.- The technical requirements which must be met in the design of a fuze are governed by the requirements of the using Service. The caliber of the cannon in which a fuze is to be used may vary over a wide range with corresponding variations in muzzle velocity and pressure. The forces available for the design of a fuze are:- (most commonly used)

(1) Pressure of propellent charge gases.

(2) Forces due to acceleration of projectile (setback force).

(3) Centrifugal force, due to rotation of the projectile.

(4) Creep force, due to retardation of projectile in flight.

(5) Impact forces due to projectile striking the target.

These forces vary with the cannon in which the fuze is to be used and if the fuze is to be used in ammunition of several different calibers for the purpose of functioning under varied tactical requirements it is evident that the new development becomes quite involved.

The various stages in the development of a new fuze design, from the time the requirements are specified until final approval for manufacture and issue are as follows. The first step is to prepare a drawing board study and thereby determine thesize limitations in the various shell for which the fuze will be used. To attain mass production the design must be based on the practical interchangeable manufacture of the components. It is highly desirable to develop a design, the components of which can be manufactured on punch press or automatic screw machines. The safety features of the fuze and the manner of loading and assembling the explosive train are very important considerations in a new design. The second step is to prepare detail drawings of the fuze which apparently meet the requirements. These working drawings must conform with the requirements of sound manufacturing methods whereby interchangeability of parts can be procured under mass production. This step involves a study of tolerances and manufacturing methods. The third step is the placing of an experimental order in the shop where the desired quantity, which is usually small, is manufactured and such changes in design recommended as may be found desirable from the manufacturing standpoint. The fourth step consists of design tests and service tests. The design tests are conducted at the experimental arsenal and the proving ground. The service tests are conducted by the using Service. The fifth and final stage in the development of a design is the action of the Ordnance Committee which recommends approval to the Chief of Ordnance for standardization.

Safety:- All types of fuzes now in use are arranged with safety devices which tend to prevent functioning until after the fuze has been subjected to the forces obtained in the cannon for which it was designed to be detonator safe, i.e. the explosive train is interrupted between the detonator and booster or projectile charge until the projectile has cleared the muzzle of the gun.

Explosive Train:- An explosive may be defined as being a gaseous, a liquid, or a solid substance, or mixture of substances, which upon application of a blow to a small portion of its mass or by a rise in temperature, or by suitable initial detonating agents, is converted in a short interval of time into other substances more stable, which are mainly gases or vapors, but may include solids and whose combined volume is much greater than that of the original substance. The chemical changes thus produced develop a sudden rise in pressurs in the surrounding medium, and the word "Explosion" is applied as a general term to the different types of phenomena occuring in such reactions.

Coincident with the evolution of gas a considerable amount of heat is evolved, which produces a flame. A high explosive is one in which the change occurs within an exceedingly short space of time, and the phenomenon accompanying this decomposition is termed "detonation".

The term "detonation" is therefore, applied to a very rapid explosion; it is not properly employed, however, when discussing the analogous reaction incident to the combustion of a slower burning explosive, such as smokeless powder.The general term "explosive" which finds universal acceptance, applies alike to high explosives, black powder, and smokeless powder. It will be seen, therefore, that the accepted distinction between the different classes of explosives is based primarily on their relative speeds of decomposition, and only those explosives are classified as "high explosives" in which this chemical change is considered practically instantaneous.

Those substances whose rate of decomposition is so rapid as to preclude their use as propellents, but which on the other hand, bring about very disruptive action, are known as detonating substances, or more commonly, as "high explosives". The various substances used for high explosives are quite numerous and the selection for use is dependent upon their cheapness of manufacture, availability, and the safety in handling.

Explosives are sensitive to the action of a detonating substance to a greater or lesser degree. In order to secure the detonation of the relative insensitive explosion in the bursting charge of a projectile, it is necessary that a detonating wave initiated by the impact of the projectile upon the target or by the functioning of the time fuze be built up to sufficient magnitude to deliver the necessary shock through the entire mass of the main bursting charge.

The elements of an explosive train for a high explosive projectile are a primer, delay element, when required, detonator, booster, and a bursting charge, so arranged that a tiny flame produced by the composition of the primer results in a high order detonation of the bursting charge. Essentially the explosive train comprises a series of explosives of varying degrees of sensitivity to detonation. The more sensitive explosive elements are used in small quantities, relative to the main charge, and constitute that part of the explosive train where detonation is initiated. The main shell charge or bursting charge being the last stage in the explosive train consists of a relatively insensitive explosive such as TNT. The action of the primer or primer detonator has not sufficinet explosive powder to detonate the main charge successfully or completely; it therefore is necessary to use a booster charge or another detonator and booster, to obtain a high order of detonation of the shell charge.

The following explosives are incorporated in the elements of the explosive train:

(1) Explosives used in the primer are usually mixtures containing mercury fulminate or lead azide, which may be made to detonate either by the action of a firing pin or by flame. Sometimes a combination of very sensitive priming mixtures and a quantity of lead azide, may be placed upon a quantity of tetryl and the three explosives combined in a unit called a primer detonator.

(2) The detonating action of the mercury fulminate or lead azide is used to initiate the detonation of the next element in the explosive train. This next element may be a detonator or a booster depending upon the strength of the primer or primer detonator. In delay fuzes, a black powder pellet pressed to produce the required time of burning may be inserted between the primer of the primer detonator and the booster in order to produce a delayed functioning of the fuze. The booster explosive is usually tetryl. The booster charge steps up the force of explosion and initiates detonation of the bursting charge. Tetryl is more powerful than mercury fulminate or lead azide, with respect to its capacity for initiating detonation in more insensitive explosives.

(3) The detonation of the booster has sufficient shock and flame to initiate the explosive in the bursting charge, which may be TNT, amatol, or explosive "D" etc. The explosive in the bursting charge is selected for its comparative insensitivity to detonation by shock, and, therefore, can be used in much greater quantities than can any of the other explosivesin the explosive train. The bursting charge of a projectile must be sufficiently insensitive to shock of discharge from the gun and the shock of impact at the target without being detonated.

SECTION III

FUZES

2- BASE DETONATING FUZE, M38A1

The base detonating fuze, M38A1, is manufactured for use in minor caliber, H.E.ammumition.

Several orders for loading and assembling M38A1 fuzes were completed in the past several years with only minor difficulties reported.

Although the tolerances of the metal parts are for the most part limited, the closing cap is designed to permit rather large variations in the internal diameter. This condition permits considerable space between maximum cup and minimum tetryl pellet. It has been found that when such a clearance exists the booster pellets become crumbled in the jumble and jolt test. Tests have indicated that this condition is not serious, fuzes thus loaded; then jumbled and jolted, have satisfacorily passed setback and functioning tests under extreme conditions. The specification has therefore been revised to permit accepting fuzes in which the pellets break up in the jumble and jolt test.

The plunger housing, resistance ring and firing pins although manufactured in accordance with the drawing will not permit assembly at random of parts with assurance of obtaining 100% arming. It is therefore necessary for the metal part manufacturer to make selective assemblies of these parts and to furnish them to the loader packed in such a manner that these assemblies remain together.

From the loading standpoint, it would be preferable to receive the metal parts for this fuze assembled except for the detonator, pellet, disc and closing cup. However, if this procedure were followed it would be impossible to detect any foreign material or moisture which might enter the interior of the fuze during transportation. Likewise, undesirable divided responsibility for the condition of the interior of the fuze would exist if this procedure were followed.

The first operation performed is the marking operation which includes all of the identification data stamped on the body using a #8 Bliss press. The next operation is the assembly of the metal parts in the body.

The detonator holder is tightened and then the distance from the bottom of the detonator cavity to the top of the firing pin is gaged to make certain that a clearance exists in every fuze.

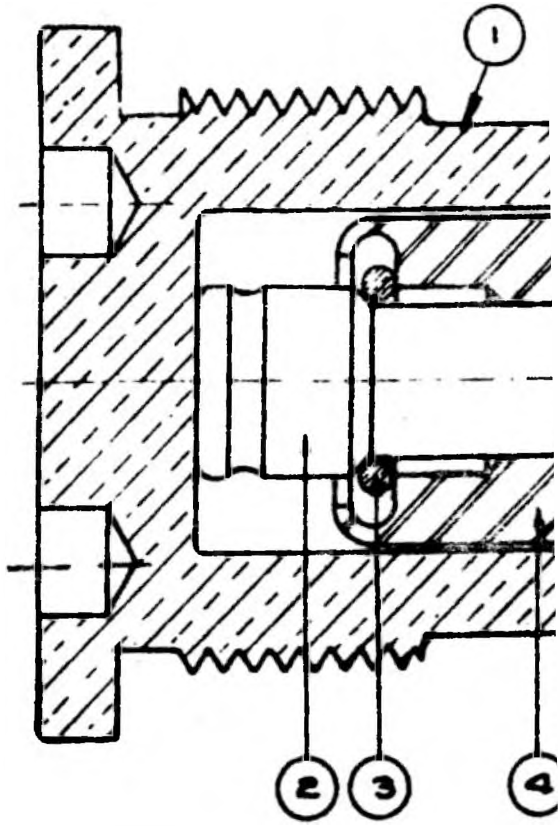
Into the detonator holder, an operator inserts first, the cushion and then the detonator assembly, being careful to leave the colored end of the detonator visible.

A felt disc, tetryl pellet and metal disc are inserted in the closing cap in the sequence mentioned and the closing cap is then screwed on the body which has been prepared for this assembly by coating the threads with glue. In order to maintain the relative position of the parts, the closing cap is staked to the body by means of a hand staking fixture.

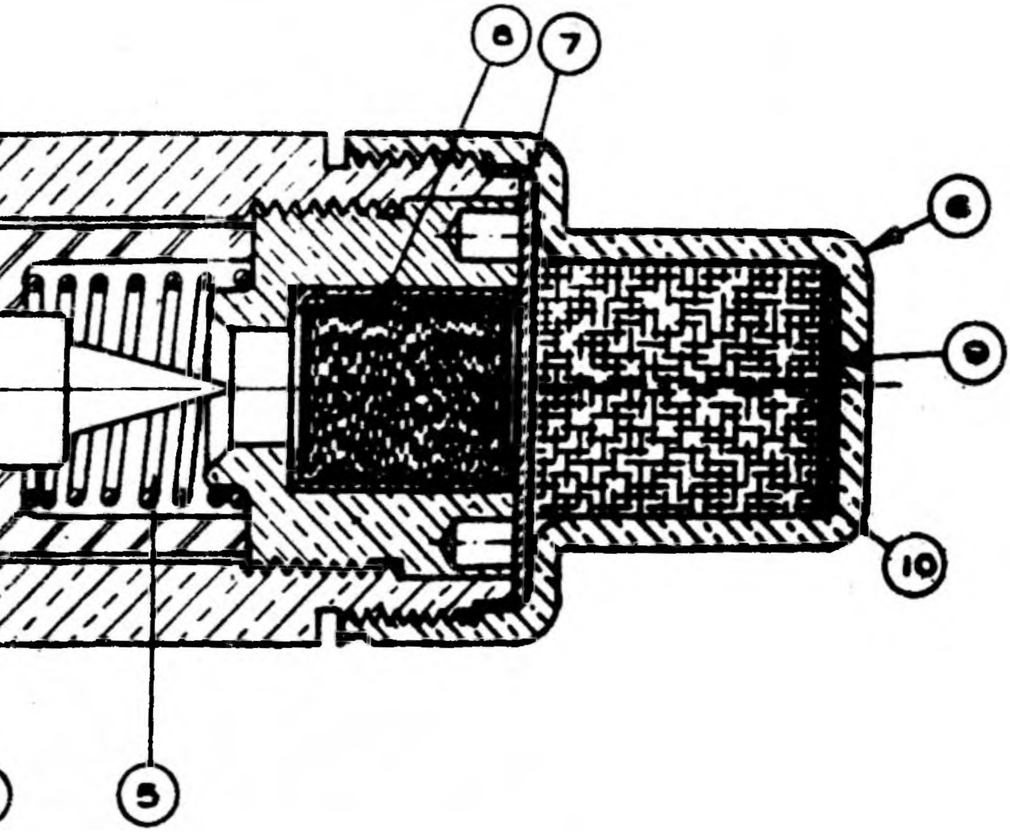
The fuzes are packed in cardboard cartons and sealed with gummed paper. An identification label is attached to each carton, and the assembly is made waterproof by dipping it in molten paraffin.

The detonators are loaded in a manner similar to the description given under Detonators and Friction Primers.

Tetryl pellet manufacture is described in a later section of the lecture.



1 - BODY
2 - FIRING PIN
3 - RESISTANCE RING
4 - PLUNGER
5 - SPRING



BASE DETONATING FUZE, M 38

6 - CLOSING CAP
7 - DISC
8 - DETONATOR ASSEMBLY
9 - CUSHIONING DISC
10 - BOOSTER PELLET

SECTION III

FUZES

3- POINT DETONATING FUZES, M48 and M51

Fuze, P.D., M48

The M48 Point Detonating Fuze is a combination superquick and delay fuze designed for use in 75 mm ammunition in conjunction with the M20 Booster. In common with others of recent design this fuze incorporates an inte gral ogive which blends smoothly into the contour of the shell to which it is attached. The complete fuze consists of four important sub-assemblies: the head, containing the superquick firing pin and upper detonator assemblies; the body, containing a plunger type interrupter; the plunger body, containing a firing pin, relay and delay element and finally, the ogive, die cast of aluminum alloy.

Before describing the functioning of the completed fuze a brief description of the sub assemblies, their parts and their workings will be discussed.

The head assembly contains the firing pin which is held in position by the firing pin support. This support must be of sufficient strength to withstand the set back force created by the firing of the gun and to be crushed at impact, which will force the firing pin to move forward and meet the detonator. This pin must have a flat surface on the end to create a friction when coming in contact with flash producing primer mixture of explosive which ignites the higher explosive lead azide in the detonator cup producing a flash of sufficient strength to travel through the fuze and into the booster assembly. The closing disc washer is to reinforce the closing disc so that when the fuze is in flight and the firing pin moves forward by creep force the closing disc will not be broken. The closing disc acts as a seal and prevents dirt or any foreign matter from entering the head assembly. The detonator holds the explosive that creates the flash from impact to the booster assembly. The detonator cushion as its name implies acts as a cushion and can be compressed enough to overcome the differences set up by the various tolerances and holds the detonator firmly when the retaining screw is inserted in place and staked.

ASSEMBLY OPERATIONS

Body Assembly

Visual inspection of interior cavity for burrs and foreign matter. Insert interrupter; spring cup spring; setting sleeve tension ring; finger action for tension of spring-setting sleeve retainer screwed in place.

Placed in arming machine (2000 R. P. M.) in non-arming (1500 R. P. M.).

Staked with double staking tool so as not to pinch setting sleeve. Again run through arming machine to insure free movement of setting sleeve.

The arming is both of the Super-Quick and Delay positions, to determine the action of the sleeve.

Operator tries with finger action to determine if spring is free and down in place.

Head

The head is visually inspected for foreign matter, and in the completion of all operations.

Firing pin support is then inserted in head, firing pin, washer, and closing disc. A rolling tool operated in a drill press, rolls closing disc into head. Give precaution in this operation so as not to distort disc. Visually inspected 100% for cracks in radius of crimping edge, and punctual closing disc.

Before detonator is inserted into head the position and condition of firing pin is examined, if firing pin extends into detonator cavity this brings the point of the pin in direct contact with detonator and may cause an instantaneous explosion, the detonator is then inserted; washer added; detonator retainer screwed into place and staked.

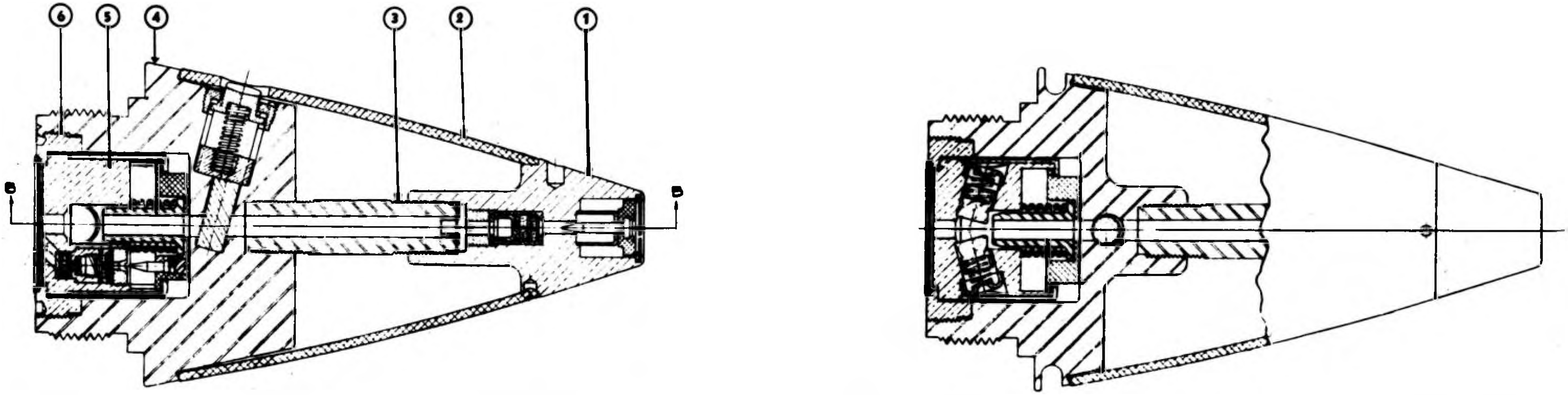
The tube is checked by the operator for excess plating and then assembled into body; then staked with a double staking tool in order that it will not be driven out of line, the body with tube is inserted and placed in arming machine for arming test; the operator can determine the results of the arming test (at 2000 R. P. M.) by a light flashing through the tube, and reflection is caught by a mirror which is mounted over the machine; then insert in non-arming machine (1500 R. P. M.) to test results.

The body holds the flash tube which connects the head to the body and makes a channel for the flash from the upper detonator to be transmitted to the flash hole in the body. The outside diameter has a recessed groove which makes a seat for the ogive which acts as a wind shield and streamlines the outside of the fuze. The body also contains the interrupter assembly. This assembly consists of the interrupter, when the fuze is in an unarmed position the flash channel leading from the detonator in the head is cut off and would prevent the detonation of the complete round in case the upper detonator functions before clearing the gun.

The setting sleeve, is the means of putting the fuze in a super quick or delay firing position The sleeve is a cylindrical shape with slot through the center which receives the spring cup and interrupter spring. The interrupter is thrown outward against the bottom of the spring cup by centrifugal force and compresses the spring which is seated in recesses between the setting sleeve and the spring cup. The outside diameter of the setting sleeve is reduced to fit the setting sleeve retainer that holds the complete assembly in the body. This smaller diameter of the setting sleeve extends through the retainer and has a screw driver slot on the top surface running in the same direction as the spring cup slot in the larger diameter. This is the only means of telling whether the fuze i in a delay or super quick firing position. The resistance spring between the shoulder on the outside diameter of setting sleeve and the inside diameter of the retaining screw keeps a tension on the setting sleeve and prevents its slipping from the required setting when the fuze is in flight. When the fuze is set for delay firing the leg of the setting sleeve prevents the interrupter from clearing the flash channel by bearing directly on its top and locking it in its original position making this part of the fuze except as a point of impact.

The delay plunger body assembly consists of the bore safe feature and the delay firing train. The centrifugal pins hold this part of the fuze safe until centrifugal force opens them and clears a space for the plunger support to enter upon the compression of the restraining spring. The plunger support prevents the firing pin from reaching the primer until the fuze goes into the armed position by centrifugal force and is held in position by the plunger head which also holds the delay firing pin in alignment with the delay train. The plunger head is held in position by the plunger housing and the plunger body which has two slots in the rim of the counterbore. The depth of this counterbore is the length of travel the plunger housing travels in the body and the slots act as guides for the ears on the outside diameter of the plunger head which in turn guides the firing pin to the delay powder train.

The centrifugal pins are held in place by the centrifugal pin springs with the plunger housing backing up their retainers, the plunger housing is locked in place by the lock pin. The plunger housing must not seat on the shoulder on the outside diameter of the body as this will permit a space between the top of the rim of the body and the bottom of the housing and allow the plunger head to turn in the assembly throwing the firing pin out of line with the delay train. There is only one right way for this assembly to be placed in the body. It is possible for it to be assembled upside down in which case it

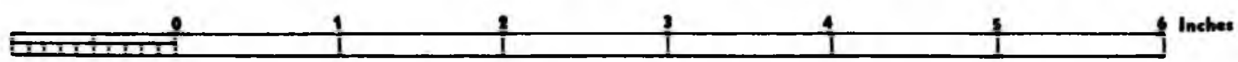


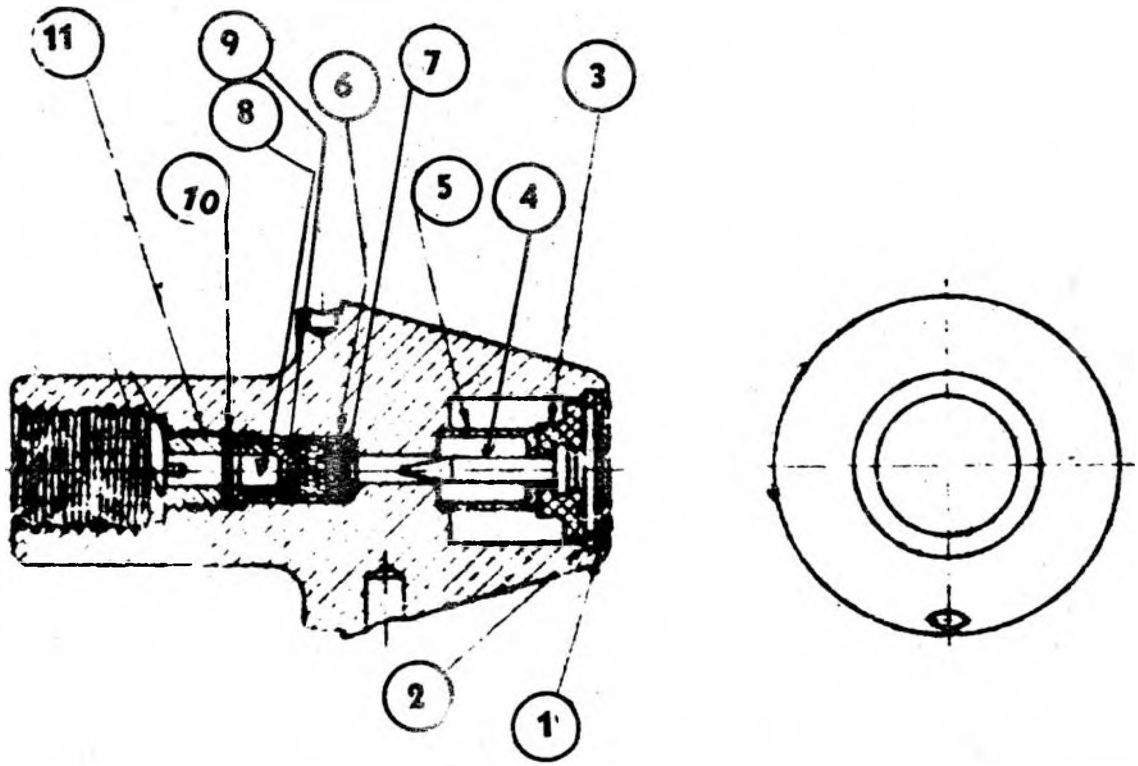
SECTION A—A

SECTION B—B

M48 FUZE

1—HEAD ASSEMBLY
2—OGIVE
3—TUBE
4—BODY ASSEMBLY
5—DELAY PLUNGER ASSEMBLY
6—BOTTOM CLOSING SCREW ASSEMBLY





M48 FUZE

HEAD ASSEMBLY

1 CLOSING DISC

2 CLOSING DISC WASHER

3 STRICKER

4 FIRING PIN

5 FIRING PIN SUPPORT

6 DETONATOR CUP

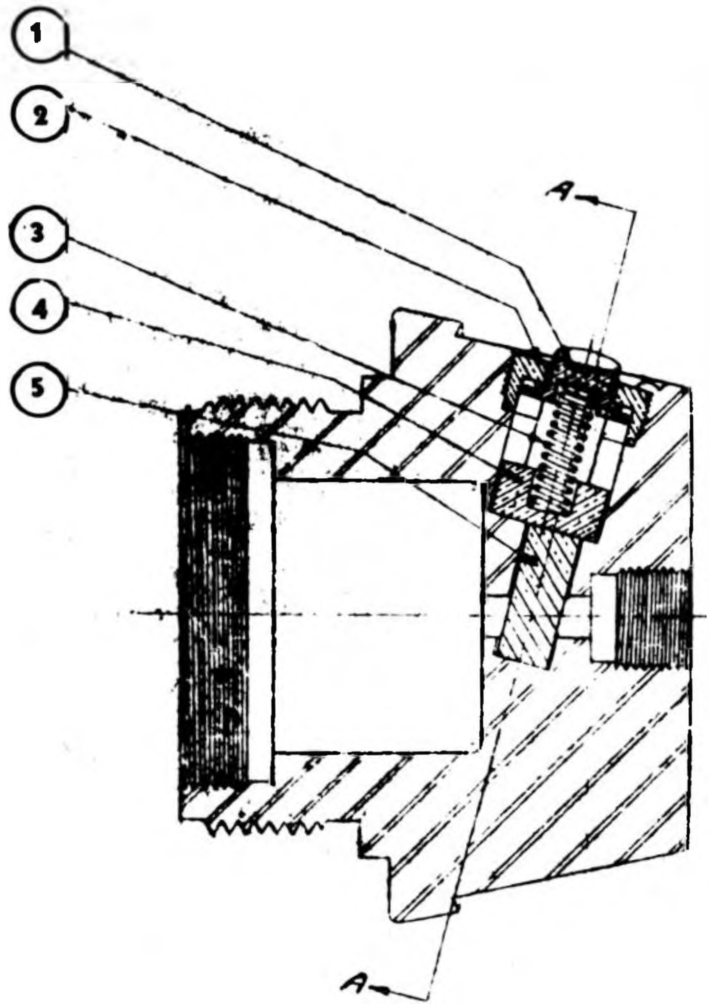
7 DETONATOR DISC

8 DETONATOR RETAINER

9 RETAINER WASHER

10 DETONATOR CUSHION

11 DETONATOR RETAING SCREW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2
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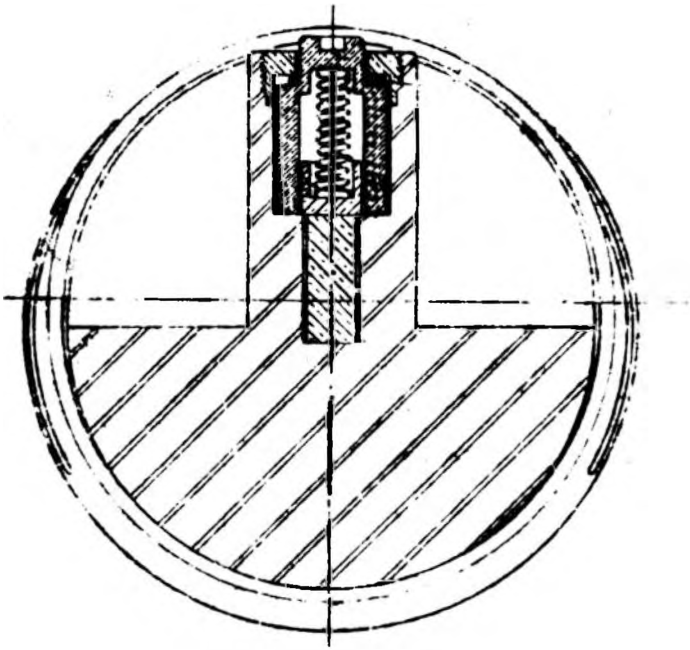


SECTION A-A

M48 FUZE

BODY ASSEMBLY

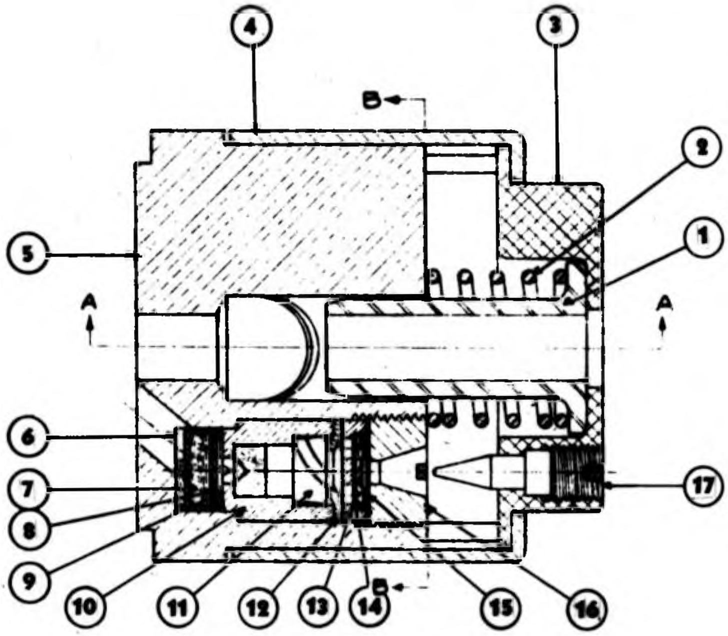
1 SETTING SLEEVE

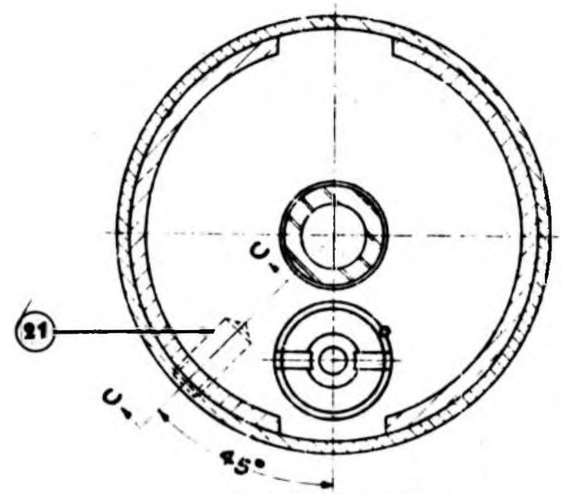
2 RETAINER

3 SPRING

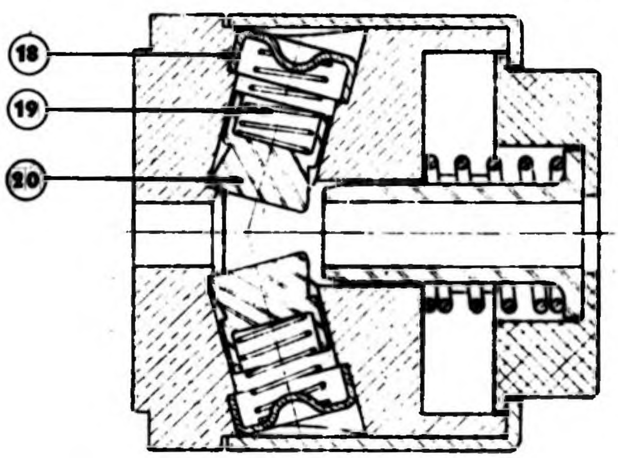
4 SPRING CUP

5 INTERRUPTER





SECTION B-B



SECTION A-A

M48 FUZE

DELAY PLUNGER ASSEMBLY

1 PLUNGER SUPPORT
2 " " SPRING
3 " HEAD
4 " HOUSING
5 " BODY
6 RELAY CUSHION
7 " CUP
8 RELAY DISC
9 " WASHER
10 DELAY HOLDER
11 BAFFLE
12 DELAY WASHER
13 PRIMER HOUSING
14 " DISC
15 " COVER
16 PLUG
17 DELAY FIRING PIN
18 CENTRIFUGAL PIN SPRING RETAINER
19 " PIN SPRING
20 " "
21 LOCK PIN

would make the complete round useless from the delay setting position of the fuze. The bottom closing screw retains the plunger assembly and seals this end of the fuze and on assembly <u>must</u> <u>not</u> bind the plunger assembly.

The interrupter cavity and centrifugal pin cavities are the bore safe features of this fuze and are drilled on a 15° angle. This creates condition in which the set back force is the dominating force while traveling through the bore of the gun. This force diminishes gradually during its travel. Centrifugal force increases while the fuze is traveling through the gun. The set back holds the interrupter and centrifugal pins in the unarmed position until centrifugal force overpowers the set back force. This does not take place until the projectile is clear of the bore.

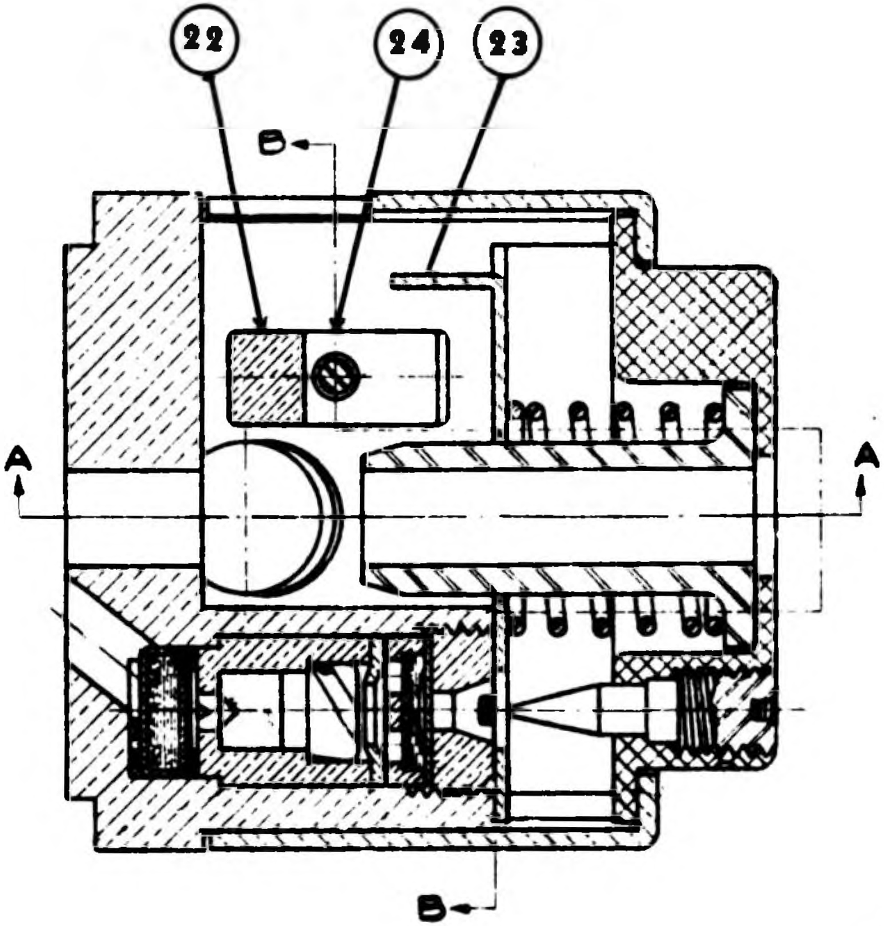
Functioning:- When the fuze is set on super quick, centrifugal force moves the interrupter against the spring cup depressing the interrupter spring and clearing the flash channel in the body. Upon impact with the target the firing pin support is crushed. The firing pin moves toward the bottom of the fuze to ignite the detonator which flashes through the flash tube, body and into the booster assembly.

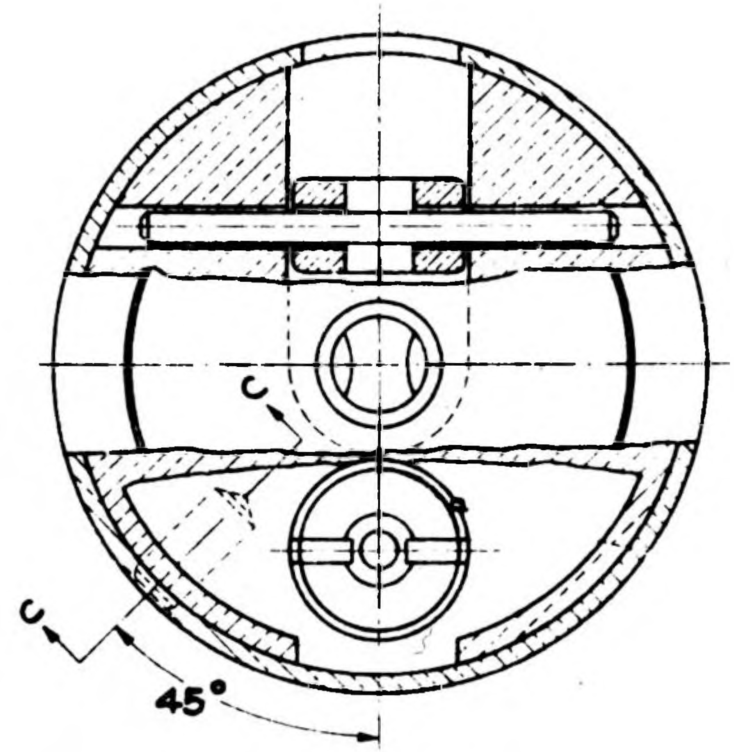
When the fuze is set on delay, centrifugal force moves the centrifugal pins outward compressing the springs, on impact the body moves forward allowing the plunger support to come in between the centrifugal pins. At the same time the primer has come in contact with the delay firing pin. This action fires the primer causing it to flash through two holes in bottom of primer housing, through delay washer, the baffle and ignites a column of black powder which in burning sets up the required delay to ignite the relay charge which starts to build a train of fire which finally ignites the bursting charge in the projectile.

Fuze, P. D., M51

This fuze is the same as the M-48, which has been described above, with the exception that the Delay Plunger Body contains a locking device that after centrifugal force moves the centrifugal pins outward this same force swings the centrifugal plunger pin lock that is held in the milled groove in the body and swings on a pivot pin and is locked by a lock check washer. This washer is held in place by the slots in the top of the body and the restraining spring. The washer also has holes to receive the delay firing pin and the plunger support.

Functioning:- Due to the initial set back force of the gun, the centrifugal pins are held in the unarmed position. As the fuze travels through the bore of the gun, this force decreases and centrifugal force increases. The set back force is completely overcome after the fuze has cleared the bore of the gun, the centrifugal pins then being forced back against the centrifugal pin springs. This action opens the channel for the plunger support. The centrifugal force also causes the centrifugal plunger lock pin to swing over, bringing the open end of the plunger lock pin in line with the plunger support, preventing the centrifugal pins from coming back into the unarmed position. Upon impact with the target the plunger body rushes forward between the centrifugal pins and the legs of the locking pin. At the same time the





SECTION B-B

M51 FUZE

DELAY PLUNGER ASSEMBLY

22 CETRIFUGAL PLUNGER PIN LOCK

23 LOCK CHECK WASHER

24 LOCK PIVOT PIN

primer makes contact with the delay firing pin and flashes through the primer housing flash holes, delay washer and baffle, igniting the delay train in the delay holder. The flash then travels through the bottom of the delay holder and ignites the relay charge, which, in turn, flashes into the booster assembly.

Setting sleeve is set at Super-Quick position before packing.

<u>Identification</u>:- Following data is placed on one side of each part:

Lot No.
Manufacture identification
Date, on,
P.D. M48

On opposite side, ogive staked to head (25 lbs. pressure).

Spot check is made by inspector, for proper alignment of head ogive and body.

<u>Plunger Body Assembly & Inspection</u>:-

Visual inspection:- Cork washer is attached to relay cup; relay cup is then inserted into plunger body - washer end down. Delay element is inspected 100% by operator for proper flash hole, sharp corners, and baffle; then inserted into plunger body, small dia. down; delay washer, inspected for burrs then inserted - angle down. Primer visually inspected for clean surfaces, placed in delay cavity (flat side down). Primer cover is checked by indicator for thickness to insure that not more than one cover is assembled on primer; the plug is then screwed into body and staked.

Plunger head, plunger support and supporting spring are placed on work pin; centrifugal pins, springs, and spring retainers are held in place by spring clamp.

Work pin with plunger, head, and support spring - placed through plunger support cavity; and nut screwed on opposite end of pin, until housing is placed on body over centrifugal spring retainers before removing clamps.

It is then placed in a fixture for drilling lock pin hole; lock pin is then inserted and staked.

Care must be taken with depth of the hole, that pin will not penetrate body too deep and allow housing to spring off.

<u>Complete Fuze Assembly, M48</u>:-

Plunger is then placed in arming machine for arming test (2000 R.P.M. to arm) (1500 R.P.M. not to arm). Before plunger is assembled in body, operator gages overall length compressed, and free height 100%.

Closing screw is assembled with 25 lbs. tension and staked.

After complete assembly, body is gaged for height from flange, where fuze makes up on projectile, and from this same point to bottom of fuze.

Body threads are gaged 10% before packing, if tight threads are found, 100% check is made.

55 bodies are taken from lot for test, 25 are sent to Aberdeen Proving Ground, 10 jolt and jumble test, 20 burning time and sensitivity test. This is covered by Specification 50-17-15.

The complete fuze is inspected for cracked or damaged ogive, stamping, staking, closing screw alignment of parts, and S.Q. setting.

All stamping on plated surfaces must be lacquered. When packed in individual containers, M-48 Fuze - M-47 Container, one inch adhesive tape is placed around complete circumference of container where lid and container join, with 1/2 inch tab overlap.

When packed in 25 lot boxes:- Box made of wood with metal container inside, wooden spacers holding 25 fuzes. Bottom spacer has holes drilled to hold bottom of fuze. Top spacer has tapered holes to fit angle of head.

Cover soldered on metal container and tested with 2 lbs. air pressure for 15 seconds to withstand atmospheric conditions.

Complete Fuze Assembly, M51:-

Same as M-48 with exception of locking device of centrifugal pin in plunger body, locking device assembled same time as centrifugal pins and inspected for free movement. When arming test is run, locking device has to be released before making non-arming test.

Booster is assembled to fuze with friction wrench. Body held by fixture, then set screw hole spotted in body, set screw inserted and staked in center to spread metal tight in booster.

M51 is packed in container M-43. Cardboard disc placed in container to separate fuze from metal bottom of container and on top of fuze if loose in container, add more discs until fuze is held tight.

Container holding M51 fuze is large enough to pack M21 with booster attached.

Inspection of the M48 & M51
Point Detonating Delay and Superquick Fuze

Before the manufacture of the component parts can be started, the inspector must carefully read the specifications pertaining to the material used. All chemical and physical tests must be applied and approved as required. All cadmium plated parts (samples) must be subjected to the salt spray test as called for in the specifications of metal parts for this fuze.

As the process of manufacture progresses the inspector should carefully watch for latent defects that could not be detected before machining. These hidden defects such as pipes, cracks, etc., might not be discovered until the machining of the piece was well under way. In case this occurs, care should be used to sort out and discard all pieces made from the defective stock.

Whenever plating is called for, special attention should be given small holes and inside diameters that may be difficult to plate. The inspector should carefully read the specifications on the salt spray test and see that these requirements are met. It is suggested that where there is difficulty in determining the proper plating that a sample be cut open; in order to satisfy himself as to the quality of the plating.

List of Parts in M-48 Fuze

Head
Closing Disc
Closing Disc Washer
Striker
Firing Pin
Firing Pin Support
Detonator
Detonator Disc
Detonator Retainer
Detonator Cushion (Cork)
Retainer Washer
Detonator Retaining Screw
Tube
Ogive
Body
Interrupter
Interrupter Spring
Spring Cup
Setting Sleeve
Tension Ring
Setting Sleeve Retainer
Plunger Body
Plunger Support
Plunger Support Spring
Relay Washer (Cork)
Relay Cup
Delay Element
Delay Element Washer
Primer Housing
Primer Cover
Primer Disc
Baffle
Plug
Centrifugal Pin
Centrifugal Pin Spring
Centrifugal Pin Spring Retainer
Plunger Head
Delay Firing Pin
Housing
Closing Screw
Closing Screw Disc
Plunger Housing Lock Pin

Springs:-

The wire used in the manufacture of springs is music wire WD 1085. This wire must meet all chemical and physical tests specified in contract drawings and specifications. The diameter of the wire must be gaged before winding. The number of coils, and the number of active coils, overall length, free height, and compressed length with required load applied must be correct after seasoning and plating. Outside diameter and direction of winding are very important in order that there be no binding or distortion after assembly.

The springs should have closed ends at right angles to axis where specified on the drawing. This is necessary to make springs bear properly on both ends.

While the safety and the correct functioning of the fuze depends greatly on the correct action of the springs, it is vitally important that they meet all specified requirements, and are inspected 100% before assembly. After assembly the interrupter spring and the centrifugal pin springs are again inspected 100% on the arming-non-arming machine.

Firing Pins:-

After physical and chemical tests have been completed and found to meet all requirements according to the drawings and specifications the material is then satisfactory for manufacture.

The diameter of the pin must be gaged to guard against taper. If the diameter tapered toward the striker it would cause a weakness in the pin.

The overall length of the pin is gaged 100%. A long pin will extend too close to the detonator in assembly which is extremely dangerous. Should the pin be short, there is a possibility that it will not fire primer or detonator as the case may be.

The point of the pin is extremely important and must be gaged to insure the diameter across the flat of the point and that there are no burrs on either the point or the angle. The point must be concentric with the diameter of the pin. This flat must be maintained in order to create friction when the firing pin comes in contact with the detonator charge.

Head Assembly:-

1:- Head
2:- Closing Disc
3:- Closing Disc Washer
4:- Firing Pin
5:- Firing Pin Striker
6:- Firing Pin Support
7:- Detonator Cushion
8:- Detonator Cup
9:- Detonator Disc
10:- Detonator Retainer
11:- Detonator Retaining Screw
12:- Retainer Washer

1:- Head

The overall length must be held in order that the proper distance be maintained between the point of firing pin and detonator. In the event of the head being short the firing pin would extend too close to the detonator which would be a dangerous condition during assembly. If long, a condition would result in which the firing pin might not reach the detonator, also it would contribute to the overall length of the completed fuze which is gaged 100% for maximum length after the fuze is completed. The crimping wall and shoulders must be concentric with the outside diameter. A thin wall or an eccentric wall will crack on the crimping operation. A heavy wall when rolled will make a shoulder on the outside surface which will be detrimental to the flight of the projectile. For proper alignment of firing pin with detonator it is necessary that striker cavity and firing pin support counterbore be concentric with the firing pin hole. In order to maintain the proper distance between firing pin and detonator it is essential that the specified depths be maintained. For proper functioning of the firing pin it is necessary that the detonator cavity be concentric with the firing pin hole and of the proper depth. Care must be taken with the chamfering of the detonator retaining cavity threads. To hold the proper alignment and length of the completed fuze, it is necessary that the depth and concentricity of the tube cavity thread be maintained. The large diameter of the head must overhang the ogive. It is suggested that this diameter be held within plus or minus .002" of the mean dimension. This will aid in maintaining the proper dimension across the nose end of head. The ogive seat diameter must be held for proper alignment of head with ogive. The location of the wrench and staking hole must be held in order that they fit the staking fixture in the loading department.

2:- Closing Disc:-

To make a proper crimp the disc must be of proper diameter and thickness.

3:- Closing Disc Washer:-

Sharp burrs on the outside diameter of the washer may cut the disc and allow moisture and foreign particles to enter the cavities of the head. This washer must be held to the correct dimension in order that an effective crimp may be made.

4:- Firing Pin:-

The firing pin information has been covered on page 82.

5:- Firing Pin Striker:-

If the striker is being manufactured separately of the firing pin, it is suggested that the diameters be held toward the minimum since when riveting, the outside diameter becomes too large due to the distortion caused by the spreading of the striker. Care must be taken that in riveting the face of the striker it is not cupped which will increase the overall length of the assembled piece.

6:- Firing Pin Support:-

Care must be taken that there are no draw cuts in this component since they weaken the support, thereby causing it to fail in the crush test which determines its strength to withstand setback force. In the trimming operation it is necessary that no chamfer is put on the cup since the chamfered section offers less resistance than if the bottom were flat. The overall length is checked 100% since a short support would bring the firing pin closer to the detonator. Side walls of cup must be of even thickness.

7:- Detonator Cushion:-

This is a cork washer the diameter of which must fit the detonator cavity.

8:- Detonator Cup:-

The inside diameter if small will cause the punch to stick in cup or otherwise to distort it, thereby setting up an extremely dangerous condition in the loading operation. The outside diameter, if large, prevents the cup from fitting the loading fixture which makes it useless. This component must be absolutely without draw marks, scratches, and cuts inside or out and maintain as much flat as possible in the trimming operation. The small hole must be concentric with the inside and free of burrs as the burrs may cut the detonator disc allowing the powder to seep out.

9:- Detonator Disc:-

Thickness of thin disc is important since firing pin must pierce it.

10:- Detonator Retainer:-

All dimensions must be held on this component in order that proper assembly in detonator cup can be made.

11:- Detonator Retaining Screw:-

The chamfer on the slotted end of this piece must not be too great since the piece is staked in place. The face of the opposite end must be straight and with good finish. A small chamfer is permitted to aid in assembly.

12:- Retainer Washer:-

This is a fuze cloth washer of which diameters and thickness must be held for proper assembly.

Body Assembly:-

1:- Body
2:- Interrupter
3:- Spring Cup
4:- Setting Sleeve
5:- Spring
6:- Sleeve Retainer
7:- Tension Spring

1:- Body:-

The diameter across the top where the max. only is shown on the drawing should be held to insure a clearance between body and ogive. The tube cavity must be concentric and straight with the axis of the body for the proper alignment of the complete fuze. The ogive seat is very important as to angle, diameter and concentricity. The alignment of the completed fuze greatly depends on the accuracy of these points. The outside diameters of the body flange must be held within the drawing tolerances to insure the proper overhang in mating of body to the ogive and the body to the projectile. The surface of the flange must be smooth finish and correct angle to insure proper stamping. The surface under the large diameter of the body flange must be straight for proper seating and staking to the projectile. The dimension from this surface to the bottom of the body is gaged 100% in the loading department as this is a factor in the clearance between the bottom of booster cup and the bottom of the cavity in the projectile. The diameter of the adjacent shoulder must be of specified dimension to avoid any interference with the minor diameter of threads in the projectile. The distance from this shoulder to the bottom of the fuze should be held because the bottom of the body must seat on the rotor cover of the booster. The undercut on either side of the outside body thread should clear the minor diameter of the thread. The body thread must be concentric and straight with the axis of the body. The closing screw threads must be concentric and straight so the inside diameter of the closing screw will align with the plunger cavity. If these two diameters do not align the plunger assembly will bind. There should not be too much chamfer on this thread as it is staked. Depth of the closing screw and plunger cavity are very important. If shallow, the plunger support may bind the centrifugal pins and not permit proper functioning and it will also bring firing pin closer to primer. Check for burrs or shoulders in either cavity before gaging, also see that proper radius is maintained at bottom of plunger cavity. Check wrench slots to make sure they do not distort projectile seat. The interrupter hole must have good finish (FF) and the proper radius in the bottom so the gage will give the correct depth. The setting sleeve cavity must have a good finish (FF) for the free movement of the setting sleeve. The eccentricity between the setting sleeve cavity and the interrupter cavity must be as specified to insure the proper action of the interrupter for either the delay or superquick setting of the fuze. The retainer screw threads must be concentric with the setting sleeve cavity so there will be no binding between the retainer and the sleeve. The flash hole should be straight with the axis of the body.

2:- Interrupter:-

The interrupter must be free from burrs on the end caused by the parting tool and the diameter should have the finish specified on the drawing. It should also have the correct radius on each end. The length of the interrupter must be maintained; if long, it might affect the action of the setting sleeve.

3:- Interrupter Spring:-

See paragraph on Springs on page 82.

4:- Spring Cup:-

The bottom of the spring cup must be straight and free of burrs. The spring cavity must be concentric with the side walls, and the finish such that there will be no binding in the setting sleeve as its functioning depends on centrifugal force.

5:- Setting Sleeve:-

As the setting sleeve governs the path of motion of the spring cup, it is very important that the width, depth and concentricity of the slot be held in accordance with the drawing. It is also important that the finish of the slot shall be FF and free of burrs. The spring recess must be of proper depth and have the proper radius to insure the proper functioning of the interrupter spring. As the setting of the fuze is controlled by the screw driver slot in the end of the setting sleeve, it is very important that this slot be properly located.

6:- Tension Spring:-

This spring must be free of burrs and in accordance with the drawing.

7:- Setting Sleeve Retainer:-

The threads on the retainer must be concentric with the large inside diameter. The depth of large inside counterbore must be maintained for the proper tension on the setting sleeve. The overall length must be held as the retainer must seat on shoulder and not extend outside the surface of the body and interfere with inside of ogive. This is also important for the staking operation.

Plunger Assembly:-

1:-	Plunger Body	9:-	Centrifugal Pin Spring Retainer
2:-	Plunger Support	10:-	Relay Cup
3:-	Plunger Head	11:-	Delay Holder
4:-	Firing Pin	12:-	Baffle
5:-	Plunger Housing	13:-	Delay Washer
6:-	Plunger Support Spring	14:-	Primer Housing
7:-	Centrifugal Pins	15:-	Primer Cover and Disc
8:-	Centrifugal Pin Springs	16:-	Plug

1:- Plunger Body:-

As the plunger assembly and its free movement in the fuze make the outside diameters important, they must come within the specified tolerances. To align the firing pin with the primer it is important that the head cavity and the slots (different widths) in the body, be concentric and in correct location. The plunger support cavity must be concentric and free of burrs to avoid binding in assembly. The specified depth of counterbore and plunger support cavity must be maintained, as these depths govern the working of the firing pin with the primer; (deep counterbore will allow firing pin to travel closer to primer when gaging compressed height of plunger assembly). Bottom corners of guide slots must be sharp and free of burrs. The centrifugal pin cavities must be of specified depth, have fine finish (FF) and <u>be free of burrs</u> as the safety and arming of fuze depend greatly on these points. The concentricity between delay and relay cavities must be held for assembly of the delay element.

Sharp corners in bottom of delay cavity (as noted on drawing) must be held for sealing. The depths are important for the assembly of the complete delay train. Care must be taken in drilling flash hole that the drill does not ruin the shoulder in delay cavity.

2:- Plunger Support:-

The plunger support being one of the safety factors of the fuze must be held to close dimensions. The overall length must be maintained to hold the firing pin away from the primer when assembled, and under no condition can this length be less than the min. length shown on the drawing. The ends must be square with the axis. The flash hole free of burrs.

3:- Plunger Head:-

The concentricity of the plunger support cavity with the outside diameter and the location of the ears are important. This combined with the location of the firing pin hole make it difficult to manufacture these as a close inspection is required to insure its correctness. Care must be taken when tapping firing pin hole that the tap does not ruin flat bottom or shoulder thereby allowing firing pin to extend beyond the max. dimension of assembled piece. A close check should be made after assembly and staking of firing pin to see that it has no bulge in plunger support cavity. Note: The ears are of different widths and the firing pin hole must be drilled on the side having the narrow ear. Surfaces must be straight and parallel.

4:- Firing Pin:-

See paragraph on Firing Pin on Page 82.

5:- Plunger Housing:-

A close check must be made of sharp corner inside of housing and that there are no burrs, and the evenness of metal maintained in drawing.

6:- Plunger Support Spring:-

See paragraph on Springs on page 82.

7:- Centrifugal Pins:-

It is of importance that finish is in accordance with drawing (FF) and that there are no shoulders or teets on bottom of pin.

8:- Centrifugal Pin Springs:-

See paragraph on Springs on page 82.

9:- Centrifugal Pin Spring Retainer:-

Inside diameter must be held and free of burrs so centrifugal pin will not foul on the arming of the fuze. Outside diameter must be held for proper fit in plunger body.

10:- Relay Cup:-

Overall length must be maintained and free of burrs. The inside and outside diameter important to meet loading requirements

11:- Delay Holder:-

The correct depth and finish of the delay is important, as the depth must be held to meet loading requirements, and the finish of this cavity must also be free of tool marks and shoulders in order to eliminate danger in loading. The concentricity of these holes is important so that the shoulder does not cut off the baffle groove. The depth and width of the slot on the bottom of delay must be held as specified on the drawing as this slot governs the amount of flash from delay. The overall length is important because it is a factor in determining the distance between primer and firing pin. Sharp corners must be held for sealing.

12:- Baffle:-

The diameters of baffle are very important, it must assemble in delay holder (press fit). The groove must be correct and free of burrs as through this groove the flash is delivered from primer to delay.

13:- Delay Washer:-

Maintain diameters and overall thickness to insure its assembly in the delay train cavity. Surfaces must be flat, parallel and free of burrs.

14:- Primer Housing:-

Surfaces must be parallel and straight, and with good finish. The powder cavity must have sharp corners. It is suggested the overall thickness be held near the maximum dimension and depth of cavity near the minimum dimension; this will insure proper dimensions after burring. The two flash holes must be on a cl to fit loading fixture.

15:- Primer Cover and Disc:-

Thickness and diameter important for proper assembly and functioning of firing pin and must be free of burrs.

16:- Plug:-

The plug must have good finish (FF) across bottom surface to insure no distortion of primer cover in assembly. The firing pin hole must be concentric with outside threads and proper angle held to insure the functioning of firing pin with the primer.

<u>Miscellaneous Parts:-</u>

1:- Closing Screw:-

As the functioning of the plunger assembly largely depends upon the correctness of the closing screw, it is important that the concentricity and all dimensions be held. It must be free of burrs. Wrench holes must not distort minor diameter of outside threads, there must not be any burrs on the outside thread and the chamfer must not be too great as this thread is staked. There must not be any burrs on the inside of the crimping wall as this will cut the closing screw disc.

2:- Ogive:-

The bottom edge of the ogive must be square with the axis and have proper bevel for seating on the body. The upper edge must also be square with the axis. Care must be taken when facing bottom of ogive that the dimension from the bottom of ogive and bottom of locating lugs are maintained.

The setting screw hole and the lugs on inside must be in proper relation to each other, and the hole must be the correct distance from the bottom of the ogive. Check the stamping at the setting sleeve hole to make sure that it is legible and has not distorted the ogive. Check the inside diameter of the small end of ogive to insure its proper assembly to the head.

3:- Tube:-

Threads on both ends must be concentric with each other for proper alignment. The flash hole should be concentric with the threads, free of burrs. The flash hole of tube must be closely inspected for plating.

Inspection of the M-51 Fuze

Plunger Body:-

The M-51 and M-48 fuze being the same with but a few exceptions, only the differences will be discussed in this paper. However, the depth of plunger head being different, it again becomes important that this dimension be held in order that the lock check washer may be assembled in plunger body in order to maintain the proper relation of firing pin with primer. The locking device slot in plunger body must be in center of body. The depth of this slot must be held; if this slot is too deep it is possible for the centrifugal pins to be forced out of their normal position into the slot. The pivot lock pin hole must be parallel with the centrifugal pin cavities for the free movement of the centrifugal plunger pin lock.

Lock Check Washer:-

Hold the alignment of the two holes with the ear on the firing pin side and lock-check on opposite side as this determines the alignment of the firing pin with the primer. The length of the lock-check-stop determines the position of the lock when the fuze is in an armed position.

Plug:-

The only difference in this plug and the plug in the M-48 is the thickness.

Centrifugal Plunger Pin Lock:-

As the lock must swing freely in the plunger body it is necessary that all dimensions be held and the lock be free of all burrs.

SECTION III

FUZES

4- Point Detonating Fuzes, M52, and M53

The M52 P. D. Fuze and the M53 P. D. Fuze are used in trench mortar ammunition. The M52 is superquick in operation and the M53 has delayed action, these fuzes replacing the old combination M45 Fuze. The two fuzes are identical except for the heads and sliders:- the M52 head contains only a firing pin assembly; the M53 head has not only a different type of firing pin assembly but also a delay element system. The M53 slider detonator, therefore, does not contain any primer mixture.

These fuzes consist of four important sub-assemblies: the head assembly, containing the firing pin assembly (and, in the case of the M53, the delay assembly); the body assembly, containing a safety pin and a set back operated safety device (no centrifugal forces are present in mortar ammunition); the slider assembly, having a detonator assembly crimped therein; and finally, the booster assembly containing a tetryl pellet. Figure 1 shows these assemblies in the case of the M52 Fuze.

Head - M52;-

The head is visually inspected to see that there are no shoulders, dirt or foreign matter in the striker cavity. The lot number, date and loading plant initials are stamped onto the head. The stamping must be legible but not extend into the wrench hole or distort the striker cavity.

The firing pin assembly and head are placed in a fixture up-side-down, this fixture supports the head and by spring action forces the firing pin through the head making the insertion of the retaining pin possible. (Figs. 8 and 9.) Releasing of the spring of the fixture allows the firing pin to draw down seating the retaining pin into the bottom of the counter-bore of the head. The firing pin must not extend below the surface of the head and still be within maximum overall length after assembly.

Head - M53;-

The head is inspected for foreign matter and presence of all holes and threads. The firing pin and striker assembly are then inserted into the head and the shear wire put in place and bent around the groove in the head.

The shear wire hole must be in the center of the groove for correct assembly. The distance from the end of the firing pin to the primer is determined by the position of the shear wire and should be carefully checked to see that the firing pin does not extend too far down after assembled.

The stamping for M-53 head is the same as for the M-52 head and the same points of inspection should be noted on i as are noted above for the M-52 head.

Body :-

The bodies are usually received at the loading plant with the slider lock pin and spring safety pin and spring, set back pin and spring and plug assembled and staked. The safety wire is also inserted.

The first operation consists of inspection for dirt and the gaging of the slider cavity. This gage is composed of a slider, 0.0012" larger than the maximum size of the slider, which is pushed into the slider cavity by the pressure exerted by a spring which is the same as that used in the completed fuze. The plunger of the gage must be flush or below the feeler surface. This gage must move freely to check the position and length of the slider lock pin and position of the safety pin across the slider cavity, also denotes any burrs within the slider cavity.

Loaded tetryl lead cups are then inserted in each of a tray of bodies (Fig. 5). The cups are fixed in position by placing the assemblies under the ram of a pneumatic staking press, which imparts a circular crimp. The cup is in inspected to see that it is flush or below the surface of the top of the booster cavity. The slider cavity also is inspected after this crimping operation to see that the lead cup does not extend into the slider cavity, and possibly foul the slider when it is assembled.

Slider:-

The slider is given a visual inspection for foreign matter and a cork washer inserted. No defective washers are used. The detonator is then inserted, the colored end being put in first. (Fig. 2). The detonator is retained by a circular crimp produced in a standard Picatinny Arsenal pneumatic staking press (Fig. 3).

The detonator must be tight and not stick above the surface of the slider. The slider is then pushed through a broaching machine to remove the metal that might have been distorted by the crimping operation and to insure correct size of the slider. If the slider is pressed through the broaching machine there is danger of exploding the detonator if it sticks above the top of the slider. (Fig. 4)

Booster:-.

The booster assembly operations are relatively simple. First a felt disc is inserted into the booster cup and on it is placed one tetryl pellet. These pellets, which are made in a Type "R" Stokes Tablet Machines as described in the section dealing with tetryl pellet manufacture are inspected as they are inserted in the booster cup.

Assembly:-

In order to prevent loss of time which would occur if an assembly operator were required to untangle a pile of slider springs before proceeding with the assembly, an additional operator separates the springs and places them individually on a rack consisting of two rows of finishing nails set in a wooden strip. (Fig. 6) Spring racks, trays of sliders, plugs, and bodies are placed where they are conviently accessible to the next operator.

The slider is then inserted and the operator rolls the body from one side to another to see that the slider works freely in the slider cavity. This is very important, since there is no arming test given this fuze and the slider must move over by spring pressure alone to arm the fuze. The slider spring and plug are inserted, the plug being screwed down about two threads by means of a special, self-seating screwdriver. The plug is then tightened to a fixed tension with a pneumatic screwdriver.

The head is then engaged into the body two or three turns and the booster cup likewise screwed into the body. The remainder of the booster cup threads are coated about $\frac{1}{4}$" wide and 360° around with Pettman cement to seal the booster from moisture.

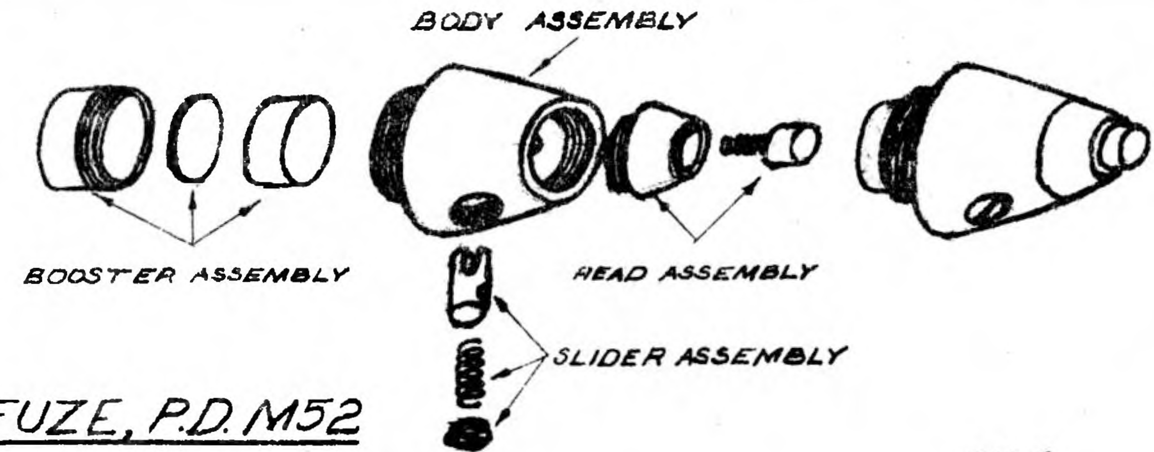
Assembly is completed by means of a friction chuck attached to the spindle of a drill press, (Fig. 7), tightening up head, body, and booster cup in one operation. The fuze is then placed in a fixture which locates from the wrench hole in the body, and the head and slider plug are staked to the body in one operation.

The fuze is then visually inspected for stamping, staking, and gaged for overall height and distance from the booster cup to the projectile shoulder of the body. Any excessive Pettman is wiped off at this time also.

Ammunition components such as these may now be stored almost indefinitely because of the adequate provisions made for packing. The fuzes are packed, two layers of 50 each, in the tin liner of a stoutly built wooden box. (Fig. 10) Hardwood separators and chipboard spacers serve to maintain them in their proper positions. Air tightness is insured by soldering the lid on (using a special low melting point solder) and testing with a pressure of 2 lbs. per square inch. It is assumed that containers capable of maintaining this pressure for 15 seconds are satisfactory. As a precaution against rusting the liners are painted with one coat of acidproof black paint (asphaltum). Packing is completed by closing and sealing the box cover, and stenciling the box according to specifications on the drawing.

<u>M-53 Assembly:-</u>

The assembly of the M-53 is the same as the M-52, except that the delay element is screwed into the head and staked before it is assembled to the body There is a slight difference in the charge in the M-53 detonator, since it has no friction powder in it. The length of milled flat and no firing pin safety hole are likewise distinguishing differences in the M-53 slider.



FUZE, P.D. M52

FIG. 1

FIG. 2

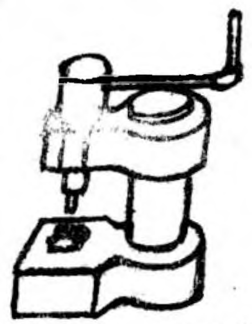


FIG. 3

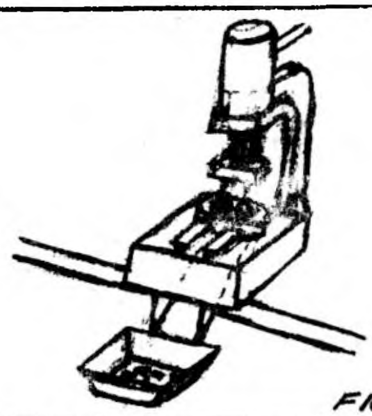


FIG. 4

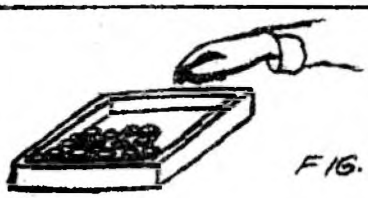


FIG. 5

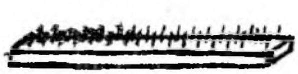


FIG. 6

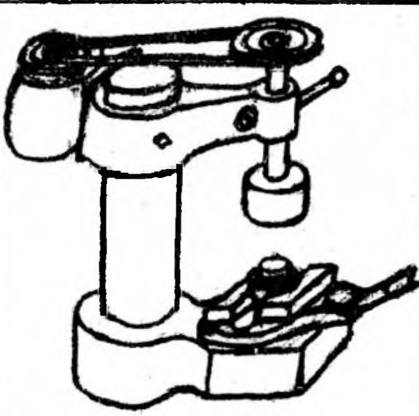


FIG. 7

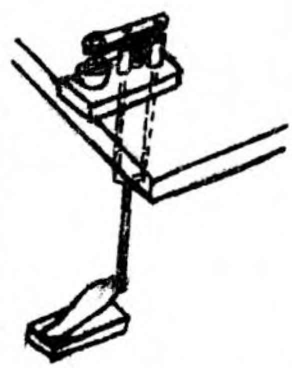
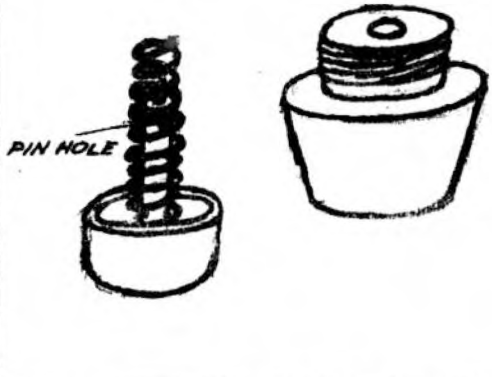


FIG. 8



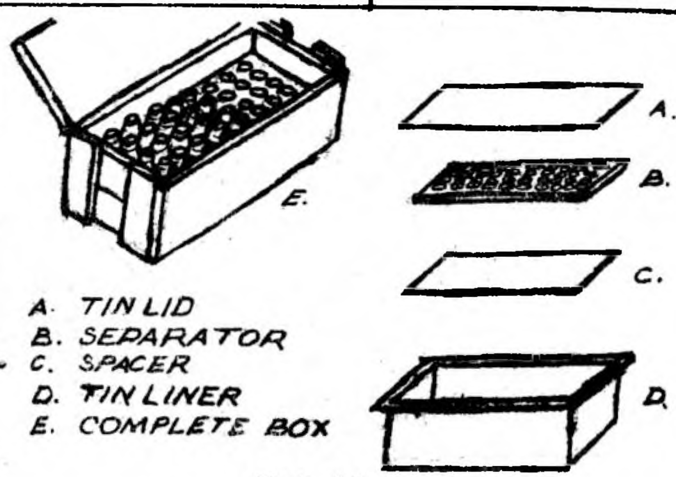


FIG. 10

M52, Inspection Details

Body;- The first operation on the body consists of making the complete outside and body threads, booster cavity and threads. The booster cavity being the open dimension on the drawing it is suggested that the mean dimension of the length from the bottom of the booster cavith to top of body be subtracted from mean dimension of the overall length and use this depth in making booster cavity. If this is held plus or minus 0.002", the dimension from bottom of body to shoulder should also be held plus or minus 0.002" of its mean dimension.

Booster cavity should have straight surface across bottom and not marred by tap. If crimping wall is too deep, the lead cup will extend into slider cavity; if shallow, the cup will extend above the surface.

The large diameter on taper should be held in first operation to about the mean between maximum and minimum dimension on the drawing. If this is done, and the angle of the taper is held closely to that shown on drawing, the small diameter on taper will come within the proper limits when body is faced off to proper length.

Use care in drilling the lead cup hole so the chips do not cut a radius on top of hole as this metal is needed in crimping operation. Keep the inside finish free of tool marks or scratches.

The slider cavity should be free of tool marks or shoulder in bottom caused by the drill running. The dimension from bottom of booster cavity to center of slider cavity must be held or lead cup will interfere with slider. A deep crimping wall will let lead cup extend into the slider cavity.

Lock pin cavity must enter slider cavity on center. If it does not, slider detonator will not align with firing pin or slider will bind on safety pin. Flat bottom and no bulge in slider cavity is necessary. Care must be taken in tapping that tap does not ruin shoulder below thread. Diameters must be concentric so that lock pin will assemble straight and not bind in the hole.

Set back pin cavity must be flat bottom, diameters concentric and enter safety pin cavity on center.

In the safety pin cavity the diameters must be concentric, show no tool marks and cross slider cavity on center. Care must be taken in the drilling operation that drill does not run; this will result in slider binding or not assembling with safety pin.

Head cavity must be concentric with outside diameter for proper alignment of head with body straight surface, and not marred in threading operation. Firing pin hole must be concentric with threads. Staking notch should not extend into major diameter of thread. Have chamfer on threads so thread will not extend above surface but not so deep that staking notch will extend into the chamfer.

Safety Pin:- Check for taper, Hole must be in center for proper alignment of set-back pin.

Set-back Pin:- Location of hole from shoulder and center of pin is important for proper alignment of cotter pin.

Lock Pin Plug:- Spring cavity must be concentric and no teat in center

Detonator Cup:- No scratches, tool marks or die cuts on inside or outside. No collet squeeze; no burrs around hole and small hole should be concentric with inside diameter. Die marks on outside radius should not be chamfered on trimming operation.

Head Striker Cavity:- Firing pin hole must be concentric with outside diameter. There should be no shoulders or tool marks on inside that will hamper action of striker. Head must overlap body on outside diameter.

Slider:- Outside diameter ff finish. The safety pin slot must be in center of slider. Lock pin groove must be in center of slider axis and straight with axis. Detonator cavity walls must have good finish and have flat bottom, and not bulge on end or outside diameter. Lock pin hole must be in center of groove and not bulge in safety pin slot. Flat surface should be parallel with safety pin slot.

Booster Cup:- Bottom must be straight and no chamfer on open end.

Booster Lead Cup:- Check for die cuts and outside diameter close to angled flange.

Striker:- Outside diameter must be free of burrs. Firing pin hole concentric with outside diameter. Depth of angle on firing pin hole should be held on minimum; this will help in holding firing pin firm in striker.

Firing Pin:- Proper flat on point should be held and no burr on end or angle. The shoulder on end that makes up in striker should be square to help hold pin straight and tight in striker.

M53, Inspection Details

With the exception of the head and slider, the M52 and M53 are the same, therefore, the head and its component parts and the slider will only be mentioned in the following.

Head:- For notes on outside dimensions see M52 head; the delay cavity should be concentric with firing pin hole and outside diameter of head. Also the depth of this cavity and length of thread are important so that the delay element assembly will properly seat in the head. In order to maintain the distance between the firing pin and the primer it is necessary to hold the dimension between the bottom of delay cavity and shear wire hole. For proper functioning of the firing pin with the primer, the dimension between delay cavity and striker cavity must be held. The diameter and concentricity of the striker cavity with the firing pin hole is important for the same reason. This cavity should also be straight across the bottom surface and no taper in diameter. Theshear wire hole should be concentric with counter bore and pass through the center of the firing pin hole to assemble with the firing pin.

Firing Pin:- Pay particular attention to the dimension from end of firing pin to the center of the shear wire hole, as this determines the distance between the end of the firing pin and the primer. The shear wire hole should be in the center of the pin for correct assembly of shear wire.

Delay Element Housing:- All inside diameters must be concentric with each other. Inside diameter must also have no taper or tool marks or shoulders. A sharp corner must be maintained on delay cavity where circular crimp is noted on drawing for proper crimp of delay element plug. The length of the delay and relay cavities and the thickness of the wall below it should be closely held for correct loading and crimping of the delay element plug. The over-all length must be held to maintain the correct over-all length after assembly. The end of the housing where the primer washer is located must be flat, and no radius, so washer will make proper seal. The concentricity of the outside threads should be maintained.

Primer Cover:- The inside diameters must be concentric with each other. A close check of the radii and depth of primer cavity must be made.

Primer Washer:- As this washer acts as a seal between the primer cover and delay housing, it should be flat and sides parallel without burrs. Check the annealing as specified on drawing.

Delay Element Plug:- For the proper crimping in the delay cavity the sharp corners and outside diameter are important.

Relay Cup:- Both the inside and outside diameters are important on account of the loading fixtures. The cup must be free of burrs. Check radii in bottom of cup.

Springs:- It is recommended that all springs be seasoned by heating rather than by bouncing, and that the seasoning temperature be 500°F.

SECTION III
FUZES

5 - LOADING AND ASSEMBLY OF M-56 P.D. FUZE

SLIDER:- The slider is inserted in a fixture which should align the slider so that the pellet hole is directly in line with the fixture hole which guides the punch for pressing the tetryl into the slider. One tetryl pellet is inserted and pressed with 47# dead weight, and another inserted and pressed to the same weight. The powder, after pressing, should be flush or above the outside diameter of the slider. If the powder is below this outside diameter it is rejected; if it is above the outside diameter it is removed in the cleaning operation which follows. This cleaning consists of wiping the excess tetryl off the slider with a dry rag. If the punch has hit on the side of the slider and marred it the slider is also rejected.

-BODY:- The body is stamped with the date, kind of fuze, loading plant initials and lot number. The body is then placed into a fixture with a pin running into the slider cavity to serve as an anvil in the pressing operation. A tetryl pellet is inserted and pressed into the flash hole between the slider cavity and the booster cup cavity. After the pellet is pressed in it is inspected to see that it does not extend into the slider cavity and is flush with the surface of the booster cavity.

LEAD CUPS:- The lead cups are inspected for cleanliness and a tetryl pellet inserted into them. The cups are then placed on a fixture of the press which rotates on a table under the punch, where the punch presses the powder in at a fixed dead weight. The pressed powder must be flush with the top of the cup and should have no cracked edges; this indicates that the powder is not tight in the cup.
The cup is inspected to see that the flange has not been cut or distorted by the pressing operation.

ASSEMBLY;- The half blocks fit into a fixture which has a slot in it like that in the nose of the fuze. This slot is so arranged that the assembling of the spring will not be too far down onto the half blocks so that they might bind in the fuze. The springs are taken up on a mandrel that fits down onto the half blocks and the spring pushed off on the half blocks and located. The spring must be located so that the ends are on the corners of the half blocks to keep from having two thicknesses of the spring between the half block and the inner diameter of the half block cavity.
This is important and must be checked frequently by the inspector. All springs should be examined before assembling to make certain that there are no loosely wound springs or springs with bent corners at the ends. Bent corners would tend to bind the half blocks and keep them from arming.

The half blocks are placed in the nose while it is held upside down. The radius of the blocks is placed toward the bottom of the groove. The head is then screwed on the nose and the whole assembly turned right side up. After the nose is tightened to the head the assembly is rolled from side to side to make certain that the half blocks move freely in the assembly. The firing pin is then inserted so that it rests in the grooves in the half blocks and the half blocks are tested for non-arming at 10,000 R.P.M. with a dead weight pressing on the firing pin. This weight is 2# and is moved up and down to relieve the firing pin so that the half blocks can move out if they will. A periodic check is made on the arming machine, which operates at 32,000 R.P.M. to make certain that the half blocks will arm. Not all half blocks are tested for arming, only a percentage.

The closing cup washer and closing cup are inserted and the closing cup crimped by rolling the crimping wall on the nose of the fuze over onto the closing cup. The closing cup is inspected to see that it is tight but not cut by the washer when crimped. The nose is then staked to the head.

The assembled head and nose is then gaged 100% from the top to the bottom. The lead cup is given a visual inspection and inserted into the detonator holder. A cork cushion is inserted, making certain that no broken washers are used, and the detonator inserted over the cushion with the colored side toward the cushion. This leaves the side of the detonator with the thin disc toward the firing pin. The detonator should be slightly above the top of the detonator holder, so that when assembled it will fit down tight into the head and hold the detonator tight.

The head is inspected to see that the firing pin does not stick down below the bottom surface of the head. This must be carefully checked to keep the firing pin from coming down on the detonator when it is assembled. The detonator holder is then screwed into the head and staked in two places This complete assembly is then gaged 100% from the flange to the bottom of the lead cup and overall length from the bottom of the laed cup to the top of the nose.

The slider is inspected to see that the tetryl is present and then inserted into the slider cavity. The slider spring is inserted and the retainer screwed in and staked. The body is then placed in an arming machine and tested for arming at 8,000 R.P.M. and then tested for non-arming at 4,000 R.P.M.

The booster cup is inspected to see that the wrench holes do not bulge the inside. A felt washer is inserted and the tetryl pellet inserted. The booster cup is then screwed in to the body with a hand wrench.. The booster cup is then staked to the body and must be flush or below the bottom of the body for the height gage used on the completed assembly.

The body and head are screwed together and staked in two places. The metal from the head is flushed into the staking notches in the body.

The completed assembly is then inspected 100% for the crimping of the closing cup; cup must be tight, no cuts or impressions from the washer caused by the crimping. The staking of nose to head, head to body and booster cup to body are also inspected. The stamping is also inspected and the projectile threads gaged 10%. The alignment of the nose, head and body is also checked.

The sides and bottom of the cardboard boxes for packing M-56 are sealed with gummed binder paper. A separator is inserted in the bottom of the box and a layer of 25 fuzes set in point up. A cardboard with holes to fit over the noses of the fuzes is placed over this layer and another separator inserted with another cardboard above it. Another layer of fuzes is placed in point down and a cardboard filler inserted and the box top glued and sealed as the bottom. The whole box is then dipped in parafin wax.

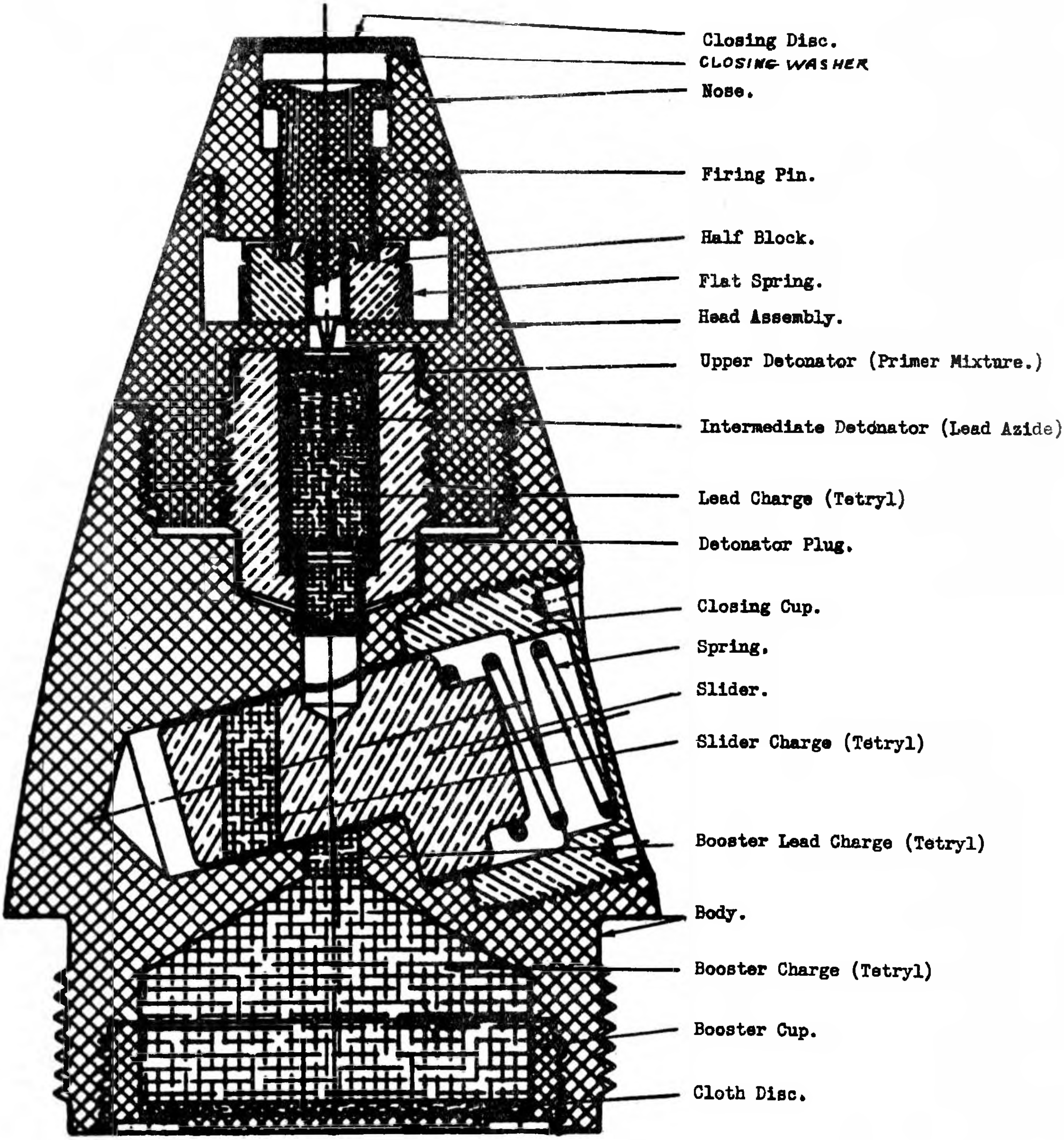


FIGURE 1 - Point-detonating fuze, M56.

SECTION III

FUZES

6. TIME FUZES DESIGN AND FUNCTIONING

A time fuze is a mechanism, which, when assembled to an artillery projectile, will cause it to function at some preselected desired point on its trajectory prior to impact with the ground.

Time fuzes of various types have been made for many years. In fact, the first missile which was provided with an interior bursting charge carried of necessity somedevice which would be classified as a time fuze. In the early stages of development of artillery when low muzzle velocities and short ranges only were obtained, the device could be of a very crude and simple nature.

The first device probably consisted of a slow burning match similar to the present miner's fuze. This match was inserted into the shell through a hole provided with sealing means. Ignition of the match was accomplished by the flames from the propellent charge and the time of burning was determined by the length to which the match was cut.

This device later appeared in a more refined form as wood or metal tube charged with pressed black powder. These tubes were furnished the Battery Commander with different calibrations, that is, rates of burning. These rates of burning were varied by varying the pressure applied to the powder and the composition of the powders used.

Adjustment of the time of burning so as to give the burst at the desired point was accomplished by first selecting the tube of proper calibration and then cutting the tube off, drilling out the tube, or by punching a hole through the side of the tube.

In some cases, it is understood that sufficient multiplicity of fuze tubes of different times of burning were issued so that it was only necessary for the Battery Commander to select the proper tube to give the desired time of burning. Ignition was effected by the propellent powder gases and the functioning of the shell charge occurred when the tube burned through and the flame came in contact with the black powder burster charge of the shell.

With the development of breech loading, rifled guns, longer range of weapons, accuracy of flight and also time of flight increased, the need arose for greater times of burning and greater accuracy.

The platen, plate, ring, or disc fuze and the tube fuze came into being to meet these demands. In these fuzes, the ignition is accomplished by indirect means, that is, by applying the forces developed by the acceleration of the projectile in the bore of the gun to fire a movable primer element. This primer at the end of its stroke came in contact with a firing pin and the flame of the primer charge communicated with the desired point of ignition of the train.

The lead tube fuze and platen fuze was probably developed simultaneously for a period. Fuzes of the lead tube type were used at one time in the United States service. Eventually the platen fuze reached undoubted supremacy over the lead tube type at least in popularity.

It is understood that today only one European power has any interest in the lead tube fuze. The time train of the tube fuze consists of a lead tube carrying a central charge of black powder. The manufacture of this tube is accomplished by loading a short lead tube of relatively thick walls and large diameter with the powder under pressure. The tube is then drawn through a series of dies which reduces the diameters and wall thickness and reconsolidates the powder in its new distribution.

The fuze employing this lead tube consists of a body, on the exterior of which, is machined a spiral in which the lead tube is laid.

This body is then covered with a thin metal shell, a fuze punch is provided which is capable of piercing the exterior shell and the lead tube. In the interior of the fuze body there is a primer contained in a movable element and passages are provided communicating from the interior of the fuze body to the space betwwen the fuze body and the surrounding shell. Upon firing from the gun, the primer pellet is carried down against the firing pin and the flash from the primer fills the interior of the body with flame which reaches the annular cavity between the fuze body and the shell. This flame ignites the lead tube at the point at which it was pierced by the fuze punching operation. Burning then proceeds both ways from this point, but the effective portion of the burning is in the lower part of the tube which leads to a black powder magazine charge. This black powder magazine charge when fired communicates the flame to the expelling charge of the shrapnel. Obviously, this type of fuze when once punched, can be repunched only for a shorter time of burning.

It is understood that this type of fuze is still of interest to one country because their experience has been that it is more uniform in functioning. This claim cannot be discussed due to lack of comparative firing data. As an obvious advantage it may be cited that the fuze can be made practically, if not absolutely, waterproof for transportation and can be retained in this condition until just before firing.

The platen or ring type of fuze is used exclusively in the United States Army today. The originator of this type of fuze is supposed to have been a man by the name of Bormann, although the first fully developed fuze was designed and patented by O. Hartmann, U.S. Patent No. 737,229 dated 8/25/03. The first fuzes of this type available to the United States Army were procured from the Erhardt Company, about 1903. Ring fuzes have been made with three rings, two rings and one ring. The three ring fuzes have been made for the purpose of obtaining greater time of burning than can be accomplished in the now conventional two ring type. Three ring and multiple groove fuzes are also used (foreign) to permit the use of faster and presumably more uniform powder. At the present time, fuzes of this type are not of interest, as it is believed that the relatively small requirements for fuzes of greater burning time can be met with mechanical fuzes.

The one ring fuze has been used in certain countries on short range projectiles such as the 37mm and 2.24 inch, but it is believed that the American service has never had a fuze of this type. A two ring fuze can be made of moderate diameter to give a burning time of 45 to 50 seconds by the use of slow burning powders and this time of burning is sufficient to take care of most of the Army requirements.

The Army has had in the past 21 second and 30 second fuzes having a flange diameter of approximately 2 3/8 inches and 31 second and 45 second fuzes with a flange diameter of approximately 3 inches.

The 30 second fuze was an adaption of the 21 second fuze manufacture by loading the 21 second rings with a slow burning powder and graduating the movable ring to suit. The 45 second fuze was made from the 31 second ring by the same procedure. The original composition used for this purpose was Army black powder diluted with approximately 16% barium nitrate. When an attempt was made by the Bartlett-Hayward Company during World War No. 1 to produce the 45 second fuze they changed to a so called coal powder in which the charcoal content of Army black powder was in part replaced by powdered semi-anthracite coal.

Of late years the 30 second and the 31 second fuzes have been removed from the Army list of standard items of issue.

In all of the fuzes of the two ring type, the body, upper ring, and closing cap are secured in a fixed relationship to one another. The graduated ring, which is the lower one, is movable in respect to the body and the other ring so that the burning time can be adjusted by changing its position. When fired from the gun the primer which is contained in a recess in the bodyand closing cap is caused to move so as to contact with the firing pin by the forces developed by acceleration in the gun. In the new designs of fuzes, the primer is held securely in the fuze body, while a plunger moves so as to strike and fire the primer

The flash from the primer is communicated to the upper ring and burning then proceeds in this ring until the flash hole to the lower ring is met. The burning then proceeds in both the upper and lower rings until the point in the body carrying the body pellet is reached and the body pellet is ignited and the magazine charge is fired. In case of failure occurs in the time train rings or impact with the ground occurs before the set time is reached, functioning then occurs by reason of the impact elementcontained in the base of the fuze. This impact element fires the percussion primer which in turn fires the magazine charge.

These fuzes carrying the impact element in addition to the time element are called combination fuzes. The percussion element is omitted in AA fuzes as impact burst of these fuzes would be highly undesirable under the normal conditions anti-aircraft fire where impact occurs in friendly territory.

The time fuzes are provided with an interruption of solid metal in the graduated time train ring. When this interruption or space is in position over the body pellet, the fuze is set safe so far as the time element is concerned.

This safe setting is used for transportation and also may be used to produce impact action alone. Canister effect from time fuzes assembled to shrapnel may be deliberately obtained by setting fuze for zero time of burning and firing in this position. There actually is sufficient delay to permit the shrapnel to leave the muzzle of the gun before functioning occurs and this functioning may then occur at some point between the muzzle and approximately 50 feet in front of the muzzle. The zero setting would, of course, produce a very dangerous condition, if fired, so set, assembled to a high explosive projectile as some of the fragments from the high explosive shell would be projected to the rear endangering the gun crew.

The mechanical time fuze is a device in which the powder train is replaced by a mechanism similar to a clock or watch mechanism.

Mechanical time fuzes have been worked on for many years. It is believed that the first mechanical time fuze made available to the U.S. was the Krupp mechanical time fuze imported about 1911. Practically all mechanical time fuzes are one of three types, the so-called Krupp type, the Schwab type or the flag type.

The Krupp type consists of a time keeping mechanism which carries on its upper face a setting disc. This setting disc is free to turn and is tied in with the cap by some means which is releasable upon firing.

The setting disc carries on its periphery a notch. The setting is accomplished by moving the cap so as to change the position of the notch in the setting disc relative to the releasing device. Upon firing from the gun, the clock work mechanism is started, the setting disc is rendered immovable with respect to the main staff of the time keeping mechanism and the setting means is released. The running of the mechanism causes the notch in the disc to approach the releasing mechanism and when the notch reaches the releasing mechanism it passes into the notch and the firing pin is released. This type of fuze has been produced with main spring actuation of the mechanism, and also with centrifugal force actuation.

The standard mechanical Time Fuze, M2, now being manufactured at Frankford Arsenal, is of the Krupp type with centrifugal actuation.

The advantage of this is the fact that we do not have in stores fuzes with main springs held under constant tension.

The Schwab type of fuze has as its principal point of difference an escapement which operates in the vertical position and at somewhat unusual method of releasing the firing pin. While this mechanism employs a main spring, when stored the main spring has only a small amount of tension. The storing of energy in the main spring is accomplished in the setting of the fuze.

The so-called flag type of mechanism is a type which has been seriously proposed on numerous occasions, but it is probably fallacious in its basic idea. This fuze consists of a mechanism which is intended to be driven by relative motion between the projectile and the central staff of mechanism which is held immovable by air resistance acting against a flag projecting from the nose of the projectile.

It is probable that the flag would produce only a small amount of slippage which would not be definitely determined due to varying conditions of atmosphere.

There are attached prints which illustrate the different types of fuzes which have been items of issue in the Army. The principal difference between the two ring time fuze as originally obtained from the Erhardt Company and as now manufactured, is in the method of venting.

The fuzes as originally procured were exterior vented fuzes, that is the rings were provided with sealing discs on the exterior contour at the beginning of each train. These discs were blown out by respectively the primer and the magazine charge of the graduated ring and venting was by means of the orifices thus produced. The change from the exterior vented type to the interior vented type was made in 1907.

A study of the records indicates that the comparative firings made at this time to justify the change were quite limited and the basic reason for the change is not definitely known. The interior vented fuzes appear to have the disadvantage of a weakened ring which is very serious when the high loading pressures which are used are considered.

The possibility of short timing of fuzes by reason of pre-ignition of the lower ring through its interior vent is also evident in the current designs. In the new designs of fuzes, the Army is reverting to the use of exterior vents.

There have been many different types of releasing mechanisms for the concussion primer, that is, the primer which initiates the burning of the time train.

Devices which are inherently safe during transportation against the shocks produced thereby are suitable for use only in the high pressure smaller caliber guns, as in other cases the forces developed upon firing are not sufficient to overcome a transportation safe device. Hence, we find that fuzes intended for use in the larger caliber guns and Howitzers carry concussion plungers, which in addition to the locking means which may be released in the bore of the gun, are held during transportation by means of a removable locking pin.

A multiplicity of devices for the percussion plunger, that is the plunger which functions upon impact with the ground, has been proposed and used. The centrifugal type of plunger used in the Army fuzes since its inception in about 1907 has been used in numerous American fuzes, both combination time, and straight percussion types, since that time.

The possibility of parts turning relative to one another while in the bore of the gun due to angular acceleration has been a subject of discussion for many years, and in the early history of time fuzes, it was the tendency to blame any malfunctioning of the fuze upon the fact that the graduated ring had turned while in the bore of the gun and devices were incorporated in certain foreign fuzes to prevent this occurrence. It is quite certain that the time train rings of time fuzes do not turn while in the bore of the gun. It has been demonstrated both experimentally by firing at Sandy Hook Proving Ground and by calculations, that the frictional forces resulting from linear acceleration will oppose any forces due to angular acceleration to the point where turning is impossible. The theoretical results calculated upon the basis of firing the Mk. II Time Fuze with aluminum rings in the 3 inch A. A. Gun, Model 1917, are as follows:

Position in Gun Bore	Setback Force Lower Ring lbs.	Setback Force Upper Ring lbs.	Frictional Moment of Lower Ring in./lbs.	Angular Setback in/lbs. $\not+$	Angular Setback in/lbs. $\underline{\not+}$
14 inches	1039	1381	904	37.9	38.0
28 "	1009	1343	878	47.8	36.9
55 "	853	1136	721	53.7	31.2
83 "	739	983	643	57.9	27.0
109 "	658	877	573	61.1	24.1
123 "	626	834	543	61.0	23.0
137.28 (muzzle)	614	818	535	33.6	22.5

$\not+$ When fired in gun having increasing twist of rifling 1 in 50 to 1 in 25.

$\underline{\not+}$ When fired in gun having uniform twist of rifling 1 in 40.

It will be noted that a factor of approximately 20 to 1 is operating against the ring turning while in the bore of the gun, that is, that this ratio exists between the frictional moment, preventing motion and the "angular setback", tending to produce motion. The figures given are based upon the assumption that the upper ring will exert setback against the lower ring, an assumption which is undoubtedly always met in the fuze. While the fuze rings upon which the calculations were based, were made from aluminum and the service fuzes have rings made from brass, this does not affect the ratio of the forces acting since the change in weight without change in contour would have equal effect on both of the critical forces.

Similar calculations made for the closing cap of the fuze indicates that with the increasing twist of rifling and assuming that the cap would bear only on the stem threads, turning of the cap would be possible. This is due to the small diameter of contact and the resulting preponderant angular torque. This point has never been checked by experimental firings. A physical check is practically impossible due to the fact that fuzes could not be recovered from such a firing except in damaged condition which would affect the accuracy of the data obtained.

Some of the factors which will affect the time of burning of a powder train fuze are the following:

<u>a</u>. Strength of primer. The effect of this factor would be at the moment of initiation only due to the possibility of blasting the time train ring.

<u>b</u>. Composition of the powder. If a powder which is slower burning than Standard Army Black Powder is desired, the composition is usually varied by adding excess sulphur, inert materials, barium nitrate or powdered coal, all of which serve as deterrents. The use of sulphur as a deterrent has been found to be unsatisfactory, and at the present time, coal, barium nitrate, and oak charcoal are only important retarding agents.

<u>c</u>. Pressure of air surrounding the fuze vents.

<u>d</u>. Temperature of air surrounding the fuze.

<u>e</u>. Rotational rate of fuze.

It will be noted that the velocity of the projectile is not included as one of the factors affecting the rate of burning. Velocity is, of course, an affecting factor, but appears as a dynamic pressure factor which is combined in the general expression of pressure of air surrounding the fuze vents. This is not of nearly as great magnitude as might be expected, according to the work of Bairstow, Fowler and Hartree as published under the title of "The Pressure Distribution on the Head of a Shell Moving at High Velocities." The distribution of dynamic pressure along the contour of the shell was found by their experiments to fall away very rapidly from the point directly on the nose of the shell, so that at the vent location this pressure is only a small fraction of that existing on a flat plate exposed to air moving at shell velocity. The total external pressure on the vents is the summation of the dynamic pressure at this point plus the static pressure or barometer pressure at the same point.

Discussion of the various factors and their effect, will follow. The strength of the primer has its effect only due to the mechanical removal of powder grains by the blast of the primer.

This effect is minimized by the proper design of primer. An attempt is being made to produce a primer which will give a maximum temperature effect with minimum blasting effect.

The effect of composition of powder does not belong in this lecture and is mentioned only incidentally. The blending of powder is a large subject in itself and is undoubtedly adequately covered in other lectures.

As stated following the listing of the factors affecting the rate of burning, the pressure at the vents of the fuze is composed of two factors, that is, dynamic pressure and atmospheric pressure. The effect of atmospheric pressure has been studied quite completely by burning fuzes under varying pressures while at rest and also while under a nominal rotation. As might be expected, the rate of burning under varying atmospheric pressure follows a curve of the general character

$$T = To \frac{Po^x}{p^x}$$

To equals the time of burning at normal pressure (P_o), T equals time at pressure P. The determination of x has been made experimentally with the indication that x is very close to .5. Where x equals .5. the formula may be written

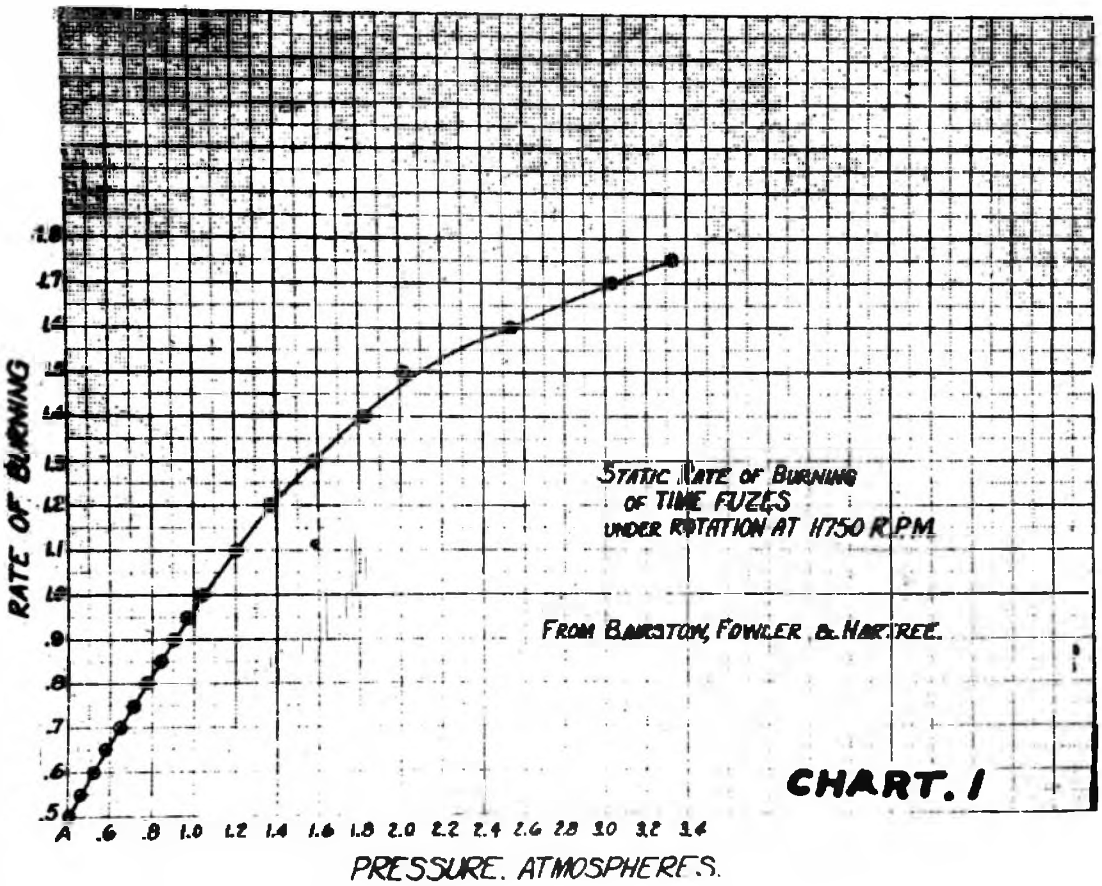
$$\underline{5.48}$$

$$T = T_o \sqrt{P} \quad ; \qquad T_o = \frac{T\sqrt{P}}{5.48} \qquad \text{or}$$

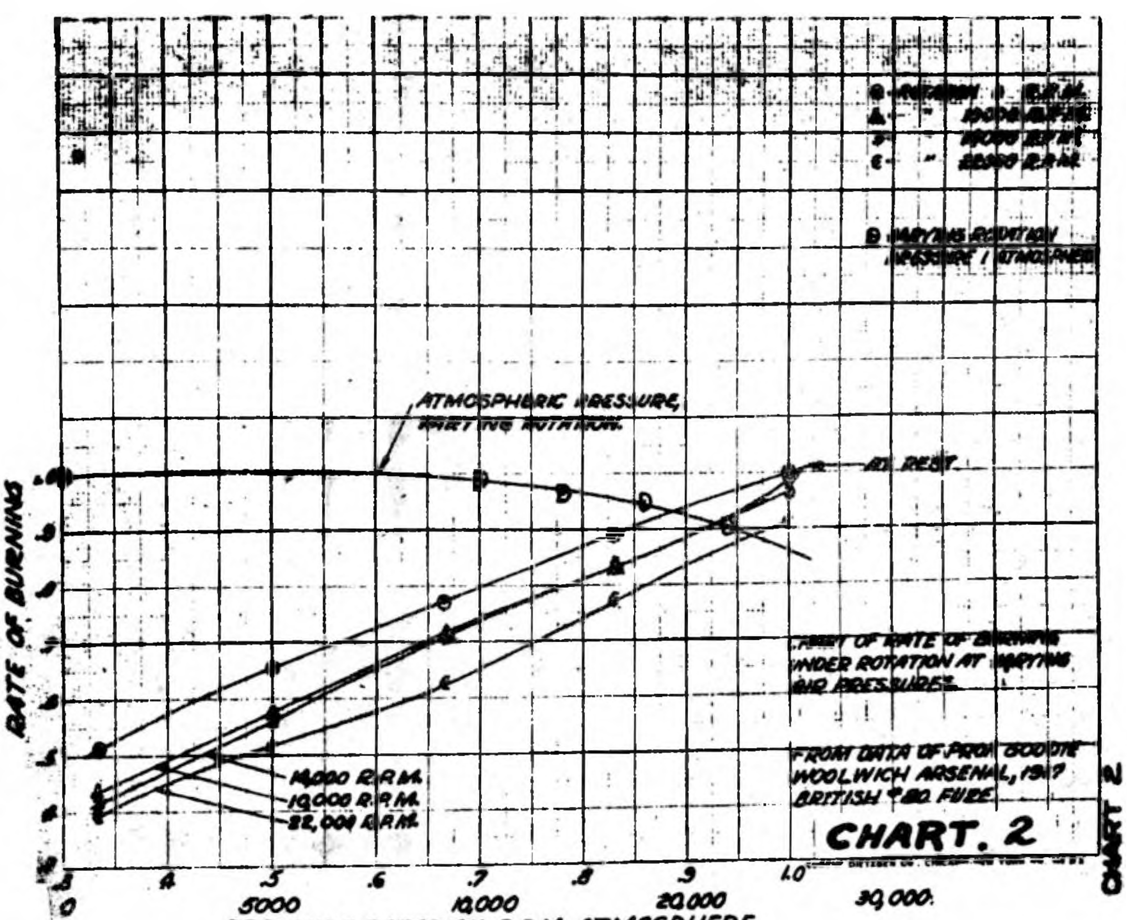
in the form $T_o = T \left(1 + \frac{P-30}{60} \right)$

will give practically the same results, with P expressed in inches of mercury. This formula is used in the static testing of fuzes to reduce the times of burning obtained to times of burning at normal atmospheric pressure (30 inches Hg).

Chart No. 1 shows the variation in rate of burning of time fuzes when rotated at 11,750 R.P.M. with variation in atmospheric pressure. This chart employs rate of burning. This rate of burning can be employed to convert to time of burning by dividing the normal time of burning, that is, the time of burning at 30 inches barometer by the factor, rate of burning. The data given below is from the experiments of Prof. Goudie and is self-explanatory.



RATE OF BURNING
STATIC RATE OF BURNING
OF TIME FUZES
UNDER ROTATION AT 11750 R.P.M.
FROM BAIRSTOW, FOWLER & HARTREE.
CHART. 1
PRESSURE. ATMOSPHERES.



ATMOSPHERIC PRESSURE,
VARYING ROTATION.
AT REST.
RATE OF BURNING
CHART OF RATE OF BURNING
UNDER ROTATION AT VARYING
AIR PRESSURES.
FROM DATA OF PROF. BOODIE
WOOLWICH ARSENAL, 1917
BRITISH #80 FUZE.
14,000 R.P.M.
10,000 R.P.M.
22,000 R.P.M.
CHART. 2
CHART 2
PRESSURE ROTATION R.P.M. ATMOSPHERE

Table II

Effect of Speed of Rotation on Burning Time
No. 80 fuzes

Rotational Speed	Time in Seconds			
	Mt.	Max.	Min.	GD
0	21.83	22.2	21.2	1.00
10,600	22.25	22.59	21.60	1.01
16,480	23.32	23.78	23.10	.68
18,400	25.18	26.20	24.14	2.06
20,410	25.79	28.50	23.70	4.80
24,100	29.21	32.00	27.00	5.00

Table III

Effect of change in Pressure under varying rotational speeds.

Vacuum Ins.	Atmos. Press	Times at Speeds - RPM				
		0	10,000	14,000	18,000	22,000
0	1.0	22.50	22.75	23.25	23.75	24.75
5	.83	25.25	26.75	26.75	27.50	29.00
10	.66	29.25	31.50	31.75	33.50	36.00
15	.50	34.25	39.00	40.25	43.00	43.75
20	.33	44.00	51.50	54.50	56.00	57.25

Table IV

Effect of Varying Temperatures on Burning Time

No.80(Degrees Fahn.	-58°	-22°	32°	50°	77°	122°	158°	212°
(Mean Time	23.77	23.34	22.71	22.83	22.28	22.06	21.82	21.04
Fuze (Mean Diff.	.17	.20	.14	.10	.35	.08	.18	.34
No.85(MT	23.96	24.19	23.40	24.15	23.16	22.72	22.15	22.20
Fuze (MD	.17	.20	.20	.13	.06	.13	.35	.16

The figures of Tables II and III are plotted on Chart 2, forming a part of this lecture.

The British No. 80 fuze referred to in the tables given above is a 22 second fuze with exterior vents. The British No. 85 fuze is a 21.2 second fuze and is identical with the 21 second 1907M Fuze except for the size of the body thread.

The effect of temperature has been studied to a considerable extent. The results have been published by the British in a publication comprising the work of Professor Goudie. The conclusion from this work was that a flight time correction due to temperature could be made on the basis of the formula T = .00053 second per degree Fahrenheit per second of mean time of burning, where T is the correction to be applied to the observed time. This correction is negative for temperature below the standard temperature and positive for temperatures above the standard temperature.

A general formula for temperature correction has been proposed as follows: $r = r_o \times (1 + Bt)$, where r equals rate of burning at temperature, t, above standard, r_o equals rate of burning at standard temperature. T = variation from standard temperature in degrees of Fahrenheit. Values of B were determined experimentally by Professor Goudie to be as follows:

.00073 for British No. 85 Fuze having a normal time of burning of 23.4 seconds
.00040 for British No. 80 Fuze having a normal time of burning of 22.7 seconds.
.00014 for British No. 84 Fuze having a normal time of burning of 30.1 seconds.

The actual changes per degree Fahrenheit in the time of burning for the three fuzes listed above are:

.017 second
.009 "
.004 "

when the fuzes are set at full time of burning. This temperature correction is probably independent of other factors such as spin, pressure at the vents, etc.

It may be presumed from the wide variation in the value of B that the results of these experiments are not very reliable. In fact, the results are given with considerable reservation by Professor Goudie, as he recognized that heating of the fuze parts by the combustion of the powder might have an overpowering effect on the primary temperature of the fuze. Temperature corrections are in general ignored in American practice.

The effect of rotation alone on the time of flight is very nicely illustrated by the summary forming a part of Aberdeen Proving Ground Firing Record No. 6693, in which rounds were fired under similar conditions from the 3 inch A.A. Gun, Model 1917, with tubes having a twist of rifling 1 in 40 and 1 in 25 at the muzzle. The corresponding rotations under the conditions of firing were 16,800 R.P.M. and 26,900 R.P.M.

The results of this firing were as follows:

Table V

Gun Twist	Fuze Lot	Muzzle Velocity Est.	Elev. Deg.	Fuze Set. Sec.	No. Rds. Cons.	Mean Time of flight sec.	Dispersion Sec. Max.	Dispersion Sec. All.	No. of Failures
1-40	8060-3	2800	60	10	5	9.15	.25	.90	0
1-25	"	"	"	"	5	11.15	1.55	.90	0
1-40	"	"	45	15	5	14.38	.21	1.15	0
1-25	"	"	"	"	4	16.55	1.08	1.15	1
1-40	"	"	70	"	5	16.29	1.38	-	0
1-25	"	"	"	"	4	20.69	3.18	-	1
1-40	"	"	30	20	5	18.70	.26	1.40	0
1-25	"	"	"	"	3a	22.25	.70	1.40	1

a = One time of flight very erratic. Not considered.

The results of this firing are plotted on Chart No. 3 as part of this lecture. It will be noted that the effect of increased elevation becomes more noticeable under increased rotation. This is further illustrated by Chart No. 4 forming part of this lecture showing the difference in time of burning between rounds fired in 3 inch A.A. Guns, Model 1917, of the two different types of rifling. It will be noted that when fired at 1,500 mils. gun elevation, the increase in time of burning between the two rotational speeds is over 5 seconds at full setting, whereas, at 200 mils., the difference in time of burning is less than 1.5 seconds.

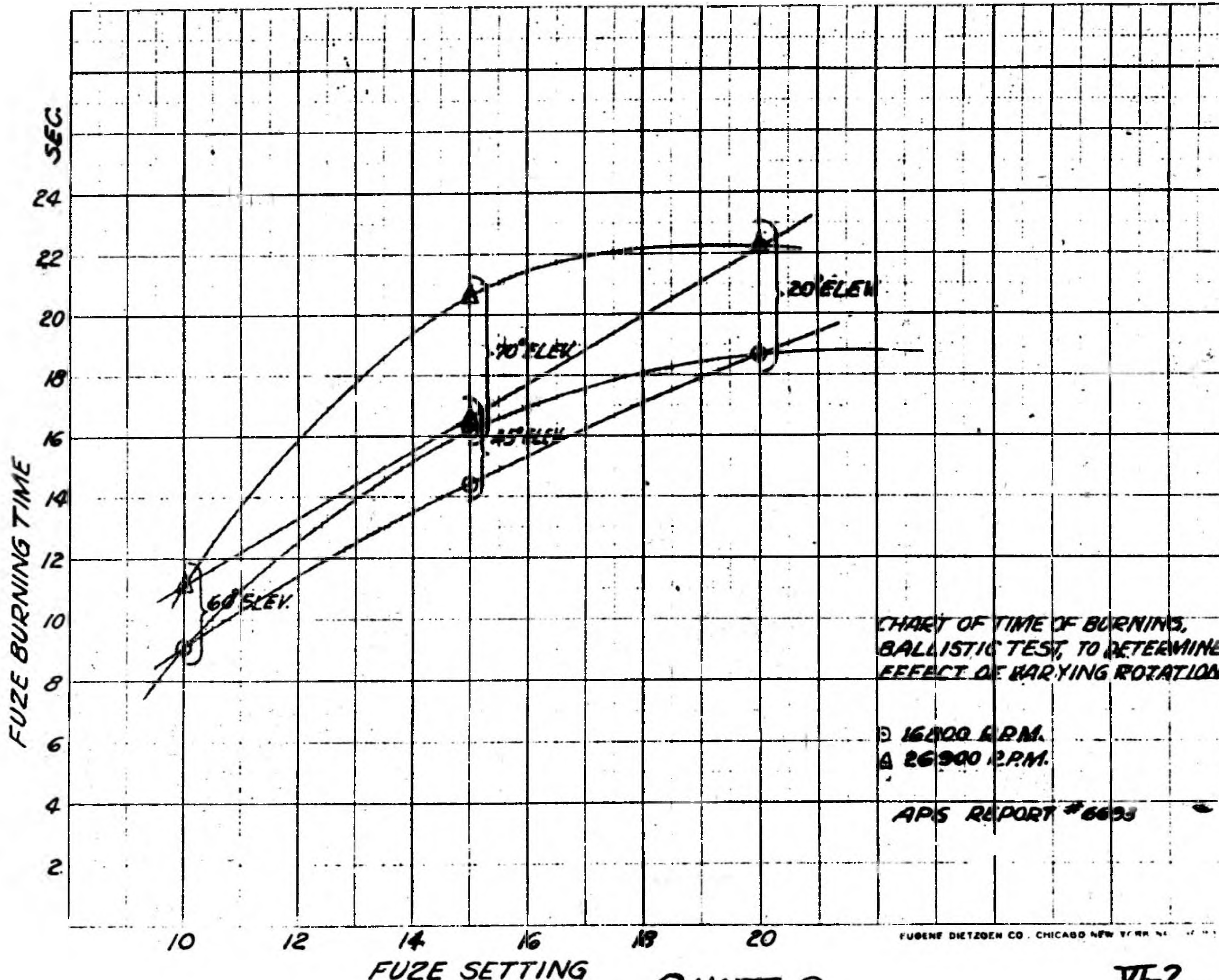
The effect of angle of elevation alone is illustrated by Chart No. 5 as part of this lecture which shows the results of firing Mk. I Shrapnel in the 3 inch A.A. Gun probably with a tube having rifling 1 in 25 at the muzzle. This information on the rifling is given with reservation as it is not definitely known. It will be noted that at 70 degrees elevation the time of burning corresponding to full setting for a nominal 24 seconds fuze becomes approximately 29 seconds and that this increases to over 30 seconds for a 90 degree elevation.

It may be seen from the data given that the conditions under which a fuze is tested are of great importance in interpreting the results. The graduations of the 21 second fuze Model 1907M are not equidistant as they are based upon the results of an extensive firing test of the fuze in the 3 inch Field Gun at a muzzle velocity of 1700 f/s and a muzzle R.P.M. of 13,650, with the elevation of the gun to give normal heights of burst of the shrapnel at the set time. If fired at any other velocity or different rotational speed or both and at different elevations than that for which the graduations were determined, the burning rate will be varied to some extent. As an instance of this, the fuzes when fired from the same weapon at 1793 f/s gave flight time as follows:

a. At 20.9 seconds setting, burning time 20.12 seconds.

b. At 16.9 seconds setting, burning time 15.91 seconds.

c. At 11 seconds setting, burning time 11.31 seconds.



SEC
24
22
20
18
16
14
12
10
8
6
4
2
FUZE BURNING TIME
10
12
14
16
18
20
FUZE SETTING
70° ELEV.
45° ELEV.
20° ELEV.
60° ELEV.
CHART OF TIME OF BURNING,
BALLISTIC TEST, TO DETERMINE
EFFECT OF VARYING ROTATION
⊙ 16800 R.P.M.
△ 26900 R.P.M.
APS REPORT #6693
EUGENE DIETZGEN CO. CHICAGO NEW YORK

CHART 3

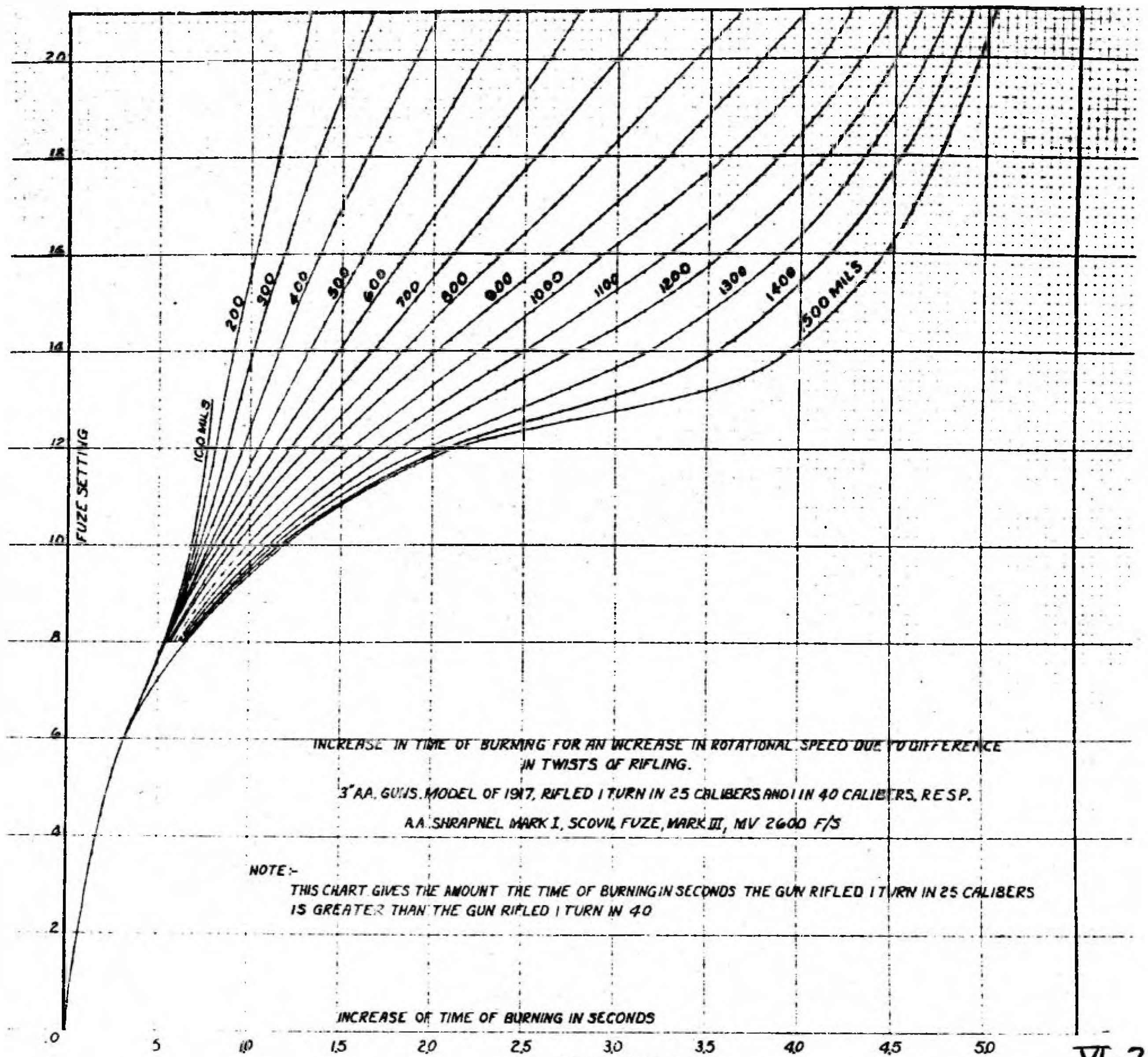
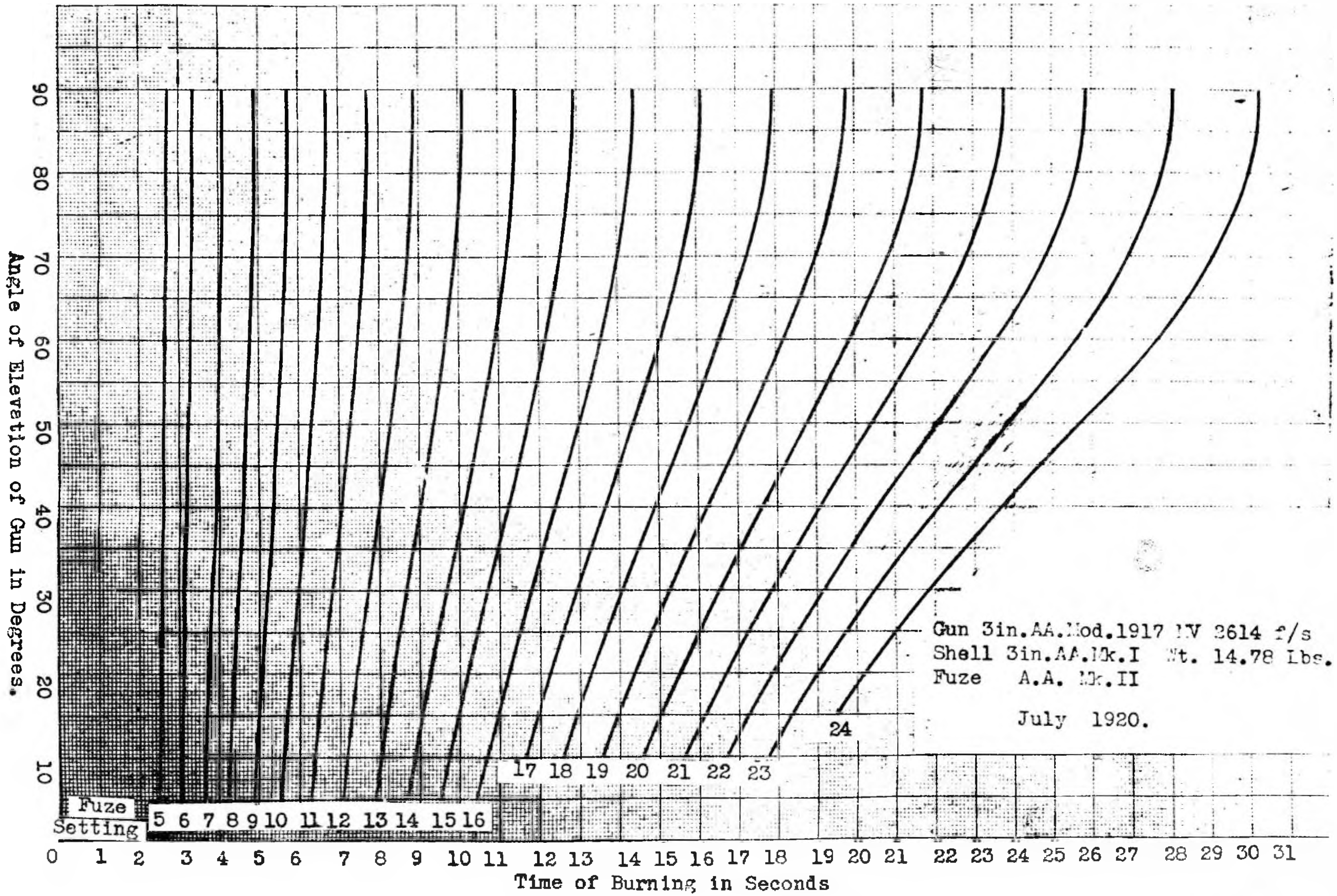

INCREASE IN TIME OF BURNING FOR AN INCREASE IN ROTATIONAL SPEED DUE TO DIFFERENCE IN TWISTS OF RIFLING.
3" A.A. GUNS. MODEL OF 1917, RIFLED 1 TURN IN 25 CALIBERS AND 1 IN 40 CALIBERS, RESP.
A.A. SHRAPNEL MARK I, SCOVIL FUZE, MARK III, MV 2600 F/S
NOTE:-
THIS CHART GIVES THE AMOUNT THE TIME OF BURNING IN SECONDS THE GUN RIFLED 1 TURN IN 25 CALIBERS IS GREATER THAN THE GUN RIFLED 1 TURN IN 40
FUZE SETTING
INCREASE OF TIME OF BURNING IN SECONDS
100 MILS
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500 MILS
0
2
4
6
8
10
12
14
16
18
20
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

CHART 4



Gun 3in.AA.Mod.1917 MV 2614 f/s
Shell 3in.AA.Mk.I Wt. 14.78 Lbs.
Fuze A.A. Mk.II

July 1920.

CHART 5

The elevations used in this firing were those used in the calibration firings at 1700 f/s. Therefore, it becomes necessary to define very definitely the conditions under which fuzes are to be tested ballistically for the conditions to be fair to the contractor. In the new designs of fuzes, no consideration is given to calibrating the time settings, the graduations being chosen arbitrarily and spaced equidistant from each other.

The flight time requirements for the 21 second 1907M fuzes have been redefined in recent years based upon results of firing in the 75 m/m Gun, Model 1897. The conditions of firing and the results required are as follows: Firings to be conducted from the 75 m/m Gun, Model 1897, with muzzle velocity of 1755 f/s.

Table VI

Fuze Setting	Elevation of Gun	Mean Time
5	5° 00'	4.80 ± .201
10	9° 30'	9.87 ± .308
15	14° 00'	14.88 ± .414
20.4	19° 00'	20.73 ± .537

The allowable dispersion is given as .4 second plus 1% of the fuze setting.

The American practice in accepting Army time fuzes is to judge the acceptability of the product entirely on the basis of mean time and total dispersion, the latter being the extreme variation between any two shots in a group fired under the same conditions. This may result in the rejection of a lot of fuzes due to one erratic fuze among the samples selected for test. Placing entire reliance upon maximum dispersion in determining the satisfactoriness of a lot of fuzes has not been universally followed by other nations. It can be cited that the British employ a practice of permitting the omission of one shot from a group with adjustment in the permissible dispersion. As an instance of this, the practice in accepting the British No. 80 Fuze was to require the following:

MD (mean difference)of 20 fuzes, .14 second max., set full.

MD (mean difference)of 20 fuzes, .12 second max., set 14.5 seconds.

GD (greatest difference) .75 second max., set full

GD1 (greatest difference omitting one fuze) .60 second max., set full.

GD1 (greatest difference omitting one fuze) .50 second max., set 14.5 secs.

GD (greatest difference) .60 second max., set 14.5 secs.

This tabulation illustrates two practices not in accordance with American practice. The MD, that is, the average deviation from the mean is given consideration and secondly, specific provision is made for omitting one fuze, provided the balance of the fuzes will show sufficiently small dispersion to come within a narrower range. The MD is considered in most physical observations to be of great importance as it is a measure of frequency as well as the extent of deviations, whereas the greatest difference or maximum dispersion is admittedly subject to considerable variations by reason of accidental selection of samples.

An additional difference in the method of testing British fuzes consisted in conducting the static fuze test with the fuze spinning at 2,500 RPM instead of with the fuze not spinning. When tested under these conditions, the No. 80 fuze must function at 22.0 $\pm$ .2 seconds. Barometer correction is made on the basis of .023 of the mean time for every inch of barometer readings above or below 30 inches, being plus when above and minus when below. This correction factor of .023 gives a considerably greater correction than the square root law given in a previous portion of this lecture.

The manufacture of Anti-Aircraft fuzes was started at this Arsenal, with little realization of the difficulties which were to arise. So far as was known this phase of the manufacture did not differ from the manufacture of combination fuzes in any material respect. The powder which had been procured commercially and used with satisfactory ballistic results in the combination fuzes was applied to the loading of anti-aircraft fuzes. It was known that performance in the anti-aircraft guns equal to that obtained in the field guns could not be expected, due to the firing conditions of greater angle of elevation and greater spin, but it was considered that the more generous allowance for dispersion would enable fuzes manufactured in accordance with practices previously successful to pass ballistic tests.

The practice used by the Scovill Manufacturing Company for war-time manufacture of loading anti-aircraft fuzes with blends of the same powders used for the combination fuzes but blended to give a slightly greater burning rate was therefore used in the preliminary loading. When these fuzes were tested ballistically a very unsatisfactory performance resulted.

Just at this time a rotating machine capable of rotating time fuzes at speeds up to 25,000 R.P.M. was being installed. This machine now forms part of the equipment of the experimental fuze plant. The first use made of this machine was in investigative work on the anti-aircraft fuzes. It was found that excessive dispersion and failures could be induced in this machine by rotating fuzes at rates equivalent to that obtained in the 3" gun with 1/25 twist of rifling, simulating exactly the performance obtained in the ballistic tests.

Experiments with powders of various types gave rise to the conclusion that the failures were due to the use of powders containing excessive quantities of sulphur which gave a soft, viscous slag. This slag acted in some way not well understood, to cause failures of the type known as "tailing out" and to cause excessive dispersion in these fuzes which burned to completion.

The occurrence of this difficulty, and its subsequent investigation, gave an opportunity to try exterior vented fuzes. The tests on the rotating machine indicated that while the change from interior to exterior vents was not a cure-all, it did result in improved performance of fuzes loaded with the proper type of powder. By the proper type of powder is meant one which contains sulphur or other low melting constituents in amounts not exceeding 10%, and which gives the desired time of burning in the fuze. Subsequent ballistic tests, so far conducted to only a small extent, tend to verify the conclusion arrived at as a result of static rotational tests, that the exterior vents are superior to the interior vents.

It is necessary to admit, however, that the performance of these fuzes in the 3" gun with 1/25 twist of rifling is still far from equal to that which may be expected from Mechanical fuzes, and the problem of the development of an entirely satisfactory powder time fuze for this gun is still open. In the 3" gun with 1/40 twist of rifling quite good results have been obtained. This is consistent with the earlier results in these two guns, as given previously, on pages 111 and 112 of this lecture.

It is probably well known that the continued use of shrapnel, for combat use, is subject to some doubt. Since the time fuze has always been associated with shrapnel for field artillery use, it might be thought that the time fuze for this use is in an equally precarious position. This is not so, since they will continue to be used with high explosive shell, and just how they fit into the picture has been thoroughly considered in Technical Staff studies. The various uses proposed are summarized at the end of this lecture.

Recognizing the effect of atmospheric pressure on the functioning of time fuzes, numerous proposals have been made to design fuzes so that the effect of atmospheric pressure may be neutralized. One specific instance of this is shown in the so-called Miller patent in which a device is claimed to use the law of flow through an orifice that "the rate of flow through an orifice will not further decrease after the pressure on the discharge side becomes less than 53% of that on the high pressure side." This, of course, requires that the fuze be entirely sealed except for the particular vent through which the combustion gases are intended to escape. This gives rise to mechanical difficulties of considerable importance. It probably has small practical value as it merely means that the pressure on the interior will reach some maximum value and not drop below that pressure. This interior pressure would depend upon the size of the orifice as the area of the desirable vent appears in the formula governing the flow of gas. Incidentally, the point at which the atmospheric pressure reaches the critical value of the relation to the pressure at sea level is about 17,000 ft. above sea level.

The Technical Staff studies previously referred to have been made in an attempt to correlate the requirements of the using Service and to prescribe the fewest number of types which would effectively meet the requirements. It has been concluded that the following types of fire will be encountered:

a. High burst ranging at the longer ranges.

b. High burst ranging at the shorter ranges.

c. Time fire with H.E. Shell.

d. Time fire with shrapnel.

e. Anti-Aircraft fire with H.E. Shell.

f. Anti-Aircraft fire with shrapnel.

The relative importance of accuracy, length of burning time, etc., is not a suitable subject for discussion at this time, but it may be stated that these wide variations in types of fire give only one requirement for an extremely long time of burning and it is estimated that this requirement will be for a fuze having a burning time of approximately 75 to 80 seconds. It is probable that this requirement will necessarily be filled by a mechanical fuze. The other requirements for fuzes that will burn in the neighborhood of 25 to 30 seconds can be met in powder train time fuzes.

LOADING AND ASSEMBLY OF M54 TIME AND SUPERQUICK FUZE

Before loading or assembly of this fuze, the Inspector should carefully read and understand the specifications pertaining to the loading, assembly and packing of this fuze. The Inspector should also assure himself that the proper powder is being used for the loading of the rings, that the pellets specified are being used in the rings and body and that the drying treatment is adhered to strictly to insure the proper conditioning of the ring so that the burning time will be uniform when the ring is assembled into the completed fuze. He should also check the weights used to tension the fuze and rings during process of manufacture and check the weights of the powder being measured into the different component parts. The Inspector should check with the Foreman periodically to be certain that the powder loading room and dry houses are operating at the correct temperature and relative humidity.

Powder for Rings, General:-

The first essential for uniformity appears in the powder used. A relatively long train of black powder, Grade A-7, (Spec. 50-14-1A), commonly referred to as meal powder because of its extremely small grain size, comprises the element in the fuze which is expected to burn the required number of seconds. The burning characteristics must be constant from ring to ring to obtain the great accuracy required of the fuzes. The black powder required is purchased, but the manufacturers have difficulty meeting our specifications. Although black powder has been used by military men for centuries, a high degree of uniformity as to burning rate has not been required when used for other types of ammunition. In the manufacture of squibs a variation of approximately 25% in burning time may be permitted, whereas in time fuzes, the accuracy must be within approximately two (2) percent. This means that there must not be a variation between the fastest and the slowest fuzes of over .5 seconds at the full setting of 21.2 seconds in any test group picked at random from a lot. This setting should give a static mean burning time of 23. plus or minus .4 in the 21 second combination 1907M and 22.5 plus or minus .4 in the Mk. III A fuze. Due to the difference in burning conditions, between firing statically and ballistically becuase of rotation, pressure, atmospheric conditions, etc., the longer times mentioned are necessary in static test to obtain times corresponding to the fuze setting when fired from the gun and burned during flight. Such accuracy requires the powder to be homogeneous as to chemical composition at least. Grain size is also a factor, especially if the various sized grains are differently proportioned as to chemicals. In tests it was found that variation in grain size accounted for a difference of as much as 10 seconds in 31 seconds of burning time due chiefly to the fact that the various grain sizes represented variations in chemical composition . (Ref. Mfg. Group Problem J12). In view of the fact that the powder tested has been subjected, in loading, to a pressure of 68,000 pounds per square inch, which should have crushed the grains, the variation in size alone was not considered responsible for the variation in time. However it can readily be seen that in production it is extremely difficult to keep the various grain sizes properly distributed due to stratification in handling. If every grain were chemically proportioned like every other grain then stratification would have little effect upon results.

In dealing with the present supply of powder, it is therefore essential to blend and to handle carefully all powders to be used for loading rings in order to obtain that homogeneity which is so essential to uniformity throughout.

Blending is also necessary to properly mix together such proportions of fast and slow powders as will give the mean burning time desired. The approximate speeds of the fast and slow powders are determined when the powder is inspected upon being purchased. By simple proportion and check by trial, the proper quantities are found which, when mixed together, result in the desired speed. In checking the calculated proportion of fast and slow powders by trial, it is customary to make up three or more trial blends of proportions intended to bracket and include the calculated proportion. These trial blends are 5 pounds in weight and are made by tumbling the proper weights of dry fast and slow powder 3 hours at 12 R.P.M. in five pound, power driven blenders, of the hour glass type which are miniatures of the standard 300 pound production type blender.

Preparation of Black Powder for Ring Loading:-

The proportions of fast and slow powders to be used having been determined, a total of 300 pounds is screened through a 60 mesh screen and dried. This drying is performed in a dryer having a capacity of approximately 500 pounds. The powder is dried at a temperature of 150°F. for six (6) hours. The dryer is charged with copper trays filled with powder to a depth of approximately 1/2 inch. A shorter period of drying under favorable weather conditions would be sufficient, but it has been found that regardless of outside humidity the duration of six (6) hours is sufficient to bring the moisture content of the powder down to approximately .2 percent, which is satisfactory for the blending operations. A powder which is not relatively dry has a tendency to lump in the blending operations and would therefore, not blend as well as free flowing powder. After drying, the proper proportions of fast and slow powders to give a total weight of 300 pounds, are weighed and emptied into the blender. The blender is rotated by power at 6 R.P.M. for six (6) hours. At the end of this time the powder is allowed to run by gravity from the blender into containers. Forty, eight ounce samples are taken from widely separated parts of the blend as the powder is removed. A set of rings is loaded from each sample and assembled with other necessary fuze components to give a group of forty fuzes for firing as a blend test. If the average corrected burning time for forty fuzes is within the allowable range and the mean deviation from the mean burning time is less than .100 second, the blend is considered satisfactory for production use. Samples of powder are also taken after the completion of the blend and sent to the Laboratory for moisture and sulphur analyses. The reason for using a 300 pound blend is that, if the 300 pounds can be made in one batch and homogeneous, it can be loaded into one lot of fuzes and thereby obviate the selective assembly of rings. This amount of powder is usually sufficient for approximately 12,000 fuzes, and should a lot of 20,000 fuzes be desired, it would be a simple matter to load one 300 pound blend in the upper and one 300 pound blend in the lower. The upper requires about 1/8 less powder than the graduated ring. The 45-second fuzes require approximately 40 lbs. of powder per 1,000 fuzes.

Until recently, standard practice called for drying of the powder to a moisture content of .2 percent, or less, prior to loading. Due to the varied humidities in which the powders might be handled from the dryer to the loading room, it was desired to have powder at a more practicable moisture content, i.e., one that would not vary in atmospheres similar to that obtained in the loading rooms, namely, 75°F. and 40 percent relative humidity. The present practice termed "conditioning the powder", is to take the powder from the blender, empty the transfer cans into small tin trays each holding approximately 1/2 pound of powder, filled to a depth of 1/2 inch, and expose this powder to an atmosphere of 75°F. and 40 percent relative humidity. These pans are racked in carrying cases of 32 pans capacity. The carrying cases are then placed in such a position in the conditioning room that the conditioned air will pass across the powder. The powder so treated will come to constant weight in from one to four hours, but the time of eight hours exposure has been selected so that all operations in connection with the filling and emptying of the trays may be performed either before or after ordinary working hours, so as not to subject the great number of employees ordinarily in the vicinity to the hazards involved in the handling of the powder. In this atmosphere the powder will hold a moisture content of from .3% to .8% depending on the hygroscopicity of powder used. The present supply of 21-second powder will hold about .45% and the 45-second powder about .3%. These pans are then emptied into 1/2 pound containers well stoppered with rubber corks and held for the use of the loading rooms. A sample from each day's powder is taken in each of the loading rooms and sent to the Laboratory for moisture analysis as a check on the proper conditioning of the powder. The moisture content of 21-second powder (14 percent coal, slow and 86 percent meal, fast) averages 0.54 percent while that of 45-second powder (70 percent coal, slow and 30 percent meal, fast)averages 0.20 percent.

Lower Ring:

The loading plant usually carries a sufficient supply of machined rings to have on hand for each day's production rings that have been in the assembly room long enough to eliminate the possibility of any moisture being on the rings caused by condensation of moisture from the room.

The rings are then given a visual inspection to determine that the rings are dry and free from dirt, oil and other foreign matter. The ring is also inspected for the presence of graduations and setting slot. The powder grooves of the rings are then coated with a solution of shellac and aniline dye and the excess solution cleaned from the surface of the ring. The coated rings are inspected to be certain that the groove is coated with as light a coating as will completely cover the groove. After the shellac solution is thoroughly dry the rings are moved to the powder loading room, where they are kept until they reach the temperature of the loading room. During this period the block numbers, showing the date and blend of powder used, are stamped on the outside angle of the ring. The stamping should be legible and not close enough to the top surface of the ring to distort the metal towards the top of ring and cause closing cap to ride on one side of the ring when assembled. The stamping should be in such a position on the ring that it will not interfere with the drilling of the vent hole.

Before loading, the rings are inspected to be sure that the shellac is thoroughly dry. This is very important, as rings that are not dry and at room temperature will cause an increased dispersion in the burning time of the complete ring.

Loading of Lower Ring:

The ring is placed into a special fixture placed into the ring and pressed to 68,000#/in^2. They are then inspected to insure that the powder train is above the face of the ring. If the powder does not extend above the surface of the ring it indicates that the powder has soft spots in it, which affects the burning time.

The flash hole is drilled into the powder train and counterbore for the safety disc drilled. The safety disc is inserted and crimped 290° around the disc with 1900# dead weight. The end of the crimping should not break into the powder train so as not to crack the powder train. The surface of this disc, after crimping, must be flush or below the surface of the ring so that the facing tool will not pull it out in subsequent operations. The metal of the ring and the excess powder are faced off and the undercut is made for the seating of the ring into the body. The upper surface of the ring is scored to make a better adhesive surface for the felt washer. The ring is gaged for diameter and depth of undercut and thickness of ring.

A hardness test is taken four times on each turn. An .081" punch is pressed into the powder at 250# dead weight in eleven places and must not penetrate more than .006".

The rings are then given a visual inspection for chipped and cracked powder trains, crimping of safety disc and cracks in the ring itself. It is then coated with special shellac, placed on a rod with separators between each ring and sent to a dry house, which is kept at 100 to 110°F, for not less than three days and not more than six days. The rings are then taken to the operating room and buffed with a wire brush and lacquered.

The exterior vent is drilled and counter-bored. The pellet hole on top of ring is drilled. The ring is then inspected for presence of the holes and cracks or chips in the powder train from the drilling operations. The powder groove is then coated with shellac and the groove cover set in position and put on a board covered with talc to set. The powder pellet is inserted and the fuze cloth washer glued to the top surface of the ring. The hole in the ring must be over the powder pellet. No glue must touch pellet or pellet hole and all excess glue is wiped from the ring. The exterior vent is filled with black powder and the disc and washer inserted and crimped 360° at 1350# dead weight. The vent disc is then coated with lacquer to make it moisture proof.

The rings are then placed on rods with rubber separators between the powder surfaces and tensioned at $12\frac{1}{2}$# and sent to dry room, which is kept at 100 to 110°F for not less than three days and not more than six days. The tension is removed after 24 hours to allow the air to circulate over the powder face of rings. After second period of 3-3 treatment, the rings are transferred to a standby storage at 80 to 90°F for 24 hours before final assembly into fuze.

Upper Ring:

The loading usually carries a sufficient supply of machined rings to have on hand for each day's production rings that have been in the assembly room long enough to eliminate the possibility of any moisture being on the rings caused by condensation of moisture from the room.

The rings are then given a visual inspection to determine that the rings are dry, free from dirt, oil and other foreign matter. The ring is also inspected for the presence of graduations, and setting slot. The powder grooves of the rings are then coated with a solution of shellac and analine dye and the excess solution cleaned from the surface of the ring. The coated rings are inspected to be certain that the grooves are coated with as light a coating as will completely cover the groove. After the shellac solution is thoroughly dry, the rings are removed to the powder loading room, where they are kept until they reach the temperature of the loading room. During this period the block numbers, showing the date and blend of powder used, are stamped on the outside angle of the ring. The stamping should be legible and not close enough to the top as to distort the metal toward the top surface of the ring so that the closing cap will ride on one side of ring when assembled. The stamping should be in such a position on the ring that it will not interfere with the drilling of the vent hole.

Before loading, the rings are inspected to be sure that the shellac is thoroughly dry. This is very important, as rings that are not dry and at room temperature will cause an increased dispersion in the burning time of the completed ring.

Loading of Upper Ring:

The ring is placed into a special fixture and powder placed in the groove of the ring and pressed at 68,000#/in^2. They are then inspected; that the powder train is above the face of the ring. If the powder does not extend above the surface of the ring, it indicates that the powder has soft spots in it, which affects the burning time. The ring is then placed in a lathe and the face of the ring and excess powder cut off to the final size of the ring. The undercut for the seating of the ring is also made on this operation. The ring is then inspected and gaged for diameter and depth of undercut and thickness of ring. A hardness test is taken four times on each turn. An .081" punch is pressed into the powder at 250# dead weight in eleven places and must not penetrate more than .006".

The pressed rings are then given a good visual inspection for cracks or chips in powder train, soft powder train or cracks in the ring itself. The surface and the powder train of the ring is coated with a special shellac solution. The coated rings are then placed on a rod with spacers between each ring and placed in a dry room, kept at 100 to 110°F, for not less than three and not more than six days. After this drying treatment the rings are taken to the operating room and the outside surface of the rings buffed with a wire buffer and coated with lacquer and allowed to dry.

The center hole is reamed to final diameter so it will fit drill fixtures. The powder vent hole is drilled. The exterior vent is drilled and counter-bored and the interior pellet hole drilled. The cross-vent hole is drilled from pellet hole to exterior vent hole. All drill holes are percentage gaged and the holes and powder train given a visual inspection to see that the holes are present and that the powder train has not been cracked or chipped by the drilling operations. The cross-vent hole must break into the center of exterior vent hole and interior pellet hole.

The interior pellet is inserted, making certain that no broken or soft pellets are used, and crimped in 360° and 500# dead weight. The disc and washer are inserted into the exterior vent and crimped 360° and 1350# dead weight.

The powder face is inspected and given a coat of shellac and the groove cover placed in position and inspected to see that it is tight. The vent hole is lacquered and the ring inspected for lot number. The groove cover is dipped into talc and the rings placed on rods with rubber separators and tensioned at 12½# and placed in the dry room at 100 to 110°F, for not less than three and not more than six days. The tension is released after 24 hours to allow the air to circulate across the surface of the rings. The rings are then moved to a lower temperature room, 80 to 90°F, for not less than 24 hours.

Bottom Closing Screw Assembly

Bottom closing screw, disc, washer and eyelet are assembled and coated with analine dye and shellac before they are shipped to loading plants.

Visual inspection of bottom closing disc for puncture, crimping of washer and coating of analine dye, before loading. Black powder is then loaded into the holes and agitated to be sure that it will hold a specific amount of powder. The rim and hub of the screw are coated with shellac and an onion skin disc is attached to retain the powder. Then surface of bottom closing screw is dipped in talc. The paper washer and shellac are allowed to dry at room temperature for four hours.

The Inspector makes an occasional check for the weight of powder being used in the bottom closing screw. This must not vary over one grain, plus or minus the requirements shown on the drawings.

Assembly of Body Assembly, M-54

The body is inspected visually for burrs in the interrupter cavity, flash hole and for dirt in any of the cavities. The interrupter is inserted into the body and the interrupter spring assembled and the retainer screwed in place and staked. The body is then tested for arming and non-arming at the specified speeds: - to arm at 2000 r.p.m. but not to arm at 1500 r.p.m. The body then goes to the loading plant where it is tested again for arming and non-arming 100%. The arming test is always given before the non-arming test to insure the fuzes being in the unarmed position when they go out of the loading plant. This procedure should always be followed in the arming test.

All arming tests should be conducted after the interrupter is staked in so that it will arm, even after the distortion of the metal by the staking operation. In some shops the arming test is conducted both before and after arming to eliminate the added expense and destruction of material from tearing the body down after it has been staked. The final acceptance test must always be conducted after staking.

Loading of Body:

The body is received at loading plant with interrupter assembly assembled and staked into position. The body pellet is inserted into the body and the platform surface of the body is coated with glue and the felt washer set in place so that it coincides with the pellet. No glues should be permitted to get on the pellet or into the pellet hole. The pellet must be flush or slightly below the surface of the pellet hole. Rubber washers and wooden rings are placed over the washer and a nut to pull the wooden ring down onto the washer is tightened in place. The bodies are then moved to the dry room at 90°F and dried for four hours, to dry and seat the washer. The specified amount of powder is measured and poured into the flash hole in the body from the bottom side so that it makes a continuous powder train from the body pellet to the bottom closing screw cavity and an onion skin paper disc is shellacked into place to hold it in.

The primer cavity is inspected to see that it does not bulge on outside of the body and the primer inserted and checked for fit. The primer must fit snugly but not be pressed in with too great a pressure because of the hazard to the operator. The primer must not be loose after assembly.

The primer striker is assembled and fastened into place with the dowel pin. The dowel pin must not bulge the outside threads on the body. The striker is inspected to see that it is lined up over the primer and not around to one side.

The loaded closing screw assembly is then screwed into the body and staked in four places. The closing screw must be flush or below the bottom of the body, after which it is painted with a heavy solution of shellac to make it waterproof.

Assembly of Closing Cap:-

The plunger is placed into the sleeve and two shear wires inserted and staked, located in a fixture from the locating plunger pin. Care must be taken that the staking does not distort the inside diameter of the sleeve and bind the plunger.

The closing cap is visually inspected 100% by the operator for foreign matter and the firing pin support, firing pin and striker, washer and closing disc assembled in order named. The crimping wall of the head is then rolled over. The completed head is inspected to see that crimping has not cut the washer or cracked the crimping wall.

The closing cap is then inverted and examined to see that the firing pin does not project down into the detonator cavity. The detonator is then inserted and the cork cushion inserted, making certain that no cracked cushions are used, and the retaining screw set in place and tightened with a pneumatic screw driver. The retaining screw is inspected to see that it is flush or below the detonator cavity so that the crimping operation can flush the metal from the crimping wall over to hold the screw in position.

The plunger assembly is then inserted and the cotter pin placed through the cap and plunger body. The plunger assembly must line up with the cotter pin holes in the closing cap to make certain that the shear wires are not damaged by the assembly of the cotter pin.

Assembly of the Complete Fuze:-

The body is given a 100% inspection for overall length, presence of primer, presence of and location of primer striker, body pellet, set line, stamping, staking and sealing of closing screw, flash hole and set screw hole for top ring, and staking of interrupter.

The groove covers of the rings are coated with caranuba wax and allowed to dry before assembly. Rings are then inspected for loose groove covers, loose fuze cloth washers and block numbers to make certain that the same blend is being used in both rings of the fuze. The graduated ring is assembled to the body with the letter "s" at or near the set line on the angle side of the body. The set screw is then screwed into the upper stem of the body and the upper ring placed on the body with the slot in the ring over the set screw. The tension ring is placed over the upper ring in a convex position. The set screw is inspected to see that it is below the upper surface of the upper ring and does not hold the tension washer away from the upper ring. This is important in setting the tension of the rings for the use of the fuze-setter in the field.

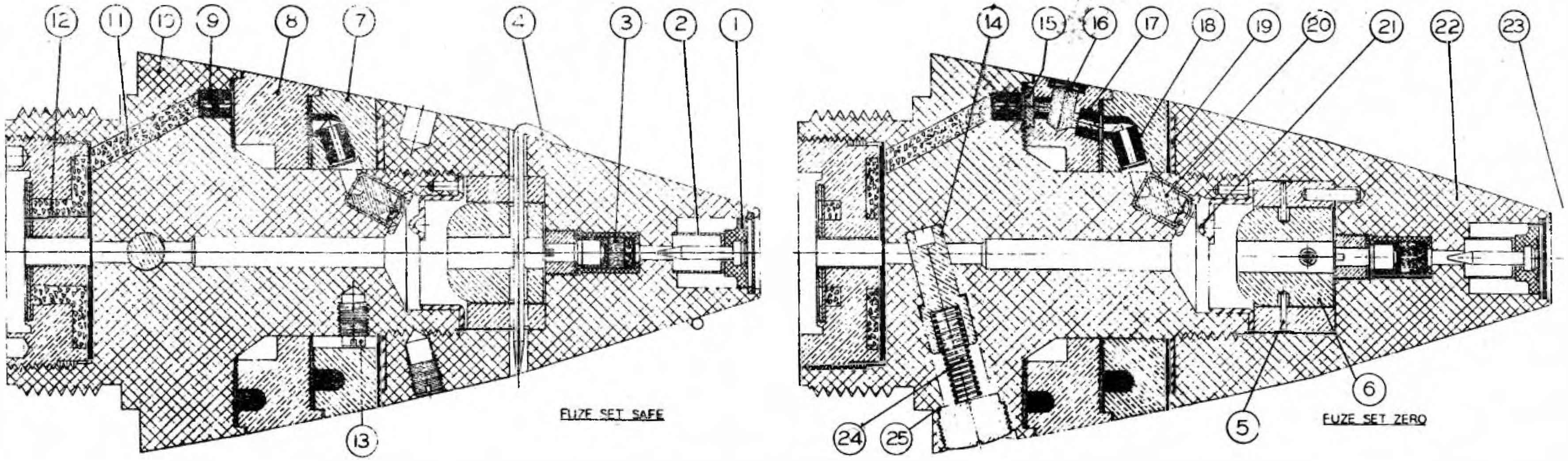
The closing cap is then screwed in place on the body and the cotter pin removed to allow freedom while tightening and setting fuze on safe. The closing cap is tightened at 40# dead weight and the graduated ring is tensioned at 35 to 65# torque. This operation tends to break any glue that might have the graduated rings stuck and also seats the fuze cloth washer into the scoring on the surface of the ring and body. It has been found advisable to apply the maximum tension to overcome any release of tension after the fuze has been assembled for awhile.

The set screw, which holds the cap onto the body is screwed into position and staked.

The fuze is then set in a fuze-setting device and set in a safe position by setting the marking "s" on the graduated ring over the set line on the body of the fuze. The cotter pin is then placed through the cap and plunger assembly and the end spread for withdrawal resistance of 10 to 35#. The fuze is stamped with the lot number, date, and the loading plant initials. The completed fuze is then check weighted to make certain that no parts have been left out and if found satisfactory in weight is inspected 100% for overall length, for distance from surface that makes up on projectile to the bottom of the body, and body threads checked 10%; and if found tight a more thorough inspection is given.

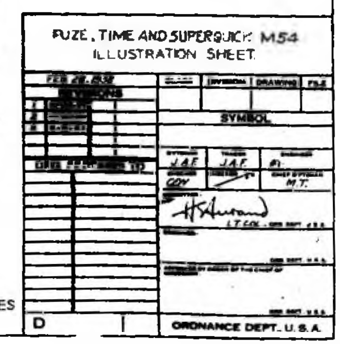
The fuze is inspected visually 100% for vent discs tightness, closing screw disc tightness and tightness of the closing disc. None of these discs must be punctured. The staking is checked and stamping inspected to see that it is legible and that the fuze is set in safe position, also, distortion or marring of the surface of the fuze.

The completed fuze is then placed in an M-47 fiber container, gum label attached and coated with white shellac. The cover and body of the container are sealed with a 2" strip of adhesive tape wound 360° around the box with a 1" tab left for pulling the tape off the box. Fifty (50) fuzes are packed into a wooden box with the data card. The metal strips which hold the box should be in such a position that none of the stenciling on the box is covered up. The box is then sealed with a car seal.



TIME AND SUPERQUICK FUZE, M54

1-FIRING PIN ASSEMBLY
2-FIRING PIN SUPPORT
3-DETONATOR ASSEMBLY
4-SAFETY WIRE
5-SHEAR PIN
6-PLUNGER
7-UPPER TIME TRAIN RING
8-GRADUATED TIME TRAIN RING
9-BODY PELLET
10-BODY
11-BODY CHARGE
12-MAGAZINE CHARGE
13-UPPER RING LOCK SCREW
14-INTERRUPTER
15-SAFETY DISC
16-VENT CLOSING DISC
17-GRADUATED RING PELLET
18-UPPER RING PELLET
19-TENSION WASHER
20-PRIMER
21-PRIMER STRIKER
22-CLOSING CAP ASSEMBLY
23-CLOSING DISC
24-INTERRUPTER SPRING
25-INTERRUPTER CLOSING PLUG



P-25727

METAL PARTS INSPECTION OF M54 AND M55 FUZE

METAL COMPONENT PARTS

Closing cap
Closing disc
Closing disc washer
Firing pin
Firing pin support
Detonator cup
Detonator disc (.002")
Detonator retainer
Retainer washer
Detonator cushion
Detonator retaining screw
Set screw
Cotter pin
Cotter pin ring

PLUNGER ASSEMBLY

Plunger
Plunger sleeve
Shear wires (2)
Dowel pins

BODY

Upper ring
Vent closing disc
Crimping support vent washer
Graduated ring
Safety disc
Groove cover, onion skin (2)
Fuze cloth washer (2)
Set screw
Primer striker
Primer striker dowel pin
Primer
Interrupter
Interrupter spring
Interrupter closing plug
Tension washer
Body charge disc
Safety disc
Bottom closing screw
Bottom closing screw disc, cloth
Bottom closing screw washer
Assembly of Body Assembly

Plunger:

Shear wire holes and cotter pin holes must align with these holes in sleeve. Outside diameter of plunger must be good finish and be free of burrs around drilled holes, so that the plunger can move freely in the sleeve in service.

Detonator Retainer:

Threads must be made for free assembly in cap and not too much chamfer on screw driver end of plug for crimping. The bottom surface must be straight and have a good finish so in assembly it will not cut and distort the detonator cushion.

Firing Pin Support:

The overall length is very important as this is one of the contributing factors controlling the distance the firing pin is held away from the detonator. Thickness of metal on side wall must be even. No draw cuts or small shoulder on the top outside radius of the cup should be allowed. The bottom should be trimmed square and not have any chamfer.

Firing Pin:

Care must be taken that the flat on the end of the firing pin is as specified with no burr. Point must be concentric with the diameter of pin. Diameter of pin must not taper toward the striker to a smaller diameter. If this diameter is smaller or the pin has an undercut under the striker, the firing pin will be weak at this point. If firing pin is made separate of striker, the outside diameters should be held toward the min., to take care of the spreading of the striker when the firing pin is riveted into the striker.

Closing Disc and Washer:

Thickness and diameter must be held for proper assembly.

Dowel Pin:

Diameter must be held for proper assembly and length held for proper seating of the plunger assembly into the closing cap.

Shear Pin:

Diameter of this pin is very important to withstand the shear wire test and jumble and jolt test.

Primer striker:

The outside diameter of the flange and body of the striker must be concentric. The location of the locating hole in the flange of the striker in relation to the firing pin must be as specified, for the functioning of the firing with the primer. The dimension from the inside of striker to the center of the firing pin is also important for this same reason. The radius on the firing pin is very important for the sealing as well as the firing of the primer.

A close check should be made on the metal, especially the narrow neck between the firing pin and side wall of the striker. There should be no cracks or defects in this part of the striker that might cause the firing pin to break off in service rather than bend over onto the primer.

There should be no punch burrs or distortion of the outside diameter of the primer striker as this would cause the primer striker to pull up out of the body when the closing cap is assembled and move the firing pin away from the primer and cause the fuze to fail in service.

Body

The closing cap threads should not extend down too far on the stem of the body or they will break into the primer hole. Also the small chamfer on the end of this thread should be kept just small enough to remove the burr or this chamfer will lead the drill off when the hole for the dowel pin for primer striker is drilled. The location of this hole is very important so that the striker will locate the firing pin directly over the primer so it will seal primer as well as fire primer. The dowel pin hole must not bulge into the minor diameter of the closing cap threads or it will keep the cap from assembling.

The primer striker cavity must be consentric with the threads. The depth and angle at the bottom of this cavity must be held to insure correct action of the firing pin and assembly of primer. The primer cavity should not bulge on the outside of the body. The superquick flash hole through the body should be concentric with the axis of the body so that the interrupter will cut off the flash hole when in unarmed position.

The angle at the bottom of the stem of the body must be held so that the graduated ring will seat down on the scored surface and not hang up on the angle of the body. The scored surface must be straight and square with the axis of the stem. This ring seat must have sharp corners (.005" max.). If not, the ring will ride on this radius and not seat properly on the flat surface of the body.

The set screw hole in the stem of the body must be held within limits since the upper ring is located by this screw and if the screw is too high it will foul the assembly of the closing cap.

Both diameters of the interrupter cavity must have a good finish and be concentric for free movement of the interrupter. The interrupter cavity retainer threads must be straight with the interrupter cavity to prevent the spring from slipping to one side of the cavity and fouling which would prevent the arming of the fuze.

Pellet hole and depth of diameter must be held. If large, will cause battering of pellet and if small, the graduated ring will seat on pellet and smash it.

Whereas the burning time of the fuze determines the acceptability of the completed fuze, and the setting slot in relation to the set line determines the time setting, it is very important that a careful inspection be made for position of these points.

The flash hole leading from the pellet hole to the bottom closing screw cavity should break into the pellet hole.

Outside surface of the body should have a good finish and stamping and set line be legible.

The body closing screw cavity must be straight across the bottom with no shoulders at the bottom so that the closing screw can make up flush or below the surface of the bottom of the body. The closing screw threads must be concentric with the axis of the body. The flash hole from the body must break into the center of the closing screw cavity so that the flash can pass through the closing screw into the booster. There should be very little chamfer on the closing screw threads, since this metal is needed in staking the closing screw to the body.

Booster threads must be in line with the axis of the body, so booster and completed fuze will properly assemble into the projectile. The dimension from the bottom face to the booster shoulder must be held within limits so that the fuze screws down to the rotor cover of the booster.

The plunger cavity in base of cap must be straight with the axis of the cap for alignment of the plunger with the inside iameter of the primer striker. If this cavity is not concentric and threads straight, it may bind plunger and prevent it from striking the primer striker.

The tension washer cavity (shallow cavity at the base of the cap) should be parallel with the bottom of the cap. Detonator cavity should be concentric with the plunger cavity and must be concentric with the firing pin hole. The depth of detonator cavity is v ry important. If deep, a dangerous condition is set up by allowing the detonator to come too close to the firing pin. Also, the detonator cavity must not be bell-shaped, throwing the small hole in bottom of the cup out of line. Detonator retainer cavity threads should not chamfer more than to take care of burrs extending into the plunger cavity as this thread is staked in assembly.

The striker cavity and firing pin support cavity must be concentric with the firing pin hole. The crimping wall at the top of cap should be concentric to prevent cracking or making a shoulder on outside radius in crimping operation.

Outside surface should be good finish. Lower diameter of cap must be held and concentric so that cap overhangs upper ring when fuze is assem led.

Plunger Sleeve:-

A ca eful inspection must be made on this sleeve:- The overall length to assemble between closing cap and body. Inside diameter must be concentric with outside diameter to align with inside diameter of primer striker when assembled into complete fuze. The dimension from center of shear wire hole and cotter pin hole to the bottom of the sleeve must be as specified so that when the plunger assembly is made and inserted in the cap with the cotter pin there will be no pressure on shear wires, as if this condit does exist the shear wi will partially shear in jumble and jolt tests. Inside diame er must have good finish and be free of burrs, resultin f m the drilling of shear wire and cotter pin holes. Any burrs on the inside would hamper the action of plunger.

Interrupter:-

The interrupter must have a good finish so that it will work freely in the interrupter cavity. The large diameter and small diameter must be concentric so that interrupter will not bind and fail to go into armed position. The spring seat in the interrupter must be concentric with the axis of the interrupter so that the spring will line up straight and not bind the interrupter to one side. The small hole in the bottom end of the interrupter must be held to balance the weight of the interrupter and insure its arming.

Interrupter Closing Plug:-

The threads must be concentric with the axis of the plug so that the plug does not screw in to one side and bind the spring to one side and prevent its arming. This plug must be held to length so that it does not extend too far into the interrupter cavity and keep interrupter from clearing flash hole. The bottom face must be straight so that the spring will not walk to one side when the plug is assembled.

Bottom Closing Screw:-

Bottom of powder cavity must be straight. The inside diameter must be concentric to meet the flash hole from the body. No burrs should be in powder holes or groove. There should be no burrs on crimping shoulder or on crimping wall so that bottom closing screw disc will not cut or tear cloth disc when crimped in place. The threads must be concentric with the axis to insure closing screw fitting up against the bottom of cavity in body, and not extend from the end of the body. Wrench holes must not bulge minor diameter of the threads. Overall length must be held to limits so that screw will make up flush or below the bottom surface of the fuze.

Bottom Closing Screw Disc:-

Diameter must be held so that washer assembles into screw. There should be no burrs that might cut cloth washer when assembled.

All cloth and paper discs must be held to limits of diameter and not be cut or torn in any way, since they seal the fuze against moisture.

Time Rings:-

Upper ring:

1st operation: Ream isnsie diameter and face small diameter of ring.

Inspection: Ring must clean up inside and be a clean round hole. Face must have good finish, straight and be square with the axis of the ring. Inside should be concentric with outside of ring.

2nd operation: Face large diameter and form angle.

Inspection: Ring should be parallel, straight and good finish. Outside angle must have good finish with specified angle and be concentric with inside.

3rd operation: Broach set-screw slot in ring.
Inspection: Slot must be straight with axis of ring. Width of slot very important for powder groove operation locates from this slot. Depth must be held for wall thickness between slot and powder groove.

4th operation; Routing of powder groove.

Inspection: Powder groove must be concentric with inside of ring. Thickness of metal from bottom of groove to face of ring must be held. Diameter of powder groove and the width of the groove are very important and must be held in order that they conform with fixture used in loading department. The distance between the ends of the groove must be held.

A careful inspection of all operations is necessary as the loading of the rings depends greatly on their correctness. Also, the Metal Components operations tie up with the loading operations and if not correct, the final test, such as burning time, will be such that it will not meet the required limits.

Graduated ring:-

1st operation: Turning up of outside diameter.

Inspection: Care that not too much metal be removed as this straight surface must clean up on angle-forming operation.

2nd operation: Reaming and straightening of expansion cavity and inside diameter, small angle adjacent to expansion cavity.

Inspection: Diameters must be within tolerances. Expansion cavity with radius not too deep.

CAUTION:- If expansion cavity is too deep on this operation when upper ring seat, on small diameter side of ring, is made, web of ring will be thin. This web should be parallel. Angle adjacent to inside cavity must clean up on facing operation.

3rd operation: Facing of ring, upper seat counter-bored, outside angle formed.

Inspection: Ring should be parallel, web of even thickness, inside diameters and upper ring seat concentric with outside diameter. Angle and good finish on outside must be held. Diameters and thickness of ring must be held.

CAUTION:-
Even thickness of web for refacing operation. Inside diameters must meet loading fixtures properly. Even depth of upper ring seat for the proper seating of upper ring and to make a gas-tight seal between upper and lower rings. Angle important for graduating operation. Good finish necessary for graduations or letters to be legible.

4th operation: Drilling of location holes.

Inspection: The corredt location, depth and diameter.

CAUTION: -
Much depends upon the accuracy of the location of these holes, as graduating, drilling of pellet and vent holes, and the routing of powder groove operations are located from these holes.

5th operation: Stamping of graduations and numerals.

Inspection: Letters and figures must be legible and in correct location. There should be little or no distortion of the inside diamerer by the graduating operation. The inside diameter is reamed before finishing in loading to insure proper diameter.

6th operation; Routing of powder groove.

Inspection: Concentricity of groove and outside diameter, thickness of metal between botton of groove and face of ring. Diameter and width of powder groove, distance between ends of powder groove, dimension from locating hole to end of powder groove, no radius of groove on face of ring.

CAUTION:-
To properly fit the loading fixtures and meet the requirements these points must be given a thorough and complete inspection. At the starting point in the routing of the groove it is necessary that the tool be relieved, thereby cleaning the tool. If this is not watched the tool may pick up turnings and cut the groove deeper at this point than over the rest of the groove or make the groove wider at this point or cut a deeper radius on the face of the ring that will not clean up in facing operation. This will cause a soft spot or spots in the groove

when the powder is pressed in, or make ragged edges of powder on inside and outside of groove. These soft spots cause wide variation in the burning time of the ring.

7th operation: Cut fuze-setter slot.

Inspection: Correct location, depth and width. Slot must have sharp corners with one side of slot having spedified angle.

CAUTION:-

The correct location of this slot in relation to graduations very important.

8th operation: Milling of flat surface adjacent to fuze-setter slot.

Inspection: Specified dimension from bottom of groove to surface, see that milling of flat has not produced burr in groove.

During all operations a careful inspection should be made for cracks in the metal. Cracks in the metal result in damaged rings when they are subjected to the loading pressure and make them unfit for further use.

TESTS ON M 54 TIME FUZES

Blend Test;-

To determine the correct porportions of the fast and the slow burning powders, all blends are verified as to burning time and dispersion -- known as the "dry blend test".

Forty samples are taken from widely separated parts of the blending barrel. The powder is exposed in trays to conditioned air for a period o. 5 hours. One set of rings is loaded from each sample and faced and operated in conditioned air without application of shellac to the powder face The fuze is completely assembled with felt washers and groove covers in conditioned air room. Complete fuze is then fired to determine the burning time and dispersion.

Loading Test:- After the rings have been in the standby storage (80-to 90° F) for at least 24 hours, ten sets from each block combination are assembled to test bodies and fired statically all on the same day. After being assembled for this test the fuzes are stabilized for at least 3 hours at a temperature of 75°F. These rings are taken from standby storage after the last rings of a lot has had at least 24 hours of this lowered temperature. This test determines the satisfactoriness of average burning time and dispersion for different days' loading, and the overall dispersion and mean dispersion that can be expected in the final Inspector's STATIC TEST.

Assembly Test:-

After several blocks from each blend have completed the 3 -3 treatment, 10 sets of rings are withdrawn for this test. Each block of rings should burn approximately the same if care and unif rm treatment has been taken in the loading and drying of the r ngs.

When the lot is completed, 5 fuzes are selected and fired statically for acceptance. In case of failure, the blocks causing failure are withdrawn and the balance is used for selection of ballistic samples for the final test which is conducted at the Proving Ground at Aberdeen. If fuzes are found acceptable in the original static test, no retest is required and fuzes are forwarded to proving ground immediately.

Jumble and Jolt Test:-

To insure that fuzes will withstand handling and transportation ten fuzes are selected and given the Jumble and Jolt Test. The fuzes must withstand this test:

No explosive elements explode.
No fuzes come apart.
Fuze must not arm or partially arm.
No inner parts, including explosive elements be broken, deformed or displaced in such a manner as to make the fuze unsafe to handle or dangerous to fire.

General:- It may be stated that the real relationship of all mechanical operations with one another and the graduations are vital factors affecting the uniformity of burning time of the fuzes. Pellet holes, if large, will result in battering of the pellet. These relationships should be closely checked with gages made especially for this purpose. Likewise, the loaded components are inspected. After the mechanical operations have been completed, the ring is cleaned of powder dust and burrs removed. The rings are fitted with the required pellets, three pellets are used in the rings and one in the body. They are of compressed black powder and are tubular in shape. A wick of nitrocellulose is inserted into the hole in the pellets and extends out on each side. This wick makes the pellets easier ignited.

After the rings from the last day of loading on a lot of fuzes has been in the standby storage at a reduced temperature for at least 24 hours, 10 sets of rings from each block combination are assembled to fuzes and fired statically all on the same day as the assembly test. The fuzes should be stabilized at 75°F for at least three hours. The results of this test indicate the satisfactoriness of the lot in regard to variations in average burning time for different days of loading and overall dispersion and mean deviation that can be expected in the final static test.

SECTION III

FUZES

7 - Primers, Detonators, Delays, Relays, Lead Cups

Primers

Compositions:- Many different primer compositions are and have been used. The ingredients depend upon what kind of a primer is desired. Primers for initiating the detonation of an explosive train in a fuze often contain fulminate of mercury mixed with other substances, such as potassium chlorate, sulphide of antimony and powdered glass. The various mixtures modify the explosive force, producing a prolonged action and a penetrating heat which enters into the mass of the explosive. The ingredients used in primer compositions should have characteristics or give results as follows:

(1) Sensitivity to friction or impact.

(2) Furnish a fuel to be oxidized to produce gas volume at high temperature.

(3) An oxidizing agent.

The principal ingredients are mercury fulminate, potassium chlorate and antimony sulphide.

(1) Antimony sulphide is used in practically all primers. When combined with mercury fulminate it furnishes the sensitivity desired.

(2) Potassium chlorate is used as an oxidizing agent. It serves to increase the heat as it is an endothermic substance, and the oxygen it supplies serves to burn the CO of the products of combustion of mercury fulminate to CO2 and thus still further increase the heat.

(3) TNT, tetryl, sulphur, etc., are used as fuels to generate the gas. Sulphur slows down the rate of ignition.

(4) Powdered glass, when added to a primer mixture, increases the sensitivity to percussion action.

(5) The non-fulminate primers are apt to fail in functioning due to the difficulty of obtaining the necessary homogeneous mixture for such primers.

(6) For quick action primers in non-delay systems requiring less flame, the percentage of mercury fulminate is increased.

Making of Primer Mixtures:-

Primer mixtures which are to be loaded into a particular fuze are mixed in accordance with the current specifications. At the present time there are a number of different mixtures in use, each having some special charateristics for initiating detonation or explosion.

The various ingredients for primer mixture are sampled at the place of manufacture. Sampling shall be done before final packing, by an inspector designated by the Ordnance Department. The physical and chemical properties of the ingredients shall be determined upon samples in a natural dry state. Where sieves are referred to in the specfications, the U.S. standard sieve will be used.

When making primer mixtures the maximum quantity of a mixture should not exceed one quarter of a pound. The mixing and drying operations are especially dangerous. The mixing of the composition was at one time done in a very simple manner by placing the ingredients on a piece of paper and then stirring them with a goose feather, or by tumbling. Under these conditions, the operation was hazardous as there was a constant danger of an explosion. At present there are two methods of mixing, namely the wet process, and the dry process.

(1) Wet process;- The essential feature of this process is that the explosive is kept wet until the mixing is completed. Only enough liquid should be used to thoroughly moisten the mixture, so that when it is worked it will form a uniform paste. Precautions should be used to prevent the composition from drying. If too wet, the liquid will carry away some of the potassium chlorate and other soluble constituents. The wet mixture is then loaded into caps which are placed in a dryer.

(2) Dry process:- Fulminate or lead azide is always stored wet until ready for use. In this process it must be dried before using. The drying is carried out in an isolated building where the material is spread out on soft fabric. The building is heated by means of hot water pipes to a temperature of about 50 degrees C. The temperature in the buildig is then allowed to drop until the explosive is cooled.

One method of mixing the ingredients consists of weighing out the proper quantity of ingredients and placing them in a revolving square shaped container, the base of which is inclined from the horizontal. The container is then revolved for about 15 minutes. A sample of the mixture is sent to the labratory for analysis. The mixture is not used until a satisfactory report is received from the laboratory.

Safety Precautions:- Extreme care in handling and manufacture of primer mixtures is imperative. No person should be at work on any of the processes unless he has been carefully trained and thoroughly understands the hazards of the processes. Employees for work of this nature should be selected for their careful and methodical habits. The various processes should be separated by fire walls, and machine operators should be protected from explosions by steel guards. Sprinkling and drenching systems are serviceable only in preventing the spread of fire. Stocks of the mixture and components in the manufacture or assembly should be kept as low as possible. Wherever possible, safety tables or float tables should be used. Safety tables must prevent waste or dropped materials from becoming a hazard. Safety shoes and safety uniforms are required. Warm water plates of low temperature are to be preferred to the blower system of drying. In no case must drying temperatures exceed 50 degrees to 60 degrees C. In mixtures containing fulminate, drying temperature must not exceed 40 degrees C. Fire involving the primer mixtures in assemblies should be treated similarly to fires involving the primer mixtures in bulk.

M-48 Primers:- The primer housing is given a visual inspection preparatory to loading for burrs, grease or oil, and dirt. A drop of shellac is put into the bottom of the housing by means of a dropper and a .002" copper disc, which has been miked to be certain that only one is used, is inserted and seated. A handful of housings are then put on a cloth and dipped into analine dye and placed on a wire screen to be air dried. The housing is then given another visual inspection to see that it is completely coated with dye, that only one disc has been used and that it has not come loose from the dipping operation.

The housing is then placed on an anvil and held in position by two small pins on the anvil which fit into the holes in the bottom of the housing.

The wet primer mixture is inserted by means of a bakelite stick into the housing and a press, rotating at 6300 R.P.M., presses the mixture into the corners of the housing and gives the mixture a concave surface. The loose and excess primer mixture is then cleaned off the housing with a rag dampened with alcohol. The primer is then inspected to see that arc of the concave surface is flush or below the outside rim of the housing and that the excess powder has been removed. The housing is then gaged 10% for diameter and height, after which the primers are dried in an oven 100° to 110° F. for 48 hours.

The outside diameter of the anvil is equal to the outside diameter of the housing, relieved on the inside, with two pins extending up into the flash holes and even with the inside bottom of the housing, making it important that these holes be in the center of the housing and the specified center distances between holes. If these dimensions are not held, they will not fit the fixture, making them useless. If the center distance is held but not in the center of the holder, it will fit on the pins, but will over hang the bearing surface of the fixture causing poor alignment. Thus when charges are pressed there will be soft spot on one side and will break out in the jumble and jolt test. This endangers the acceptance of the complete lot of fuzes.

M26 Primer:- This primer is used in the M106 Tail Bomb Fuze. The gilding metal primer cups are visually inspected to see that they are free of dirt, grease and other foreign matter and inserted in a fixture. The fulminate of mercury primer composition is then measured and poured into the cup and pressed to the specifications given on the drawing. The primer disc (also of gilding metal) is then inserted and the cup moved to another fixture where the top is crimped down 45°. The cup is then taken to another fixture where the top of the cup is crimped down flat over the disc. During the crimping operation a tool comes down flat on the disc and holds it to prevent any warping or wrinkling of this disc. This action is known as teating, being similar to the teating action used in the M48 relay.

The completed primer is sealed with waterproofing beeswax and then inspected visually for seating of primer disc, tears or cuts in the disc, cracks in the crimping wall from the crimping operation and the presence of water-proofing wax. The cups are also gaged 10% for height and diameter.

It has been found expedient to load the primer holder itself in a building separate from the building used to assemble the rest of the fuze. Hand operated presses are used and the various components handled in fixtures which follow the work rather than staying at a particular operation. This is the usual procedure in the case of primer and detonator loading.

The primer holder is inspected for cleanliness and located on a fixture from the small diameter on the primer cavity. A black powder pellet is inserted and a primer retaining washer placed over it. The primer is then coated with N. R. C. compound around the peripheral surface and inserted into the primer holder. Another primer retaining washer is inserted over the primer, and the wall of the primer holder crimped down over it before the N. R. C. compound dries. Brass sealing discs are then placed in the three vent holes and secured in place by N. R. C. compound. The completed primer holder assembly is inspected to determine tightness of primer and sealing of primer into holder. The crimp must be 360° and not damage the primer cup.

Detonators

General:- The use of detonating compositions depends largely on their sensitivity to initiation and to impact. One important requirement is their ability to withstand the shock produced by setback. Where detonators are to be initiated by primer composition, the sensitivity to ignition of the detonator becomes an important factor. Sensitivity to friction may also be required in detonators that function by stab action.

The detonators used in ammunition contain from eight to fifteen grains of mercury fulminate or lead azide. The quantity used partly depends on the strength and material of the enclosing casing and also upon the gap across which it is necessary to propagate the detonating wave. It also varies with the detonator composition and the kind of explosive to be detonated. Data obtained through experimental procedure or tests controls detonator design. The minimum quantity which under the worst conditions will detonate tetryl, is generally used.

To obtain the full effect of a detonating composition, it must be properly confined or reinforced. The top part of a detonator, or initial spot of ignition, is not as effective as the bottom or lower end which develops the full velocity of detonation.

Detonator compositions are pressed at from 3000 lbs. to 10,000 lbs. per square inch. It was believed that any pressures above 30,000 lbs. per square inch would "dead press" or cause the composition to become inert. This, however, is doubtful because pressures as high as 150,000 lbs. per square inch have not "dead pressed" the component. The effect of such high pressures is to render the composition less sensitive to a flash or detonating wave.

The cylindrically shaped detonator is the easiest and safest to load and has been found the most efficient of those used to date. Annular and other odd shapes should be avoided.

Detonators are held securely in place in the fuze by retaining (screw) plugs or by crimping.

It is safer to load cups with such quantity of composition that it will not flow over the top edge of the cup. To insure a uniform density and to keep the loose height down, two or more pressings are used.

For the purpose of removing the detonating composition from the sides of the cup, a felt washer may be used in advance of the punch during the pressing operation.

Safety Precautions:-

Special precautions must be observed when dealing with the very sensitive substances used for loading primers or detonators. The danger is diminished by restricting the quantities that are allowed to be present in any one building. The various ingredients, before mixing, are sifted through fine sieves to remove all gritty particles. Initiator explosives are kept and transported in small "candy boxes" of soft smooth material. In buildings where quantities of a pound or more may be present, en masse, the floors are covered with linoleum or other smooth surface material..

Detonator Loading Fixture:-

A brief description of loading fixtures, bringing out the locating points for the various components parts while being loaded and assembled; why these points must be held; and if not held what may happen in the loading plant.

The loading fixture consists of 3 parts, namely: Sleeve, Anvil, and Guide.

1. -Sleeve: The sleeve is a cylindrical bushing where the inside diameter is the maximum diameter of the detonator cup. This sleeve supports the outside diameter of the cup, and prevents it from spreading during the pressing of the powder.

2. -Anvil: The anvil has 4 steps of different diameters. The smallest diameter is the minimum diameter of the firing pin hole in the cup, and with a height equal to the minimum thickness of of the bottom of the cup. The next larger diameter is the same as the minimum outside diameter of the cup which makes a seat for the cup and allows the sleeve to fit over this diameter. This makes it important that the small diameter in the bottom of the cup (firing pin hole) be concentric with the outside of the cup. The next diameter and surface on the anvil is the resting place for the guide of which the inside diameter is the same as the outside of the sleeve, making a snug fit when the guide is placed over the sleeve and the anvil. The fourth and largest diameter forms the base of the fixture. This diameter locates in a stationary V block on the press, and centers the assembled fixture in alignment with the punch for the pressing of the powder.

3. -Guide: The guide is similar to a cup that houses the sleeve and anvil together, and has a counterbore in the top of the inside cavity to receive that part of the detonator cup which extends above the sleeve. The top of the guide is countersunk to receive

the punch of the powder press, and to act as a funnel in pouring the powder. This makes it very important that the outside diameter of the cup be concentric with the inside diameter.

Inspection of Detonator Cups:-

If the small inside diameter (firing pin hole) of the cup is not concentric with the outside; it will not fit in the loading fixture, and the cup would be useless. If the outside diameter is large it will not fit the sleeve, or, if scratched or cut, will make it difficult to assemble in the sleeve and would be dangerous in forcing out of sleeve after being loaded.

The thickness of the bottom is important in that the locating pin of the anvil does not extend in cup. This would cause trouble in the seating of the detonator disc if thick would leave this disc to bulge in firing pin hole in pressing the charge.

If the cup does not have uniform wall thickness, but the outside is concentric with the firing pin hole, the excess metal on the wall will be broached by the punch. The chip formed will act as a firing pin, which in turn would detonate the detonator.

The bottom must be of the correct thickness and must be flat. When the arbor press comes down to seat the detonator disc, rough or concave surface would tend to mutilate the disc. If the radius on the inside bottom of the cup is not as specified on the drawing, or if the inside is concave, holding the charge within tolerance would be difficult. The bottom, if rounded, would seat improperly on the fixture and the height of the compressed powder would be out of tolerance.

Loading of Detonators and Primer-Detonators:-

Before loading, a visual inspection is given each detonator cup to make sure that no burrs, dirt, oil, or other foreign matter is present, and that no tool marks appear on the inside. The cup is then inserted into the cylinder sleeve and made flush with the bottom, and then placed on the anvil. After the detonator disc (usually .002") is miked to make certain that only one is used, it is placed in the cup and seated with an arbor press. Then, in the case of primer-detonators (ie,, detonators set off by stab action), friction powder is measured out in a scoop, poured into the detonator, and pressed at 282 pounds dead weight. Detonators designed to be set off by detonating wave or flame action do not have any friction powder inserted, and have a 0.001 inch disc instead of a 0.002 inch disc.

Lead azide is then measured in a scoop, poured into the cup, and consolidated in a barricaded press at 282 pounds dead weight.

A tetryl pellet is then inserted and the powders reconsolidated to a fixed height, given in the specifications. This height should be checked at intervals by the inspector to insure the proper height and amount of powder. The detonator disc is then inserted with the painted side up.

In the case of detonators which contain no tetryl, such as the upper detonator in the M-48 fuze, a retainer washer and detonator retainer are assembled and pressed into the cup in place of the tetryl.pellet.

The figures given in the paragraphs above may not be equally applicable to all detonators. In the case of the M-103 Nose Bomb Fuze, for instance, the consolidating pressures ar only 191 pounds dead weight, and two tetryl pellets, reconsolidated separately, are used instead of one.

The sleeve, containing the cup, is then moved to another fixture so that the forming tool can come down and form the top of the cup down 45° around 360° of the top of the cup. It is then moved to another fixture and the top of the cup flattened down the rest of the way.

The cups are then forced from the sleeve in the direction that they were pressed to make the cup pass through the same point in the sleeve and give it uniform diameter. This eliminates any difference in the diameter caused by the pressing operation.

The completed cup is then visually inspected to detect any cups that have cuts or punctures in the disc, loose or wrinkled discs, cracks in the wall of the cup, condition of the crimp and then gaged for height and diameter.

The completed detonators are then placed in composition boards with holes drilled to carry 100 detonators and taken to another b building where they are cleaned by rumbling. This rumbling consists of emptying the detonators from the board into a canvas bucket and a measured amount of sawdust is poured over the detonators and another hundred detonators emptied over the sawdust and the bucket removed to a chute over the rumbling machine and the bucket emptied into the rumbler by remote control. The rumbler is operated by remote control and the detonators rumbled until they are free of excess powder on the outside, and the graphite from the sleeve which is used to make the detonator slide out of the sleeve easily after the pressing. The detonators are then replaced in the fiber boards, which when filled, are placed in a fiber container, cardboard separators being placed between adjacent fiber boards.

Delays

Black Powder Delay Elements:-

The black powder pellets used for delay elements are made on the Stokes Pelleting Press or a similar machine. It is necessary to determine the correct average weight for delay pellet for the lot of powder to be used as the quantity specified on the drawing may be only an approximate guide. A small quantity of delay holders should be loaded with delay pellets of the specified weight and the necessary addition or deduction of the weight will depend on the results obtained in chronograph firing tests.

Density in Compression:-

The pellets should be compressed hard enough not to be easily broken or chipped by the necessary subsequent handling. The experience of the operator enables him to determine the quality of the pellets as they are produced by the machine. In case of doubt the tools can be set up in a hand press and a standard obtained by consolidating pellets under a pressure which will produce the required degree of hardness. The density of the hand made pellets will be duplicated by pellets of equal height and weight with the same tools on the machine. Further detailed instructions regarding the manufacture of delay pellets will be obtained from the current specifications that apply.

Loading Delay Elements:-

In the loading of the delay element for a fuze, care must be exercised in the execution of every detail. Intelligent and experienced operators should be employed on the work. The importance attached to the dependable functioning of each and every fuze used with ammunition, makes it imperative that every element accepted for service be entirely satisfactory. Every possible precaution should therefore be exercised to this end by the loading contractors. The increments that make up a delay powder should be weighed in a manner which will avoid accumulated error.

It should be remembered that in all delay holders whether assembled to their respective primers or with two separate assembled components, that flat bottoms and square corners are essential for sealing. The concentricity of all diameters are also important for proper loading.

1. M-48 Delay:-

This delay holder has a two part loading fixture, the anvil and the sleeve.

The anvil has a counterbored recess made to the max dimension of the small diameter of the outside of the holder with pin in the center to extend inside of the housing. This makes it necessary to have the outside of the small diameter concentric with the flash hole.

The sleeve houses the holder and seats on the anvil, and with the guide in place, it is located on the press by a V stop that controls the alignment of the holder with the punch making it necessary that the inside be concentric with the outside diameter and the flash hole in the bottom.

As this punch is so near the inside diameter of the holder there must not be any burrs or shoulders on the inside as this will create a dangerous condition.

Delay holders are dipped into analine dye and placed on trays where they are agitated for 10 to 12 minutes until dry, to prevent their sticking together.

Before loading and assembling, a visual inspection is given each delay holder, especially on the inside, for false shouldered burrs, and foreign matter; the baffle is inspected for burrs in and around the flash groove.

The holder is then placed in the fixture, located by the flash hole, and one black powder pellet inserted and consolidated at 702 # dead weight. Delay holder is then visually inspected for presence of the pellet. The baffle is inserted into the delay holder and pressed in with a mandrel press, locating from the flash hole and pressed enough to make up tight on the shoulder in the holder.

The completed delay element is again inspected for presence of the pellet and excess powder is brushed off, make sure the top of the groove in the baffle is clear for the passage of the flash from the primer. The body elements are then placed 1700 in a mason jar and sent to the Gordon Drier for at least 72 hours.

2.-<u>M-53 Delay:-</u>

This loading fixture consists of three parts, namely, anvil, guide and primer holder.

The anvil has a recess with pin extending up into the recess so when the delay holder is placed on the fixture the pin will extend into the flash hole and is even with the bottom of the inside cavity. This means that the flash hole must be concentric with the outside diameter.

The guide of the loading fixture acts as a funnel for the centering and inserting of the relay cup, black powder pellets and the plug and is a guide for the centering of the punch in pressing the 90° angle on the relay cup and the delay powder pellets also the plug. This means that the three inside diameters must be concentric with each other, so the punch in its downward movement will not skin the metal from the side walls. This burr would act as a firing pin and may detonate the charge while pressing.

The primer holder is a plunger type fixture. The primer is placed on the plunger with the primer cover over the top and the pressure is applied on the top of the primer cover pressing the primer in the primer cavity. This means that the finish on the inside of the primer cavity must be good and this diameter must be held so there will be no distortion of the primer and it will be held firm on the assembly of the primer.

After being visually inspected the delay housing is placed into the fixture. The guide is inserted into the top of the housing to guide the punch of the presses.

Before inserting the relay cup into the delay housing the bottom of the cup is dipped into N.R.C. and inserted into the delay housing and seated with a small fiber or rawhide rod. The fixture is then set under the press and the cup pressed in at 702# dead weight. This operation completes the crimping of the cup, which comes to the loading with 45° angle crimp around the top. Two black powder pellets are inserted into the housing through the guide and pressed in separately at 702# dead weight. A plug is then inserted with the small diameter down and pressed in on the pellets and staked into position. The weight used for this staking is 1000# dead weight. The primer is placed on a fixture and the primer cover pressed down over it. This screw is then screwed onto the housing and tightened over the copper washer which goes inside to give a good seating of the housing and screw. The top of the primer is sealed into the primer cover by running a pointed stick covered with N.R.C. around the hole and on the primer. The completed assembly is gaged for overall height.

3. M-103 Delay:-

The delay holder is inspected for dirt, chips, or other foreign matter. If clean, the holder is placed on a fixture for the pressing of the delay powder. This fixture locates from the relay cavity with a pin sticking into the small diameter between the delay cavity and relay cavity. Two black powder pellets are inserted and pressed according to the specifications given on the drawing. The holder is then taken form the fixture and a cork cushion inserted into the relay cavity. No broken cushions should be used. The relay cup is then inserted and the delay washer set in place and the crimping wall crimped down 360°.

The completed delay holder is then inspected for tight washer under the crimping or that the crimping wall does not extend above the top surface of the delay holder. The outside diameter is checked to see that the holder has not been distorted by the pressing operation. The crimping wall must be flush or below the surface of the holder so that it will not extend into the slider cavity and foul the slider and keep it from arming.

Relays

A relay, or as it is sometimes called, an exciter, is a small detonator of such size and design to detonate the principle detonator, by boosting up the energy of a powder gas which, due to distance traveled or expansion, has become so reduced in pressure and temperature that it will not surely fire the principle detonator. The powder usually used for relays is lead azide.

M-48 Relay:-

Before loading and assembly, a visual inspection is given each cup to make sure that it is not bent and is free from dirt, burrs and other foreign matter. The cup is then gaged for proper height by placing it on the loading anvil which is the correct h height.

A sleeve for holding the cup during loading is placed on the anvil and a cup inserted and loaded with lead azide. For precaution the barricade door is closed in front of the press while the pressure is applied at 115# dead weight. The excess powder is removed from the cup with a cloth dampened in alcohol and an onion skin disc and aluminum disc inserted in the cup. The cup is then placed in a fixture and a 45° angle crimp made around the top of the cup 360°. A second operation flattens the top of the cup down 360°. The cup is then removed from the sleeve. The bottom of the cup is coated with shellac and the cork cushion set in place. The completed cup is then inspected for any powder on the exterior of the cup, if the aluminum disc has been cut, or the crimping operation has loosened the disc or cracked the wall of the cup. The height of the cup is gaged 100% and the diameter gaged 100%. The cork washer is inspected to see that it is in place and tight.

M-103 Relay:-

The relay cup is placed into a fixture and lead azide measured and poured into the cup and pressed at 232 lbs. dead weight. The cup is then placed in another fixture and an onion skin disc inserted and the top of the cup crimped down 45°. The cup is moved to another fixture where the top of the cup is flattened down over the disc. The completed cup is then gaged for overall height and diameter 10%. The cup is inspected to see that the paper disc is not torn and is properly seated, that the crimping wall is not cracked from the crimping operation.

Lead Cups

M-20 Booster Lead Cup:-

After determining the cleanliness of the cups they are placed into a fixture. This fixture consists of (1) a block of fiber or some pressed composition which has holes the size of the cups drilled into it; (2) a hopper over a board with holes in it the size of the pellets. Below this board is a baffle which holds the pellets in the board until it is removed. The tray containing the cups is inserted below the baffle and the pellets in the upper board are allowed to drop into the cup. Two pellets go into each cup. The cups are taken from this tray and placed in the fixture of the press which is on a revolving table. The table indexes around until the cups come under the press and the cups are pressed. The cups are removed from the press fixture and slide down a chute into sawdust to remove the excess tetryl from the cup. The cups are then visually inspected to see that the top of the pressed tetryl is not cracked and that the correct diameter is not distorted or the flange of the cup distorted.

M-103 Closing Cup:-

The closing cup is inspected visually to see that it is free of dirt and other foreign matter and then placed into a fixture and one tetryl pellet inserted and pressed at 191 lbs. dead weight. Another tetryl pellet is then inserted and re-consolidated to a fixed height as given on the drawing. The completed cup is then checked visually to see that the pellets are not cracked, or loose in the cup. The cup is also inspected to determine if the cups are cut or distorted by the pressing operation. The diameter and overall length are gaged 10%. The completed cups are placed in the slider and crimped 360°. The crimped cups must be flush or below the surface of the slider plate so that it will not foul the slider and keep it from arming.

SECTION III

FUZES

8-BOOSTERS

TYPES OF BOOSTERS:- There are two types of boosters now in use, namely the H.E. shell booster and the chemical shell booster. In both types the explosive is confined in a "booster casing" which may be a separate unit from either the shell or fuze. In the case of the chemical shell the adapter and booster is fabricated as one unit, this being necessary in order to provide a seal for retaining the chemical contents in addition to that provided by the standard pipe thread engagement.

In the H.E. shell the adapter is a separate part from some boosters. In either case the boosters are provided with a metal or bakelite lined fuze cavity. When the ammunition is shipped unfuzed the fuze cavity is closed by means of a fuze hole plug which prevents the admission of any foreign matter.

When the need of a booster was recognized and adopted as a standard component of the detonating train, a design of a special type of booster was evolved for use with H.E. Anti-Aircraft ammunition in order to permit the use of the existing design of time fuzes. The time fuze being an ignition fuze makes it necessary to incorporate a detonating element in the booster, which simulated the detonating train of a detonating fuze. The presence of the detonator in the booster, therefore, requires some means of preventing premature functioning in the bore of the gun. This detonator safe requirement is accomplished by using a rotor or interrupter which is interposed in the explosive channel between the detonator and booster until the action of centrifugal force, after the projectile leaves the muzzle, causes the explosive lead in the interrupter to coincide with that of the booster, thereby exposing the booster to the action of the detonator.

The detonating trains in base fuzes contain all explosives from the primer to the booster thereby simplifying the design and manufacture of the detonating train.

GENERAL REQUIREMENTS OF BOOSTER EXPLOSIVES:- The booster charge is a very important element of the detonating train in the round of ammunition in which it is used. The initial impulse on the fuze primer initiates functioning of the round. Upon the booster often depends whether a high order or low order of detonation is obtained. When used with high explosive shell there are certain special requirements to be met.

High explosives, which are used in shell or bomb are necessarily, insensitive, and the arrangements for effecting a high order of detonation must also be such as to prevent premature explosion. The booster charge must be sufficiently insensitive to withstand the shock of discharge of the gun when compressed into the booster cavity or casing.

It must also be readily detonated by the initiator, such as mercury fulminate or lead azide.

A further requirement is that the booster charge should be capable of withstanding long periods of storage without deterioration.

TETRYL:- The explosive characteristics of tetryl, (Trinitrophenylmethylnitramine), are such that it may be classified as an ideal booster explosive. Tetrly is sufficiently insensitive to shock, so that when loaded to the correct density, it can be used safely as a component of a detonating train in armor piercing projectiles. When loaded properly it is capable of withstanding the shock of setforward when the projectile strikes caliber plate. On the other hand, it is sufficiently sensitive to detonate upon the action of the detonating wave of the initiator. It is non-corrosive and consequently has no effect on metals with which it comes in contact. This characteristic is important as the formation of any sensitive metallic salts might cause premature explosion in addition to the destructive effect on the metal.

Tetryl also posesses the property of being non-hygroscopic. After it has been dried, the amount of moisture which it will absorb has no serious effect on its functioning. Tetryl is about 18% more powerful than TNT. When pure it melts at about 129.25 degrees C. and its ignition temperature is 185 degrees C.

MISCELLANEOUS BOOSTER EXPLOSIVES:- TNT was used as a booster explosive during the World War, but has been replaced by tetryl, the latter material being more effective for this purpose.

Picric acid has been used as a booster explosive but only to a limited extent as a component for detonating trains. It combines readily with practically all metals to form picrates some of which are sensitive to friction and shock. For this reason, it must be kept out of contact with lead and zinc, and when used as a booster explosive the cavity must be lined with a non-metallic substance which will reduce the possibility of forming the sensitive metallic salts.

PRESS LOADING:- The former method of loading boosters was by the direct pressing. This method of pressing the explosive into the booster casing was a slow and hazardous process. At the same time it afforded no accurate means of determining the specific gravity of the explosive charge after loading. This method of loading boosters by pressing is also objectionable from the standpoint of production cost.

PELLET LOADING:- To overcome the objections of the press method of loading, the pellet method of loading was adopted. One of the important advantages gained by this method is increased production. This method consists of making up the booster charge into a number of pellets of the size and form desired. The pellets are produced on an automatic pelleting or "pill" machine. The production capacity of such a machine is about twenty-five pellets per minute, the material being fed through a hopper. The operator can take charge of a number of such machines. These pellets are then placed into the casing or cavity for the explosive without further preperation. When inserting the pellets into metal parts care must be observed to avoid breaking them.

DETERMINING DENSITY:- Specific gravity of pellets.- Five hundredths of one percent (0.05%) of each kind of pellet shall be taken from each 24hr. day's output (minimum number, 10) for determining specific gravity. A one-third section shall be removed from the top and a one-third portion from the bottom ofeach pellet selected, for specific gravity determinations by the mercury displacement method as follows:

The sample is cleaned to leave no sharp corners and accurately weighed on a labratory balance. The apparatus for obtaining the displacement consists of a glass beaker with ground top, a piece of flat glass of sufficient size to completely cover the top of the beaker, and a semi-hard rubber perforated plate, pierced at each corner with sharp pointed pins so that about one-half inch ($\frac{1}{2}$ inch) of pin protrudes from each side. The beaker is first filled with clean mercury the rubber plate inserted and the mercury leveled off by pressing down with the flat glass plate until it is seated firmly on the top of the beaker and no bubbles appear under the glass. The sample is then placed beneath the prongs of the rubber plate and the mercury leveled off as before, the excess mercury being caught in a clean bowl. The mercury displaced by the sample is weighed and the specific gravity of the sample calculated as follows:

$$\text{Sp. Gr. is equal to } \frac{\text{Weight of sample in air x sp. gr. of mercury}}{\text{Weight of mercury displaced}}$$

Sp. Gr. of mercury at 20 degrees C. is taken as 13.55.

SAFETY PRECAUTIONS IN HANDLING BOOSTER EXPLOSIVES:- Explosive materials that have been spilled in buildings or along tracks or roads must be taken up at once and no such material shall be allowed to accumulate under flooring or in other concealed spaces. All operating buildings and magazines must be kept clean and orderly and their immediate surroundings must be clear of any inflammable material. All implements and tools must be kept in their proper places. Explosives of highly inflammable dust must not be permitted to accumulate. The tools used by the operators shall be only those approved by the safety board and the method of their use will be followed as designated. Employees must not wear shoes with exposed metal nails or plates unless covered by sound overshoes. Shoes must be cleansed of mud and grit before entering the operating rooms or magazines. Pockets in clothing will be eliminated as far as practicable. All safety exits must be clear of obstructions and such exits must be conspicuously marked as "SAFETY EXITS".

SANITARY PRECAUTIONS:- The explosives used in boosters comprise substances which poison either by absorption through the skin, inhalation of vapors, or sometimes by being swallowed. They are usually slow acting poisons but recovery from their effects is slow, and sometimes changes start which are prone to be progressive. These substances have a pronounced local irritant action and the inflamnination caused on exposed portions of the body becomes the chief obvious characteristics. Tetryl, on account of its wider use, will probably cause the most trouble. In plants where women are employed in handling tetryl, special precautions will be used as to the clothing women are required to wear to prevent the most disagreeable results.

Process rooms must be strictly observed. Mechanical appliances for the removal of fumes and dust will be installed according to safety rules. A supply of cool, pure drinking water, free from harmful bacteria, must be readily accessible. The common drinking cup is dangerous. Sanitary precautions covering bodily cleanliness, protective clothing and provision for eating meals are important in preventing the absorption of poisonous substances and will be observed by all employees working in buildings where fuze and booster components are loaded.

Manufacture of Tetryl Pellets:-

Tetryl pellets are used extensively in connection with loading of fuzes and boosters.

Although the manufacture of tetryl pellets has for some time been carried out with only minor difficulties, it has in the past caused as much trouble as any other single component in the complete round of ammunition. In pressing tetryl pellets it is necessary to have mixed with the loose tetryl some form of lubricant to ease the action of the dies. Several years ago stearic acid was used for this purpose. Stearic acid not only serves as a good lubricant but has excellent binding qualities; that is, it holds the compressed grains of tetryl together so as to insure uniform density through out the pellet. However, under atmospheric conditions similar to those exis ting in the tropics it has been found that stearic acid melts and forms a coating over the tetryl crystals. This condition is objectionable inthat the stearic acid desensitizes the tetryl to such an extent that it may not initiate detonation of the main explosive charge of the shells or bombs. For this reason the use of stearic acid was discontinued some years ago and natural flake graphite substituted therefor. Although graphite is a very good lubricant it does not have the same binding properties as the acid. In fact, if anything, it will cause a bridging of the tetryl while under compression. At the time this change was made the Loading Department at Picatinny Arsenal had considerable difficulty in manufacturing tetryl pellets of the proper and uniform density. After considerable study it was found that a coarser granulation of tetryl than had previously been used with the stearic acid binder was necessary when using the graphite lubricant. Without going into detail it may be stated here, that this involved several months of experimentation in the tetryl plant before the coarser crystals could be consistently obtained.

Since the destruction to be expected from a detonation of tetryl is very great, the amounts used in any single process are limited to the minimum amount consistent with safety and economical operation. All operations requiring it are properly barricaded to limit the effects of a detonation and minimize the propagation of fire. The floors, walls and ceilings of the plant are frequently washed down to prevent the accumulation of explosive dust.

Tetryl for use in the manufacture of booster pellets is screened through a 10 mesh (Tyler) screen and foreign material removed, after which, the tetryl has admixed to it in a tumbling barrel 2 percent of graphite, which as previously referred to, serves as a lubricant for the dies of the pelleting press. Tetryl for use in the manufacture of lead and small detonator pellets is screened through a 28 mesh and held on a 40 mesh Tyler screen. By controlling the granulation of these close limits more uniformity is obtained in the weight and density of the pellets.

For the manufacture of large pellets, the presses used are of the Stokes Type R. In this type, the pressing is performed entirely by the upper ram, the lower ram serving only as a knockout punch. Small pellets such as are used for leads or detonators are made with the Type "E", "F", or "N" Stokes presses.

After trial runs to permit adjustment of the press for production of pellets having the required size and density, 2 pounds of tetryl with graphite admixed is placed in the hopper of the press. The operator leaves the booth and starts the unit. The hopper is automatically shaken to deliver the proper charge in the die. The charge is compressed and the finished pellet ejected. The cycle is then continuously repeated. The pellets are checked for height, weight and density for compliance with drawings and specifications.

Booster, M20

The M20 booster presents no difficult nor unusual loading or assembling operations. Azide-tetryl detonators similar to those in the M52 P.D. Fuze are now used in this booster. The tetryl booster pellets are manufactured on Stokes pelleting presses, as described in the section dealing with tetryl pellet manufacture. The rotor of the booster cannot be tested statically since arming is dependent upon setback as well as upon centrifugal force. However, the centrifugal pin is tested for arming and non-arming by the metal parts manufacturer before inserting the setback pin.

The M20 Booster was originally designed as a part of the M39 A1 P.D. Fuze but was separated from the fuze when it was decided to use the booster unit in connection with either a time or point detonating fuze The fuze designation was then changed to M39A2 fuze . The M39A2 has been superseded by a new design known as the M48 P.D. Fuze which has proved to be a satisfactory substitute.

The following loading and assembly operations are performed upon the metal parts received by the Loading Plant:

a. With varnish shellac, one paper disc is attached to each of a tray of rotor covers.

b. Closing cups in which a tetryl pellet has previously been consolidated are inserted and crimped in each of a tray of bodies.

c. Operators then assemble the rotor, lock pins, rotor cover and screws and tighten and stake the latter. Insertion and staking of the detonator into the rotor is performed in one of the buildings of the Detonator Line.

d. After placing one paper disc in the bottom of each booster cup a pellet is inserted and the assembly is screwed and staked to a body.

e. The boosters are gaged for thread diameter, concentricity of cup in body and overall length and are then packed and sealed.

In order to insure safety and dependable functioning, representative boosters are selected from each lot and are subjected to a jolt and jumble and firing tests.

A more detailed description of the M20 Booster assembly operations is given in the following pages.

Action of M-20 Booster:-

This booster is used on shell up to but not including the 105 mm. shell, usually in conjunction with the M-48 P.D. Fuze.

The inertia (set back) created by the firing of the gun compresses the centrifugal pin lock pin, releasing the centrifugal pin, and by centrifugal force the centrufugal pin spring is compressed by the outward movement of the centrifugal pin; thereby releasing the rotor, which leaves the rotor free to turn by centrifugal force bringing the rotor lock pin in line with the cavity in the side wall of the rotor cavity.

Then the rotor lock pin moves outward and partially extends in this cavity after which the rotor lock pin lock moves forward by creep force and prevents the lock pin from falling back, in the rotor. This brings the detonator directly in line with the flash hole in the fuze and above the lead cup. Where upon impact of the fuze with the target the detonator in the rotor receives the flash from the fuze and transmits it to the bottom closing cup, then to the booster pellet in the booster cup and into the bursting charge of the projectile.

Action of M 21 Booster:-

The M21 booster is used on 105 mm. and larger shells, usually with the M-51 P.D. Fuze.

As this booster differs form the M20 only in that the centrifugal pin lock pin is illiminated, due to the use of this booster in larger caliber guns and being replaced by a cotter pin to hold the rotor in an unarmed position . This is manually removed when the fuze is Field assembled.

This booster is assembled to the fuze and held in place by a set screw in the side wall of the booster body.

The centrifugal pin holds the rotor in an unarmed position after the cotter pin is removed. Then by centrifugal force the centrifugal spring is compressed by the outward movement of the centrifugal pin thereby releasing the rotor which leaves the rotor free to turn by centrifugal force bringing the rotor lock pin in line with the cavity in the side wall of the rotor cavity; then the rotor lock pin moves outward and partially extends into this cavity after which the rotor lock pin moves forward by creep force and prevents the lock pin from falling back into the rotor. This brings the detonator directly in line with the booster closing cup; when upon impact of the fuze with the tartet, the detonator in the rotor feceives the flash from the fuze, and transmits it to the booster closing cup, then to the booster pellet, into the booster cup, then into the bursting charge of the projectile.

Assembly of M20 and M21 Boosters:-

The rotor is inspected visually for burrs, dirt, chips or other foreign matter. A cork detonator cushion is inserted into the detonator cavity, making sure that no defective cushions are used , and the detonator inserted with the painted side down. It is then placed in a fixture which locates from the bottom of the rotor in the small diameter of the detonator cavity. The detonator is then crimped in 340°. The 20° not crimped is opposite the pivot pin hole and is not crimped because of possible distortion of the pivot pin hole which would bind the rotor when it is arming.

The rotor is then inspected to see that no metal has been pushed into the pivot pin hole by the crimping operation, that the detonator is tight and that the crimping has not extended above the surface of the rotor.

The rotor lock pin is inserted in the lock pin hole and the rotor lock pin lock inserted in its cavity. This assembly is then inspected to see that the lock and lock pin lock do not extend out of the rotor so that they might bind the rotor.

The body is visually inspected for dirt, chips or other foreign matter. The body is then placed in a fixture which locates the body from the wrench holes and a staking tool cut slots into the body below the fuze threads. The lead cups are then inserted and the body placed on a fixture, locating from the rotor cavity and the lead cup crimped 360°. It is then inspected to see that the lead cup does not extend into the rotor cavity and that the lead cup does not extend above the booster surface.

The rotor assembly is assembled into the body by holding the body upside down and inserting the rotor by means of a pair of tweezers. Care must be taken that the rotor lock pin and lock pin lock do not fall out, as there is no other way to check their presence after the rotor is inserted.

An onion skin disc is shellacked over the flash hole of the rotor cover, making sure that no shellac is in the flash hole or the rotor cover by wiping the excess shellac off with a rag dipped in solvent. The date, lot number and kind of booster and loading plant initials have previously been stamped into the rotor cover. Care must be taken in this operation that the covers received at the loading plant do not have a dish shape which would make them not seat in the booster properly.

The rotor cover, with disc in place, is then inserted into the body of the booster and is staked in four places by pushing metal from the cover into the staking notches made in the body and flushing the metal from the body down over this part of the cover which is flushed into the staking notches. The staking is then inspected to make sure that the cover is tight and that the cover disc is in place. It should also be inspected to see that the metal from the body does not extend too far into the fuze cavity and interfere with the seating of the fuze.

A paper washer is placed in the booster cup and the tetryl pellet inserted. The booster cup is then tightened into the body with 43# dead weight. The completed body is then gaged 100% for overall height.

The completed body is placed on a fixture on its side and a tool comes, stabs the cup into the body. It is then turned 180° and staked again. The body is then gaged for concentricity of the body and cup. Body threads are gaged 10% inside and out. If the threads are found tight they are given a more thorough inspection to determine the cause.

The completed booster is given a visual inspection for staking, presence of the cover disc, that the detonator is not under the cover disc, which would mean that the rotor is in an armed position.

The completed booster is then placed in a cardboard container and another cardboard disc inserted between the bottom booster and the other booster which goes on top of the first. The lid is then screwed on the box and the whole box dipped in parafin wax to seal out moisture. One-half of the box is dipped and allowed to cool and solidify, then the other end of the box is dipped in parafin. These containers are packed in wooden boxes which hold 25 containers or 50 boosters and sealed with car seals.

Action of M-22 Booster:-

There being no arming device in the M-22, this booster is not bore safe. The M-22 can be used on all fuzes that take the M-20 or M-21 booster. However, it is usually used in conjunction with the M-57 P. D. Fuze. This M-57 P. D. Fuze is similar to the M-48 and M-51 Fuzes with the exception that it does not have any delay firing mechanism.

METAL PARTS INSPECTION OF M20 BOOSTER

Body:-

Outside Body Threads:
To insure proper assembly of the booster body in the projectile, these threads should be closely checked for size and concentricity with the axis of the body.
Booster Thread:
As the alignment of the booster cup with the diameter above this thread is gaged 100% after being loaded, it is important that this thread and shoulder be concentric with the axis of the body. Care must be taken that burrs from first thread do not extend above the bottom surface of the body. The bottom surface of the body should be straight and of good finish, as booster pellet bears on this surface when the booster cup is assembled to the body. If this surface is convex the booster pellet may crack, or if it is concave the closing cup may extend into the rotor cavity.

Closing Cup Hole:-

The inside finish must be kept free of tool marks or scratches. The concentricity of this hole is important on account of the crimping operation. The crimping wall of this hole must be concentric with closing cup hole and correct depth. If the crimping wall is too deep the closing cup may extend in the rotor cavity and interfere with the action of the rotor, and if shallow it may extend above the bottom surface of the body and crack the booster pellet when it is assembled to the body.

Centrifugal Pin Lock Pin Cavity:-

This must enter the centrifugal pin hole in the center so the lock pin will assemble with the centrifugal pin. The diameter must be concentric to insure freedom of action of the lock pin and spring. Depth of the large diameter must be such that it will allow the plug to be brought down flush with the surface. The dimension must be held between the center of body and center of lock pin hole to insure the locking of the centrifugal pin which in turn locks rotor.

Centrifugal Pin Cavity:-

All diameters must be concentric to insure free movement of the centrifugal pin and spring. It is important that the dimension from the center of the body to the bottom of this cavity be held to insure locking of rotor and functioning of the centrifugal pin lock pin. The dimension from the bottom of centrifugal pin cavity to the bottom of the counterbore must be held so the centrifugal pin screw will not bind on the centrifugal pin lock pin.

Body Plug Cavity:-

The location of this hole determines the position of the rotor when in an armed position. Sharp corners and diameters should be maintained where plug seats in cavity for correct crimping.

Rotor:-

Have top and bottom surfaces parallel and make the bottom surface flat. The drawing calls for FF finish on the bottom so the rotor will turn freely.

The important parts of the profile are the surfaces next to the stop pin in both the armed and unarmed positions of the rotor. In the unarmed position the centrifugal pin slot must be free to center with the centrifugal pin without binding. In the armed position the rotor lock pin must center with the lock pin cavity in the body and not be held out of position by the surface which bears against the stop pin. The relative positions of the pivot pin hole lock pin hole and detonator cavity must be held to insure proper arming.

The thickness of the wall at the bottom of detonator cavity must be held for proper assembly of the detonator. The detonator cavity must be concentric with the flash hole and be free of burrs and tool marks. Care should be taken in burring not to remove metal needed for crimping of detonator cup in rotor. Care should be taken when reaming detonator hole that bottom does not bulge.

Pivot pin hole must be concentric and straight with the axis of rotor and have good finish (FF) shown on drawing.

The rotor lock pin and lock pin lock holes must be clean and free of burrs. The lock pin lock hole must break in the center of the lock pin hole.

Centrifugal Pin:-

For the proper functioning of this pin with the lock pin it is important that dimension from shoulder to center of lock pin hole be maintained. This hole should be in the center of the pin to avoid any binding with the lock pin.

Centrifugal Pin Lock Pin:-

There should be no burrs on either end of this pin.

Centrifugal Pin Screw:-

The length from the end of screw to the underside of flange is important because if this is too long it may bind the centrifugal pin lock pin. The inside diameter must be free of shoulders so spring will not be fouled in arming of rotor. Check for bulge on inside caused by putting screw driver slot operation.

Booster Cup:-

Bottom surface inside and outside should be straight and have the proper radii. Guard against collet squeeze when threading the cup. Perfect threads are necessary and no burrs should be left below last thread as this will interfere with booster Pellet. Check closely for cracks in the material.

Booster Closing Cup:-

There must be no die cuts or draw marks on either the inside or outside of the cup. Check the outside diameter especially near the flange. The dimension under the flange to the bottom of the cup is important as a long cup may extend into the rotor cavity. The radius on the inside of the cup must not exceed the maximum dimension shown on drawing for loading reason. The radius under the flange must be held for proper fit with the crimping wall in the body. The outside diameter of flange must be concentric with the inside of the cup. There must be no cracks resulting from forming the flange angle.

Lock Pin Closing Plug:-

Over-all length must be held so the plug will not extend above the bottom surface of the body. The inside diameter should be concentric with outside threads and have specified radius to prevent spring from fouling.

Rotor Cavity:-

By the locking of the rotor in the armed and unarmed position and the alignment of the detonator cavity in the rotor and the closing cup when armed, the position of the rotor cavity is determined by the relative position of the center of the cavity and the center of the body; this dimension must be held. For following reasons the depth of the rotor cavity must be maintained; if this cavity is shallow the rotor may bind with rotor cover, and if deep, the closing cup may extend in this cavity. The bottom must have good finish (FF) with the specified crown and the sides should be parallel with the axis.

Pivot Pin Hole:-

This hole must be concentric with the rotor cavity and be parallel with the axis of the body. The diameter of the pivot pin hole must be held within the drawing tolerance for a press fit of the pin. If this hole is large it will not stand the jumble and jolt test, and if small the pivot pin may bend in assembly. The chamfer on the top of the pivot pin hole is for the removal of any excess plating or burrs which may be found after the pivot pin is assembled. The pivot pin must not bulge the bottom surface of the body.

Rotor Stop Pin Cavity:-

The location of the stop pin cavity is important in determining the armed position of the rotor and should be held according to drawing; the diameter of stop pin cavity must be held for press fit of stop pin; if diameter is large pin will drop out in jumble and jolt test, if small, pin will bend in assembly. The chamfer at top of stop pin cavity is for the easy removal of any excess plating or burrs which may be found after the stop pin is assembled. The stop pin cavity must not bulge the bottom surface of the body.

Rotor Pivot Pin:-

Outside diameter very important and must be held for press fit in body. Length of pin with no burr on end important that it does not interfere with rotor cover.

Stop Pin Hole:-

Outside diameter must be held for press fit and not bend in assembly.

Rotor Cover:-

Cover must be straight and flash hole concentric with outside diameter.

Rotor Lock Pin and Lock Pin Lock:-

Length and diameter must be held for the proper assembly in rotor. Care must be taken that no burr on chamfer on end of these pins to insure free movement.

Detonator Disc:-

Care must be taken as burrs on these discs are dangerous from the loading standpoint. Heavy disc must be colored on one side for proper assembly reasons and if made with sharp corner or very small burr, the burr would be on painted side and not be in the powder chamber of the detonator.

Body Plug:-

The diameter must be held and free from burrs for proper crimping. These are the important points of this component.

Adapter and Booster, Mk. IIIB

Loading and Assembling:-

Adapter and Booster, Mk. IIIB is used in 75 mm H.E. Shell, Mk. IV, fuzes with M46 and M47 Point Detonating Fuzes. Four tetryl pellets are required for each booster; two hollow pellets, one solid pellet and one solid pellet having a radius on the bottom.

The two hollow pellets assembled in the nose end of the casing form a cavity within which the detonator of the fuze is located in a subsequent operation. The manufacture of these pellets is described under the subject "Manufacture of Tetryl Pellets."

The following is a short description of the procedure that is followed in loading, assembling and packing these boosters:

> The booster casings are inserted in trays for convenience in handling. The tetryl pellets are inserted in the casings, care being exercised that the pellets are assembled in the correct sequence. The distance from the top of the casing to the face of the pellets is gaged to determine the number

of felt washers required to fill the void between the fuze socket and the pellets. The required number of felt washers is then placed on the fuze socket. The loaded casing is inspected to insure the presence of pellets after which the fuze socket is inserted a short distance. Glue is applied to the under side of the fuze socket flange and the socket is then seated either by hand or on a Mandrel press, if necessary. After inspecting to determine that the socket is in place, glue is applied to the threads of the casing. When the glue becomes tacky, the adapter is assembled to the casing, by hand and tightened by means of an assembling fixture, consisting of a vise and a pin wrench which engages slots in the adapter. By means of a pneumatic press the casing is staked to the adapter in two places and then the adapter threads and concentricity of the fuze socket are checked on a friction drive gaging machine. A dial feed rotary marking machine, which has replaced the older reciprocating type, rapidly stamps the identification data on the beveled surface of the adapter and ejects the components to a hopper, from which they are removed and gaged for length. The exterior surface of the booster casing and the bottom of the adapter are coated with shellac varnish, using a saturated varnish brush in conjunction with a friction driven spindle. A closing plug is inserted into a wrench in an assembling machine and assembled into the adapter. Two felt washers are assembled over the casing and seated around the base of the adapter. The adapter boosters are then ready for packing into shipping boxes which have been prepared with all the necessary marking.

M100 and M101 Adapter Boosters

The adapter boosters as used in bombs are in essence composed of only two parts: The container for the tetryl booster charge and the adapter which fastens the booster to the bomb and accepts and retains the fuze. It is usually closed with a plug to keep the fuze well clean and prevent its threads from being damaged.

The M100 and M101 are made up of components that are identical except for two items: The tetryl pellets and the chipboard liner. The M101 Adapter Booster has booster pellets of a smaller diameter than the M100. Since the same steel booster case is used with each booster a chipboard liner is required to take up the space left by the smaller tetryl pellet diameter. The loading and assembly except for this change is identical.

The steel booster case assembly is received complete from the Metal Components Department. An operator places the tetryl pellets in an inclined brass trough. From this trough the pellet column is slid into the chipboard liner in the M101 or into the steel booster case of the M100 booster. The chipboard liner is then inserted into the steel booster case for the M101.

In a tray provided for the purpose an operator places the detonator socket assembly, open end down. A felt washer is placed over the small end followed by the tetryl ring pellets in sufficient number to project above the end of the detonator socket. The same requirement is set for the tetryl pellets in the liner so that the tetryl will always be in contact throughout the length of the column and not interrupted by an air space when the ring pellets rest on the top of the chipboard liner. Such an interruption might be the cause of failure of the explosive train. This assembly of the detonator socket is then inserted and threaded in the end of the booster case and the assembly tightened with a wrench, the case being held in a vise with wooden jaws designed to protect the casing. With the case still in the vise an operator rolls in the socket end of the booster case. The machine used for this purpose is a pipe thread cutter with the cutters removed and rolls substituted.

After the rolling is completed the assembly is painted by hand on the booster case surface. Care must be taken to keep paint clear of the brass top of the detonator socket. The entire booster assembly is gaged for length.

M102 Adapter Booster

The M102 Booster is made up of a booster casing, an adapter and a closing plug. The loading and assembly involve for the most part simple operations that follow in sequence.

A felt pad is dropped into the booster casing and a tetryl pellet placed on top of it. The adapter assembly is next made up. A closing cup assembly with a tetryl charge in it and its end coated with acidproof black paint, is inserted in the small hole in the base of the adapter, and the adapter crimped in an air operated press. After coating the threads with Pettman cement the booster casing is screwed onto the adapter and tightened in a fixture with a hand friction wrench. The operator gages the height of the booster case above the flange of the adapter. The assembly is then painted with oramge shellac varnish. To facilitate the painting the booster is placed on a rotating spindle whose speed is slow enough to allow an operator to coat the surface and end without touching the threads. The closing plug whose threads have been lightly coated with shell grease is threaded into the top of the adapter and tightened, hand-tight, with a wrench. After visual inspection they are packed and stored. The loading of the closing cup assembly is described in the article on Primers and Detonators.

M107 and M108 Adapter Boosters

These boosters consist of two main assemblies: the booster case assembly and the adapter assembly. The M108 is the same as the M107 except that it has a longer booster case and more tetryl pellets.

An operator after coating the threads with glue, screws the booster case plug into the booster case, after which it is tightened in a turning fixture by means of the wrench holes. A felt disc is dropped into the booster casing to form a soft seat for the tetryl pellets which are pushed in. The tetryl loading is done at a separate table to confine the dust as much as possible.

The lead cup, its end painted with acidproof black paint, is inserted in lead cup holder and crimped in a pneumatic press to maintain it in its place. The holder threads are coated with glue and the holder screwed into the adapter. These parts are then tightened in a turning fixture.

The booster case assembly and the adapter assembly are now threaded together. This operation must be done soon after the threads of the lead cup holder are coated, otherwise the glue will congeal and block the threads. The assembly is tightened in a fixture using a friction wrench and gaged for height above the adapter top. The assembly is then rolled over inked letters to imprint the ammunition data on the surface of the booster casing subsequent to which the overall length is gaged. Two set screws with conical points are then screwed into the flange end of the adapter and after threading in the closing plug, these screws are tightened. To make its removal easy, the closing plug is coated on its threads with shell grease. The booster is then visually inspected and packed. The description of the loading of the lead cup will be found in the article on Primers and Detonators.

SECTION III

FUZES

9. - BOMB FUZES

World War Types:-

Demolition Bombs, as manufactured in this country during the World War, were of the type which has since been designated as "Mark I". Typical of this series, which ran from 25 pounds to 1100 pounds in size, is the 100-lb. Mark I Demolition Bomb. The smaller sizes were formed entirely of pressed steel sections welded together. The larger sizes had cast-steel nose sections welded to pressed-steel rear sections. All were joined by both circumferential and longitudinal welds. The forward sections were thicker and heavier than the center and rear sections. Both nose and tail were completed by forgings. The nose forging was threaded to receive a closing plug and the tail forging to take a firing mechanism or fuze.

This tail firing mechanism consisted of a die-casting supporting a long axial tube at the closed inner end of which was a wedge-shaped firing pin. Around this tube, somewhat above the inner end, a booster charge was provided. A primer-detonator assembly was suspended in the open end of the tube by a transverse arming pin in the cone of the fin assembly. The arming pin was held in place against the action of its spring by an arming wire entered through a hole in the opposite end of the pin. The other end of the wire terminates in a loop which was engaged by an arming pawl in the bomb rack.

When the bomb was dropped, the arming wire, being retained by the arming pawl, was withdrawn from the arming pin. The arming pin spring then ejected the pin and freed the primer-detonator assembly. As the bomb descended the primer detonator assembly was free to slide slowly forward in the tube until its rim-fire primer rested against the end of a small lead pin extending slightly above the ridge of the firing pin in the end plug of the tube, and the collar-shaped detonator was centrally located within the booster. Upon impact with the target, the forward motion of the entire bomb was arrested sufficiently to cause the inertia of the primer detonator to deform the lead pin and plunge the rim-fire primer against the firing pin. The flash from the primer, augmented by the explosive effect of the axial charge of black powder in the primer detonator body, exploded the detonator, whose effect was relayed to the booster and thence to the entire explosive charge of the bomb.

The action of this tail fuzing arrangement was slow enough to permit some penetration of the bomb into the target, but when deeper penetration was found desirable the axial charge of the primer detonator was changed to highly-compressed black powder whose slow-burning properties gave a delay between the firing of the primer and the eventual detonation of the bomb.

Post-War Modifications:-

The Mk. I series of demolition bombs proved generally unsatisfactory. Their bodies, or cases, were not of sufficient strength, due largely to the numerous welded joints. The stabilizing fins were not stiff enough to prevent wobbling in flight. The fins had to be removed in the field in order to insert the tail fuze. After the Armistice a modification of the Mk. I series was undertaken with a view to eliminating, insofar as possible, the unsatisfactory functioning that had been experienced. The 25- and 50-lb. sizes were declared obsolete due to their small capacity and these were not considered in the modifications. All of the other sizes were provided with newly designed fuzes for both nose and tail, together with new boosters and detonating arrangements. The modified series of bombs was called the Mark IMI Bombs.

These Mark IMI bombs were equipped in the nose with the Mark VII fuze. This is a simple firing mechanism and requires for its completion either an instantaneous or a short delay Mark IIB primer-detonator, and an adapter booster, which is really a part of the bomb. The tails were fitted with a similar adapter booster and used the Mark V Tail Fuze with a second primer detonator.

The Mark VII Nose Fuze consists of a threaded body into whose axial bore a flanged striker is secured by a transverse copper shear wire. Between the flanges of the striker and body is a circle of steel cylinders or discs which maintain the relative position of these two parts. Securing these discs in place against the action of a bent leaf spring is an arming cup, mounted in an axial thread and equipped with a double wind vane. Affixed to the cup and the body are two sets of eyelets through either of which the arming wire may be passed to restrain the cup from being unscrewed by the action of the air against the vanes. When the bomb is released, the arming wire is withdrawn and the vane cup assembly unscrews from the fuze and liberates the discs. This leaves the striker held in place only by the copper shear wire which is readily sheared when the striker contacts the target. The striker is then driven inward and its point fires the primer of the primer detonator, the booster and the bomb.

The Mark IIB Primer Detonator, which is held in its place within the adapter booster by the fuze, consists primarily of a Head, a Body, and a Detonator. The Head was originally the brass end of a commercial 16-gage shotgun shell, but later a turned metal part of approximately the same general shape and size. It serves mainly to hold a percussion primer in axial alignment with the firing pin of the fuze, and to seal the primer detonator assembly against escape of the gases produced by the combustion of the explosive elements. The Body serves as the connecting link between the Head and the Detonator, and holds a relay charge of black powder pellets whose purpose is to supplement the flash from the primer and insure proper functioning of the detonator. The Detonator is a drawn cup of the same dimensions as a commercial No. 8 blasting cap, and contains an upper charge of mercury fulminate or lead azide and a lower charge of tetryl. In the delay primer detonator the small tubular section just below the primer is filled with highly compressed black powder to produce the desired interval between impact and explosion.

The Adapter Boosters each consist of an adapter; a booster case, which contains the tetryl pellets of the booster charge; and a socket which provides the seat for the primer detonator. These units are always assembled to, and shipped with, the bomb, while the fuzes and the primer detonators are shipped separately.

The Mark V Tail Fuze is also of the arming-vane type of firing mechanism without any integral explosive parts. Its lower end is arranged so that a Mk. IIB Primer Detonator may be assembled to it before it is screwed into the tail adapter booster. When the arming wire is withdrawn, the vane unscrews the long arming stem that secures the plunger and leaves the plunger restrained only by a light spring between it and the primer detonator. When the bomb is retarded upon impact with the target, the plunger drives forward and its striker point fires the primer.

Since there is an inherent delay in the mechanical action of this type of tail fuze, and therefore strictly instantaneous action cannot be obtained, a delay primer detonator is always used in the tail of the bomb. In the nose, either an instantaneous or a delay primer detonator is used, depending on the probable nature of the target.

The Mark III Series:-

While the foregoing modifications to the war-built bombs improved them considerably, their bodies, principally on account of the longitudinal welds, were incapable of passing the strength tests that had been decided upon, and their fin assemblies were not sufficiently rugged to insure the desired degree of stability. Therefore, a new series of demolition bombs was developed. These Mark III bombs were also made in the 100-lb., 300-lb., 600-lb., and 1100-lb. sizes. They employed the same fuzes, primer detonators, and adapter boosters as the Mark IMI bombs. The 100-lb. size is built with deep-drawn nose and rear body sections joined together with circumferential welds. No longitudinal welds are used. The 300-, 600- and 1100-lb. sizes are designed with cast-steel noses and deep-drawn rear body sections joined together with circumferential welds. The fin assemblies are designed as units, capable of easy assembly in the field, and do not require removal from the bomb body in the fuzing procedure. The fin surfaces are held in a rigid assembly by braces. The Mk. III type bombs carry an explosive content of approximately 55 percent of the total weight.

Cylindrical Demo. Bombs:-

In 1921 the design of a 2000-lb. demolition bomb was started and was based in general on the British 1600-lb. bomb, but was made considerably stronger through the use of seamless steel tubing in place of a riveted drum used by the British for the cylindrical body. This initial design of our 2000-lb. Mk. I bomb had a cast steel nose riveted and welded, and a cast rear cap welded, to the cylindrical body. It carried nose and tail fuzes and detonating trains similar in principle to those used in the standard type of streamline bodied bombs. The explosive content was 49 percent of the total weight. Proving ground tests were conducted on July 18, 1921, and the battleship Ostriesland was sunk with one of these on July 21 of the same year, or 115 working days after the first experimental order was placed. This bomb proved to be generally satisfactory but several changes were found to be desirable. The first change was to attach the rear cap to the cylindrical body by means of a large screw thread rather than by welding. This facilitated and reduced the cost of loading. The second change was the elimination of the heavy nose casting and the substitution of a forged nose integral with the cylindrical body and formed by a swaging operation. This arrangement resulted in a stronger bomb, reduced the total weight 100 pounds and increased the explosive content from 49 percent to 52 percent.

Experience showed, however, that a threaded rear cap of large diameter was often difficult and sometimes impossible to remove for loading after the empty bodies had been in storage for some time. In order to avoid this difficulty the design was again changed. The new design is made by forging the heavy nose and the cylindrical portion in one piece as before and then the open end is reheated and swaged into a conical form until the opening is reduced to about one-third of its original area. A rear cap of practical size is then threaded over the end to close the body. This design and contour is the standard for all sizes of demolition bombs today.

Concurrent with the foregoing change in body design was a redesign of the fin assembly and the development of new fuzes for both nose and tail. The new fin assembly is attached to the bomb by a shallow drawn cup which fits over the rear cap, instead of by a long tapered cone extending well forward over the rear part of the body. The four radial fins are attached to the sidewalls of the cup, and a large portion of each fin is bent at a 45-degree angle from the radial section so that it joins and is riveted or spot-welded to the adjacent fin. Thus the greater part of the assembly is formed into a very rigid square box with four diagonal extensions. This design has reduced the manufacturing cost, has greatly improved the stability characteristics of the bombs, and has produced a fin assembly that is far more convenient to handle in the field. The tail fuze developed for the cylindrical bombs is the M100 type and is supplied in three lengths, the two longer fuzes being designated M101 and M102 respectively. The shortest fuze M100 is being used in the 100 and 300 pound bombs, the next size in the 600 and the largest in the 1100 and 2000 pound bombs. This fuze is not complete in itself, consisting only of a firing mechanism and a primer-detonator unit, the booster (M102) being supplied with, and as part of, the bomb. The M100 tail fuze consists of a body housing the primer-detonator assembly, or the delay element assembly as it is called, and a plunger restrained in the unarmed position by a threaded stem engaging in a threaded hole in the plunger and the base of the fuze body. The rear portion of this stem is attached to a wind vane through a delayed arming mechanism, the delayed arming mechanism being simply a set of gears which reduce the number of turns of the arming stem with respect to the number of turns of the arming vane to 1 in 30. Therefore, as the arming vane spins, the arming stem slowly unscrews from the plunger until it is entirely free, then on impact, as the bomb is retarded by the target, the inertia of the plunger will carry it forward to strike a primer of the delay element assembly. The delay element burns and then sets off the detonator which transmits the detonating wave to the booster and thence to the bomb filler.

The new nose fuze (Fig. 1) is designated as the M103 and is a complete fuze, housing firing mechanism, delay element and booster, and which may be set either for superquick action or short delay. No booster need be supplied in the bomb. The M103 fuze consists of a body housing, a delay element of the type used in the M100 type of fuze. The lower portion of the body is slotted perpendicular to the axis to accommodate a slider which carries a detonator. A booster is assembled to the body in a thin metal cup below the slider cavity. A brass plate with two booster leads is placed below the slider and between it and the tetryl pellets of the booster. This plate is provided to secure "bore" safety in case the detonator should be exploded anywhere except in the two armed (instantaneous or short delay) positions. A firing mechanism is assembled in the upper part of the body. This firing mechanism consists of a striker head equipped with two firing pins, one on the axis and extending for a considerable distance into the body, the other rather short and situated directly above the primer of the delay element. A setting device is provided in the body. This consists of a stem mounted perpendicular to the axis and extending through the entire length of the body, projecting into the slider cavity on the one end, and against the arming gear on the other. This arming stem is provided with a shoulder. A setting pin is mounted perpendicular to the arming stem hole and, from the outside of the fuze, may be so adjusted to project into or clear the arming stem hole. If it is desired to set the fuze for delay action, the setting pin is allowed to project into the arming pin hole where, upon spinning off of the arming vane assembly (which is similar to the action of the Mark XIV fuze) the arming stem, since it bears against the arming assembly, will follow it as it rises, being forced upward by a coil spring. The distance that it can go upward, however, will be governed by a flange on the arming stem coming in contact with the setting pin. As the arming pin moves upward it clears the end of the slider and allows it to be pushed over far enough for the detonator to align with the relay of the delay element assembly and the first booster lead. The slider is stopped in this position by the arming pin engaging against a stop on it. Further, it is located by a latch mechanism mounted in the body, which engages in a groove in the slider. For instantaneous setting, the setting pin is so positioned that it clears the arming pin hole, in which case the arming pin entirely clears the slider cavity and the slider springs force the slider over until the detonator aligns with the instantaneous firing pin and the second booster lead. Delayed arming of this fuze is accomplished by a gear mechanism, mounted within the arming vane cup, which reduces rotation of an arming screw, to 1 turn in every 70 turns of the arming vane. As the arming screw moves upward it carries with it the arming vane cup and at the proper time releases a series of steel cylinders from between the pressure head and the body assembly, as in the case of the Mark VII MII fuze. In addition, it allows the arming stem, governing slider motion, to move.

Modernized Bombs:-

The box-type fin assemblies developed for the cylindrical demolition bomb proved to be such an improvement over all earlier types that experiments were undertaken to determine whether this type of fin assembly would improve the stability of the old streamlined bombs of the Mk. I Series. These tests were so successful that all remaining bombs of the Mk. I Series are now being equipped with fin assemblies of the new type. The 100-lb. Mk. IMIV Bomb shown in Figure 2 illustrates the result of this modernization program.

On account of a lack of concentricity between the fuze threads of the nose and tail adapter booster and the detonator sockets in the bombs of the older types, difficulties have arisen from time to time in attempting to fuze these bombs with a Mk. IIB Primer Detonator assembled to the Mk. VIIMII Nose Fuze and the Mk. VIII Tail Fuze. Consequently, the present modernization program will include an improvement in the nose and tail fuzing arrangements in addition to provision of the box-type fin assemblies. All nose adapter boosters which now require the Mk. IIB Primer Detonator will be modernized by filling the primer detonator sockets with a socket charge assembly consisting of small tetryl pellets encased in a light aluminum container. These charge assemblies will be secured in the sockets by a force-fit sheet metal cup, which will be pressed into the interior of the adapter until it seats firmly on the top of the detonator socket flange. The tail adapter boosters of these bombs will be removed and will be replaced by new adapter boosters designed for either the M100 Tail Fuze, previously described, or a new type tail fuze (T18) which is being considered to supplant the M100.

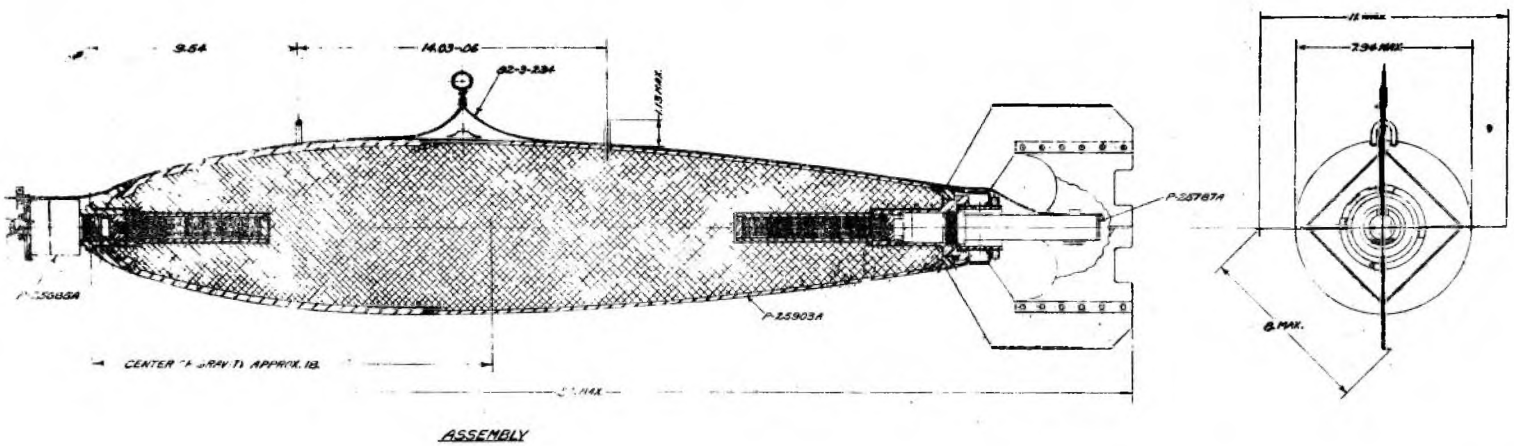
Since the fin assemblies of the streamlined bombs of the Mk. III series and the 2000-lb. cylindrical bombs of the Mk. I series, which remain in War Reserve, are considered sufficiently rugged for continued use, they will be retained and the modernization of the bombs of these two types will be confined to the foregoing improvement in the nose and tail fuzing arrangements only.

The nose fuze intended for all modernized demolition bombs is the T18 (M105). This fuze is of the arming-vane type and, like the M103, is provided with a gear reduction between the arming vane and the arming thread, so that approximately 500 revolutions of the vane are required before the arming discs are released from between the flange of the striker and the fuze body. This fuze is also of the selective type, which may be set for either instantaneous or delay action; the setting being made by manipulation of a convenient setting pin projecting from the side of the fuze body. When set for instantaneous action, one firing pin fires a primer which flashes directly to a relay charge and thence to the detonator. When set for delay action, the instantaneous primer is removed from the firing position and a second firing pin fires another primer, which must operate through a delay element before reaching its relay charge and the detonator. It will be noted that the delay feature of this fuze is always in the firing position and, even when the fuze is set for instantaneous action, it is available to explode the bomb if the instantaneous element should fail.

The tail fuze, which is being provided for the modernized demolition bombs is the T17 (M106) shown in Figure 3. This fuze is of the arming-pin type and carries the conventional tail fuze plunger which, after ejection of the firing pin upon release of the bomb, is restrained only by a light spring situated between it and the primer. Since this fuze is intended primarily for low-altitude demolition bombardment, the plunger is considerably heavier than usual and the plunger spring is correspondingly lighter. Likewise, the primer is of a much more sensitive type than is usually found in bomb fuzes. When the primer of this fuze is fired upon impact of the bomb with the target, its flash, reinforced by the effect of the black-powder pellet directly beneath the primer, ignites the end of a coiled length of miner's fuse. This slow-burning fuse provides a length of delay sufficient to enable all planes of a low altitude bombardment formation to reach a point of safety before ignition is communicated to a second hollow black-powder pellet and thence to the detonator and the bomb.

Practice Bombs:-

In order to make use of the large number of empty bomb bodies remaining from wartime manufacture and to provide the various air units with target practice ammunition, several methods have been employed from time to time to equip these bodies with a satisfactory practice loading. A recent example of a target practice bomb produced in this way is the 100-lb. M39 Practice Bomb. This is a 100-lb. Mk. I Bomb Body equipped with one of the new box-type fin assemblies and filled with approximately 62 pounds of dry sand and 2 pounds of black powder. In order to provide the maximum of field training to both ground and air personnel, two fuzes and the usual arming wire assembly are supplied. Both fuzes are fitted with blank-loaded 24-gage shotgun shells instead of Mk. IIB Primer Detonators. The nose fuze and shotgun shell assemble into a metal adapter and closing cup and are furnished for training in the fuzing operation only, since the two-pound practice charge of black powder is located in the tail of the bomb. This bomb gives adequate training in all of the phases of high altitude bombardment, but has the disadvantage that, if dropped from high altitudes onto soft soil, it



ASSEMBLY

LINE NO.	NAME OF COMPONENT	DRAWING NUMBER OF PIECEMARK	APPROX. WEIGHT (POUNDS)
1	ASSEMBLY, COMPLETE	P-25902	123.
2	BOMB, LOADING ASSEMBLY [illegible]	P-25903A	118
3			
4			
5	FUZE, BOMB, NOSE T18	P-25685A	3.2
6	FUZE, BOMB, TAIL, T17	P-25787A	2.4
7			
8	[illegible] WIRE ASSEMBLY	[illegible]	.18
9			
10			

LINE NO.	DESIGN DATA — NOMENCLATURE	WEIGHT (LBS)
1	BODY	42.7
2	FIN ASSEMBLY	2.6
3	ADAPTER-BOOSTER, MK B VIII D	2.0
4	ADAPTER-BOOSTER, T4	3.8
5	FUZE, BOMB, NOSE, T18	3.2
6	FUZE, BOMB, TAIL, T17	2.4
7	FIN LOCK NUT AND COUPLING	.74
8	ARMING WIRE ASSEMBLY	.18
9	EXPLOSIVE (TNT)	65.
10	TOTAL	123.
11	PERCENTAGE OF EXPLOSIVE BY WEIGHT	53.%
12		

FIG. 11 XI-2

0 2 4 6 8 10 12 14 16 18 20 22 INCHES

BOMB, DEMOLITION, 100 LB, MK. I M IV
ASSEMBLY, COMPLETE

NOV 22 1938

REVISIONS

DWG. PERTAINS TO

SYMBOL

C.G.R. C.G.R.

L.F.Y. M.T.

H. Aurand

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ORDNANCE DEPT. U.S.A.

P-25902

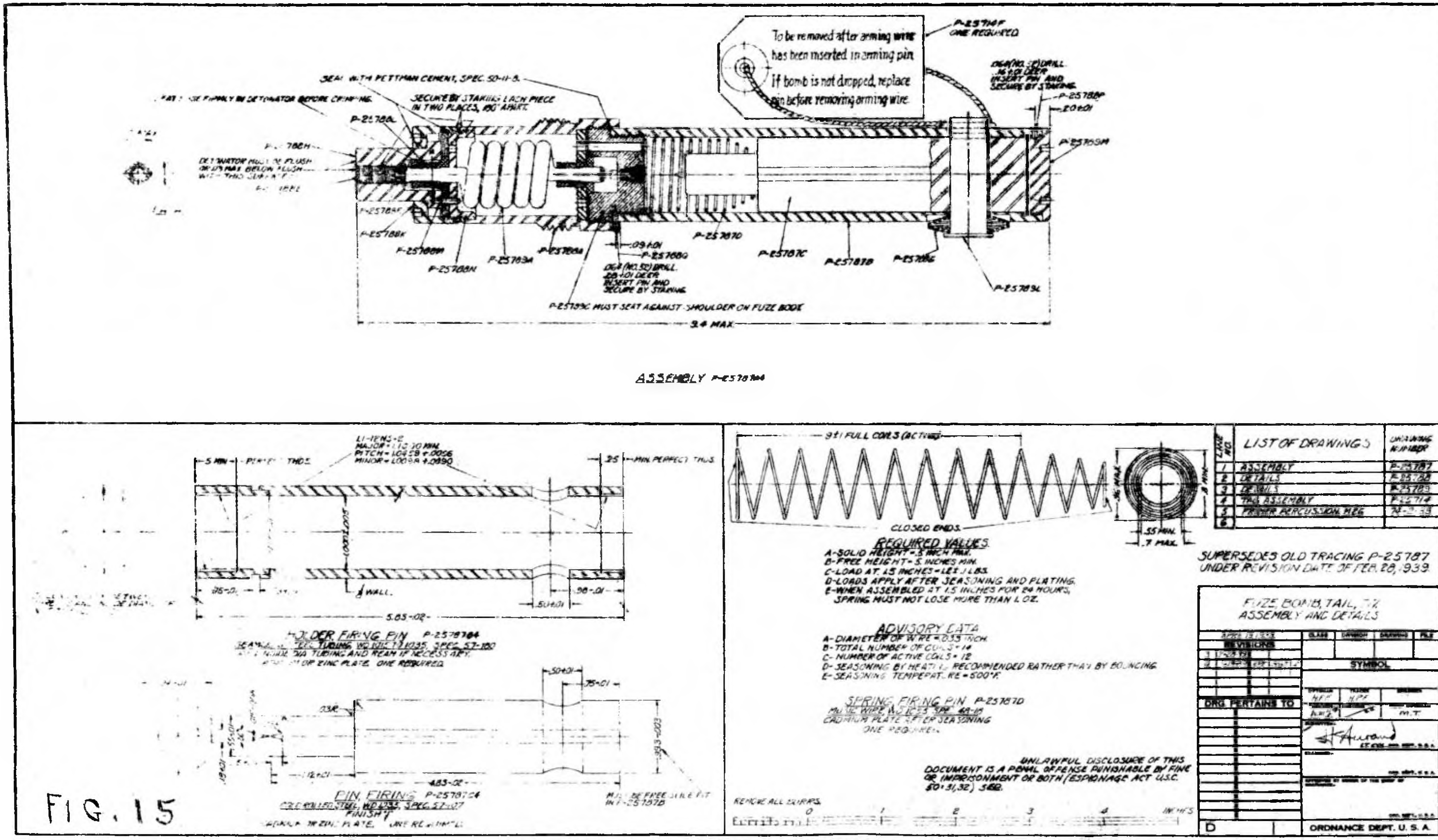


FIG. 15

X1 - 2

 SUPERSEDED BY NEW TRACING P-25787 UNDER REVISION DATE OF MAY 15, 1939 penetrates too deeply into the ground before the tail fuze functions and the powder charge bursts the body. The result is that the smoke from the powder charge, instead of being liberated as a rather large puff above the surface of the target, is obscured by the loose earth which falls into the hole after the bomb.

A more satisfactory and a cheaper practice bomb for high-altitude bombardment is the M38A2 Practice Bomb. This bomb has a very light sheet-metal body which is filled with sand up to the bottom of the cylindrical opening within the conical rear end. A large size commercial tin can containing about three pounds of black powder and equipped with a simple arming-pin-and-plunger type of fuze fits into the loading tube to provide a spotting charge. The empty bomb bodies and the spotting charge assemblies are shipped separately. The bomb bodies are filled with sand and the spotting charges are assembled to them in the field. A blank-loaded shotgun shell attached to the inner end of the fuze acts as a primer detonator. The usual arming wire is employed to retain the arming pin until the bomb is released from the airplane.

For low altitude bomb bombardment practice a miniature practice bomb, M36, is provided. This bomb consists of a one-piece die-cast body, about 8-1/2 inches in length and weighing approximately 2 pounds, with a cylindrical opening extending along its axis. In this cylindrical opening a blank-loaded 10-gage shotgun shell and a very simple percussion firing pin are placed. When the bomb is dropped, impact with the target deforms the light metal cup of the firing pin assembly and fires the charge of the shotgun shell. The smoke from the charge is projected upward through the opening in the tail and is readily visible from low altitudes, particularly in dive bombing.

FUZE, BOMB, NOSE, M103.

A general description of the features of the M103 Nose Bomb Fuze appears in the ammunition design lecture pertaining to demolition bombs. The processes for loading and assembling the various components differ but little from those given for other types of bomb and artillery fuzes. In particular, the manufacture of such parts as detonators, primers and tetryl pellets conforms to the standard practice as described in the appropriate sections. The assembly of the fuze can be better understood if reference be occasionally made to the drawing included in this section.

As with other fuzes, several operations are performed on pneumatic or Riehle presses. The delay pellet, the relay assembly, the primer, the detonator and the booster closing cap are all loaded, seated and crimped in barricaded presses, usually in buildings other than the striker assembly building.

It will be noted that some similarity exists between the vane cup assemblies of the M103 and M105 fuzes. In both a vane driven gear train containing a large eccentrically amounted gear rolling within an internal gear is used to give the large speed reduction necessary for adequate delay in arming. "Safe" dropping is made possible by the provision of 13 arming discs, short cylinders which prevent motion of the striker until the vane cup has been withdrawn sufficiently to permit their ejection. Ejection is accomplished by a flat spring into the ends of which are assembled two discs. The remaining eleven are loosely seated around the periphery of the coiled spring.

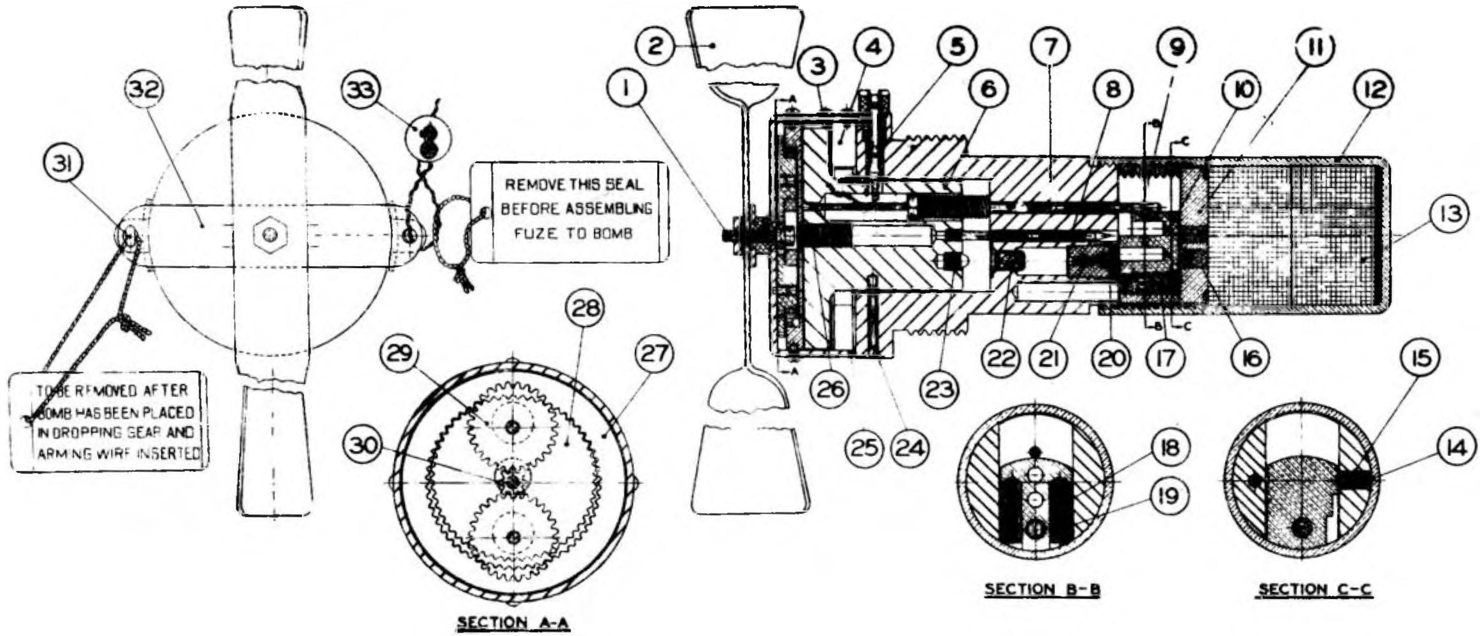
The slider is constrained to move in a channel formed in the fuze body separated from the booster cavity by a brass slider plate containing the instantaneous and delay tetryl closing cups. This slider plate, located by lugs, is retained by one screw.

ASSEMBLY OF M103 FUZE

Striker Assembly:-

The striker is visually inspected for dirt, burrs or foreign matter and presence of all holes. The instantaneous and delay firing pins are then inserted and tightened down to approximate height and then gaged for height until they are within the limits on the flush pin gage. The pins are then staked in. They are then gaged 100% for height and straightness along the axis of the striker, after which the stake marks are coated with lacquer to prevent rust.

The arming screw is soldered into the internal gear and then a hole drilled and pin inserted and staked to hold the arming screw and internal gear together. The arming screw and internal gear assembly are tested by pressing down on the internal gear assembly to try to push the arming screw out of the gear. After this checking, the arming screw is coated with light oil to make it operate freely. The internal gear is then assembled to the striker and run down against the striker face. The internal gear must move freely in the striker and must be parallel with the surface of the striker.



NOSE BOMB FUZE T3-E5

1 - VANE SHAFT
2 - VANE
3 - VANE CUP SCREW
4 - ARMING DISC
5 - SETTING PIN
6 - STRIKER
7 - BODY
8 - INSTANTANEOUS FIRING PIN
9 - ARMING STEM
10 - SLIDER
11 - SLIDER PLATE
12 - BOOSTER CASE
13 - BOOSTER CHARGE (TETRYL)
14 - SLIDER LOCK SPRING
15 - SLIDER LOCK
16 - BOOSTER LEAD (TETRYL)
17 - DETONATOR
18 - SLIDER SPRING
19 - SLIDER SPRING CUP
20 - RELAY
21 - DELAY CHARGE
22 - PRIMER
23 - DELAY FIRING PIN
24 - SHEAR PIN
25 - VANE CUP
26 - ARMING SCREW
27 - INTERNAL GEAR
28 - EXTERNAL GEAR
29 - ECCENTRIC DRIVE GEAR
30 - DRIVE GEAR
31 - COTTER PIN
32 - VANE STRAP
33 - SEAL

0 1 2 3 4 5 INCHES

FUZE, BOMB, NOSE, TYPE T3E5
ILLUSTRATION SHEET

APRIL 16, 1936. REVISIONS

DRG. PERTAINS TO

SUBMITTED: LT. COL. ORD. DEPT. U.S.A.

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PICATINNY ARSENAL U.S.A.

Vane Cup:-

The vane cups come to the assembly building with the drive gear and vane cup eyelets riveted in. The drive gear is assembled through the bearing and the vane holder assembled and a small pin inserted and staked. Then the vane lock is turned several revolutions by the operator to see that the drive gear will turn freely. The eccentric gears are then assembled and the external gear assembled and the vane lock checked by turning to see that the gears are in line and that the gears will turn freely.

Assembly of Striker Assembly and Vane Cup:-

The striker and internal gear are assembled to the vane cup assembly and the vane cup key set in place and fastened with a screw. This keeps the vane cup from turning around on the striker when the fuze is arming. The vane cup screws are then inserted and screwed tight. All the screws are then soldered to the vane cup to keep them from working out. A vane is then temporarily placed on the vane holder and the whole assembly placed inside a barricade and the vanes turned by air from a small pipe to test the arming of the arming screw. The arming screw is then run back into the striker by reversing the direction of the air currents on the vane. The air is stopped before the arming screw jambs down and the vane is run down right by hand and then backed off several rounds to keep the arming screw from binding so that it will not arm in service. A safety cotter pin with tag attached is inserted into the vane cup eyelet and vane lock. A safety wire is then inserted into the hole in the vane holder, through the vane lock and through the vane cup eyelet and sealed with Ordnance seal.

Body:-

The body is inspected to make sure that all holes are present and that the body is clean and free of foreign matter. The body lugs are then pressed in, making sure that they are in straight, since loading fixtures locate from these lugs. The setting sleeve assembly is inserted and the body drilled with a small hole down along side the setting pin assembly. A small pin is inserted and staked in place to hold the setting pin assembly. This operation must be checked to insure against distorting the setting sleeve and binding the setting pin. After the staking operation, the stake marks are coated with lacquer to prevent rust.

Primers are received at the loading plant from commercial sources and are placed in a dry house for 48 hours at 90 F. A small number are then subjected to sensitivity test. They are gaged 100% for diameter and the shoulder of the primer must seat on the gage flush.

The body is placed in a fixture and a primer is inserted into the primer cavity and the body located under the punch of the press. The primer is then pressed in at 250 lbs. dead weight. It is then gaged

100% for height and crimped 360°. After crimping the primer into the body, it is gaged for the depth of the primer cup. The top of the primer must be flush or below the surface of striker cavity, according to drawing. The sealing washer for the delay cavity is inserted into the body, care being taken that the washer is properly seated. The delay holder assembly is inserted and screwed down about two threads. A coating of N.R.C. is placed on the remaining threads and the delay holder screwed down tight with $3\frac{1}{2}$ lbs. dead weight and staked. The body is located from the striker cavity for this operation. Care must be taken that the delay holder assembly does not extend from the bottom of the body into the slider slot as this will foul the slider when the fuze is going into the armed position.

The body is placed in a fixture that locates from the body lugs and the slider plate placed on the body with the open ends of the closing cups facing outward. The slider plate screws are inserted and tightened at $1\frac{1}{2}$ lbs. dead weight.

The discharge spring is wiped with light oil and one safety disc inserted into each end of the spring. Then this spring is placed into the vane cup over the bottom face of the striker with the looped ends of the spring turned out. Then the remaining eleven (11) safety discs are inserted. Care must be taken that the striker head is kept in an upright position until assembled to the body to prevent the discs falling out.

The body assembly is placed over this while the cup assembly is held upside down. The setting pin is pulled out until the striker moves down far enough into the body for the setting pin to engage it and hold the striker and vane assemblies to the body. These units are then moved to the loading department for complete loading and assembly.

The Inspector should assure himself that the arming screw will arm, that the correct number of safety discs are present, that the setting sleeve is neither too deep or too shallow and that the setting pin is neither too long or too short. This is very important. If too long, it will extend into arming stem cavity and not allow fuze to be set on superquick. The height of delay and instantaneous firing pins should be checked and the instantaneous firing pin should be checked to insure that it is not bent or the point damaged.

The arming stem spring is placed on the large end of the arming stem and the arming stem inserted into the body cavity. Setting pin inspected to see that it does not extend in arming stem cavity on superquick setting. The shear pin is inserted into the body and staked. The arming stem must move freely in the body and not be bent. The vane cup assembly must be securely fastened to the body.

The steel sleeve is placed on a fixture which is an ordinary slider plate mounted, and two tetryl pellets are inserted, a filler disc is placed on top of the second pellet. No cracked or chipped pellets are to be used. The booster case is slid over the assembly and loaded.

The body is placed in a fixture and the slider is inserted with colored side of detonator facing slider plate, and slider spring cavities of slider facing outward. The slider lock and spring are inserted and the booster case is screwed on just enough to cover slider lock spring. This must be watched closely to see that the slider lock spring is held in place and not fouled by screwing the booster cup over it. The slider springs are inserted into the spring cavities of slider and slider spring cups assembled over the free ends of the springs. The booster case is then screwed on the body threads finger tight, care being taken that the slider springs are held in place. The fuze body is then placed into a fixture and an assembly ring placed over the booster case so as not to mar the brass casing, and the case tightened with a toggle wrench.

This series of operations must be carefully checked to insure proper functioning of the fuze in service. The slider must work freely within the slider cavity and the slider springs must not be bent or bound by the assembling operations. The slider lock pin and spring must not bend after the booster case is assembled and tightened.

The booster case is staked to the body, located in the fixture by the body lugs.

Inspection of Completed Fuze:-

The completed fuze is gaged 100% from the bottom of booster case to the first body thread, gaged 100% for concentricity of the booster case with the body, and weighed 100%. The completed fuze is visually inspected for presence of shear pins and staking, staking of booster case, and that the setting pin is set on delay, legibility of stamping, presence of tag seal, tag assembly, car seal and all other general conditions.

Packing:-

A metal support is placed over the head of the fuze (less vane) so that the lugs on the body will engage the holes in the support. A cardboard disc is placed in the bottom of the container and the fuze inserted vane cup down; one more cardboard disc is placed over booster cup to pack the fuze securely. The top of the container is assembled and sealed with a strip of adhesive tape around the joint of top of container and a three-quarter inch tab is left for easy opening of the container. This operation must be watched to see that the tape is properly applied so no paint can get into the container in the next operation.

A gummed label is applied to the outside of container which is coated with clear shellac varnish.

The fuzes are then packed 25 to a wooden box with cover end of container up. Twenty-five vanes are inserted into the box in units of five wrapped in kraft paper. A data card and enough fillers to pack the fuzes securely are inserted and the lid is then assembled and tightened down with screws. The seal recesses are coated with shellac and the ordnance seal inserted, two on top and two on bottom. The box is then inspected for stencilling date, weight, and lot number as required by specifications and drawings.

Inspection of M-103 Fuze Parts

Body:-

The face across the flange must be straight and have a good machine finish to insure the free movement of the arming discs. The flange should be of even thickness and straight on the under side for the seating of the fuze on the bomb. The body thread and booster case thread should be concentric with one another. If too much eccentricity exists between these two threads, the booster case will bind to the side of the booster cavity in the bursting charge when assembling, or the flange will not have proper seating with the bomb. The lug cavity must be drilled for a press fit and must not bulge on the face of the flange. The shear wire hole should be drilled to break into the center of the striker cavity to properly align with the hole in the striker. The location of the shear wire hole and the setting pin hole in relation to the face of the body must be held to insure that the safety discs do not foul between the body and the striker.

The setting pin assembly cavity must be straight with center of striker cavity. If this cavity is deep, the setting pin may not clear the arming stem, and not allow the fuze to go into an armed position. The striker cavity must be straight across the bottom with the specified radius to insure that the striker does not ride on the radius and prevent the firing pin from reaching the striker.

The slider slot must be in the center of the body. It must also have a good finish and square corners in the bottom. Care must be taken that the gas hole does not bulge or break into the cut of the $1\frac{1}{2}$ - 12 threads. The firing pin hole must be concentric with the striker cavity. The arming stem cavity must be parallel to and in the correct location with respect to firing pin hole.

Care must be taken with primer hole as this is a very close tolerance and primer must press into this cavity. It must also have a good finish on the inside to insure its assembly without cutting primer. Extreme care must be taken with the depth and concentricity of the crimping wall and the counter-bore of this cavity.

When drilling, the delay cavity, care must be taken that the roughing drill does not go too deep and ruin the primer cavity wall. The depth of the delay holder cavity is important, so that the delay holder can be assembled and not extend into the slider slot. It must also have a square shoulder for sealing of the delay chamber.

The slider lock spring hole must not bulge on the top surface of the body. The slider plate screw hole must be in correct location or the slider plate will interfere with the assembly of the booster case.

Striker:

The face of the striker must be straight and have a good finish. Arming screw threads must be straight with the axis of the striker and must be concentric with the outside diameter of the flange. If this thread is not straight, the internal gear will not assemble properly and will not be parallel which may cause a binding on the inside of the vane cup.

The vane cup key slot must be straight with the axis of the striker so as not to bind while the fuze is in the arming motion. The under side of the flange must have a good finish and have the specified radius. The two diameters of the arming stem cavity must be concentric with each other and have no burrs resulting from the drilling of the setting pin hole.

The superquick firing pin thread must be concentric and perpendicular to the striker. The height of the firing pins should be gaged 100% after staking. The dimension from the underside of the flange to the center of the shear wire hole and the setting pin hole must be as specified on the drawing to insure the free movement of the safety discs. With the outside diameter of the striker, it is important that there be no taper, and it is suggested that this diameter be held toward the min. dimension. The outside diameter of the flange must be held as this is close to the inside diameter of the vane cup and it must not bind.

Slider:

The slider must have a good finish on all surfaces with all sides square with the top and the bottom. The slider spring cavities must not bulge the side walls. The firing pin hole, arming stem hole and detonator cavity must have good finishes on the side walls and flat bottoms.

The flash hole should be concentric with the detonator cavity. Check for bulge on bottom of slider caused by the reaming of the detonator cavity.

Arming Discs:

Surfaces must be flat, parallel and have a good finish. The discs must be of the correct thickness, and the edges rounded off. There must be no cut-off nib. If these arming discs do not fly out, the fuze cannot go into an armed position.

Discharge Spring:

Little trouble can be expected from this part, but be sure that the spring is of the proper length and that the loops are well formed and will hold the arming discs properly.

Delay Firing Pin:

The contour of this pin is important in that it must not puncture the top of the primer. There cannot be any burr on the rounded side of the firing pin.

Arming Vane:

Care must be taken that the vane blades are bent in the proper direction and angle. Check for cracks that may occur on the forming of these blades. Strengthening ribs and stamping must be on the front side of the vane.

Vane Cup Assembly:

The eccentric gear pins must be held firm and must be square with the bottom of the vane cup. These pins must also be in perfect alignment with the center of the vane cup and at equal distances from the center, as specified on the drawing.

The inside diameter of the vane bearing must be concentric with the inside of the cup and flush or slightly below the inside surface of the cup. The rivets holding the bearing on the cup must be flush or slightly below the inside surface.

The vane cup screw holes shall be parallel with the bottom of the cup, held to the dimensions on the inside of the cup and square and perpendicular to the axis of the cup.

Be sure that the hole in the eyelet lines up with the hole in the vane strap so that the arming wire can pull free without binding.

Arming Vane Assembly:

Be sure that the vane cap is riveted on the same side as the rib. Check to see that the vane assembly will snap onto the vane holder; that the pin that rivets the vane assembly together extends far enough to lock the vane to the vane holder; and that the pins line up with the holes in the vane strap assembly.

Vane Holder:

Lock pin hole must break into the center of the drive gear cavity and be of the specified height. If this height is not maintained the holder will bear on the vane bearing and prevent the vane from working free. The bottom surface must be straight to prevent its twisting out of shape when riveted to the strap. Outside diameters must be held for the proper assembly of the vane. The diameter at the bottom of the groove must be over the max. dimension for the locking of the vane.

Vane Cap:

The inside diameter is important in that it receives the vane holder sleeve and ring. The hole in the top of the cap must have a concentric inside diameter, so that when the vane holder sleeve and ring are assembled, they will align and receive the vane holder. The cap should be straight across the bottom to rivet on the vane and not be distorted.

Vane Holder Sleeve:-

The inside diameter must be concentric with the outside diameter. The overall length, if long, will bind the vane holder.

Vane Cup:-

The vane bearing hole must be concentric with the inside diameter of the cup. The dimension from the bottom of the cup to center of the screws must be held, and must be parallel so that the internal gear will not bind when the fuze is arming. Due to the close allowances between the internal gear and the inside of the cup, the contour of the inside of the cup is very important.

Vane Strap Eyelet:-

Be sure that the contour of this piece is smooth and the holes are in correct location, as specified on the print.

Drive Gear Bearing:-

The length and diameter of the boss that extends into the cup is very important. If the length is long, it will bind the gears; the diameter locates the bearing in the vane cup. All surfaces should be square with a minimum amount of curvature.

Drive Gear:-

The height of the small hole should be correct from the gear teeth. This is necessary since this determines the amount of end play in the gear. The diameter of the shaft is important in that this acts as a bearing. The P. D. and contour must be correct to avoid binding of the gears.

Eccentric Gears:-

Be sure that the P. D. and tooth contour are correct. The amount of eccentricity and the diameter of the eccentric boss are important.

External Gear:-

The P. D. and the tooth contour must be correct. The diameter of the center hole is important in that it is usually used to locate the piece for cutting the teeth. The two holes that assemble to the eccentric gears must be in their correct location and be the right size.

Internal Gear:-

The dimension of teeth are important. The tolerance for the outside diameter of the gear is only 0.0015 inches and must be held or trouble may be encountered in the arming test. The surface should be flat with no ridges. The outside and inside diameters and the arming screw hole must be concentric.

When the arming screw is assembled to this gear, it must be straight and square with no excess solder. Check to see if the web of the gear has warped after the arming screw has been soldered to the gear.

M-106 Fuze, Bomb, Tail

The loading and assembly of the M-106 Tail Bomb Fuze is essentially concerned with a simple plunger type in which a miner's fuze is used as a delay element. It does, however, present some points of difficulty for which adequate precautions must be taken to secure effective operation of the fuze as a whole. The loading of the detonator, primer, and primer holder is covered in the section on primers.

For purposes of loading and assembly, the M-106 fuze may be grouped into three sub-assemblies: the Body, containing the Ensign Bickford safety fuze for the delay; the Firing Pin Assembly, and the Detonator Holder Assembly.

Body:-

The Bickford fuze in the body assembly requires rather elaborate handling before it is ready for use. Long pieces are cut from the spool approximately the required length plus a small amount to be removed later. To facilitate cutting, the fuze is passed through powdered talc giving a sharp, clean face on the fuze ends. The talc prevents the asphalt from adhering to the knife. The fuze is then inserted in the upper fuze collar on which the fuze retainer has been placed. This assembly is made permanent by squeezing the collar on its smaller diameter in an air operated press. The squeezing serves two purposes: to keep the collar tight on the fuze and to hold the fuze retainer on the collar during assembly, by means of the ridges this process raises along the surface of the collar. After this operation the fuze assembly is taken to an air-conditioned room where the collared end of the fuze is daubed with a priming composition. After being allowed to dry for at least 2 hours and preferably overnight, the fuze assembly is coiled around a steel mandrel and after removal is inserted in the fuze body. Care must be taken to so shape the ends that they protrude from the axis of the body. Previous to inserting the coil, the body closing plug, its threads coated with Pettman cement, is screwed into the body and tightened using the wrench holes in connection with a special turning fixture. The coiled fuse is inserted in the body and the free end left to protrude a specified distance from the body through a hole in body closing plug.

To facilitate handling from this point on, an empty primer holder with its smaller diameter threads removed, is threaded into the open end of the body. This temporarily holds in the fuse coil enabling the operators to work on the free fuse end. Due to the fact that repeated handling such as the the fuse has received up to this point, tends to fray the cloth casing and break out pieces of the powder center of the free end, a small predetermined length is cut off from the overall. The cutting is done by pushing the free fuse end of the body, assembly through a hole in a steel plate and bringing a steel knife edge down along the plate face, leaving a clean surface on the end of the fuse. The lower fuse collar is put on this free end and the fresh surface of the fuse is pushed into the open end of the lower detonator charge. This assembly is put in a fixture under a pneumatic power press and squeezed just as the other end was to retain the collar from slipping off. The fixture used for this operation, in addition to serving this function, also by means of stops, gages the length of the assembly from shoulder on the collar to the closed end of the detonator cup. This operation finishes the work on the body assembly.

Firing Pin Holder:-

The firing pin holder is inspected for tool marks and rust in cadium plating and then put into a fixture and the firing pin inserted lining the arming pin hole in the firing pin with the arming pin hole in the firing pin holder. The arming pin and spring are inserted from the bottom and the foot pedal pressed down to compress the arming pin spring and push it up to the other side of the firing pin holder. The safety cotter pin and tag with instructions is then inserted into the outer hole of the arming pin and the pressure released. This assembly is inspected to see that the arming pin will move freely through the firing pin and the firing pin holder and not bind. The top of the firing pin is inspected to see that it does not extend high enough for the firing pin holder plug to screw down on it in assembly and bind the arming pin. The point of the firing pin is inspected 100% for bent firing pin points and for presence of flat.

The plugs are stamped, showing date, loading plant initials and the lot number. This stamping must not distort the shape of the plug or the threads so that it won't assemble into the complete fuze. The firing pin holder is set into a fixture and the plug started by hand then tightened by a wrench to a slippage of the belt on the drill press. The assembly is then located in a fixture from the wrench holes in the plug and a hole drilled for a small pin through the firing pin holder into the plug. The plug locking pin is then inserted and staked.

The firing pin spring is assembled into the firing pin holder, small end first. The spring is compressed by screwing the primer holder assembly into the firing pin holder finger tight. The primer holder assembly operations are done in another building.

Detonator Holder:-

The detonator holder assembly consists of a detonator holder fitting down on the detonator cup, and retained, collar fashion, by the body cap which threads down on the end of the body assembly. The detonator holder has a small pin projecting from the side fitting against the body assembly end. This pin enters one of the wrench holes drilled in the body closing plug, preventing the detonator end of the fuze from being twisted and damaged when the body cap is turned to tighten it.

Assembly:-

The body with the detonator holder assembly loosely threaded on it is picked up by an operator, the dummy primer holder removed, and the remaining body assembly threaded into the firing pin holder. The next operator puts the whole assembly in a vise that holds the firing pin holder tightly and using the wrench holes in the end of the body cap, the entire assembly is tightened until the turning fixture lifts a weight off its support. To secure this assembly and to prevent the threads from backing off at the bottom edge of the body where it fits around the firing pin holder a small hole is drilled and a pin inserted and later staked to secure it in its place. To secure the body cap to the body, it is crimped at its lower edge. Both the pin staking and the crimping of the body cap are done in a barricaded air operated press to protect the operator from possible explosion of the primer and the detonator.

Inspection:-

The completed fuze is then gaged 10% for outside threads and 100% for overall length. The detonator holder is gaged for depth below shoulder 100%. The angle of the spread on the cotter pin is inspected and the crimping and staking inspected. The stamping is also inspected for correct date and lot number.

Packing:-

The fuzes are inserted into the containers with the bottom end first after the bottom support has been set in place over the detonator holder. The top support is then inserted over the fuze in the container so that the clips hold the fuze firmly. The container covers are then placed on the containers and sealed with a piece of adhesive tape which is wound so as to leave a tab on the end for opening the container. The whole conainer is then sprayed with black acid-proof paint and dried four minutes at 165° F. The label is then applied to the container and coated with clear shellac. Fifty of the fuzes in containers are packed in wooden boxes with a data card and the boxes closed with screws and the necessary data stencilled on the outside of the box.

Fuze, Bomb, Nose, M 110

The M 110 Fuze is used on small fragmentation bombs.

The fuze is armed by a vane which is wired in the unarmed position by a car seal wire passing through the arming wire guide and the vane lock. When the bomb is loaded in the racks, an arming wire is attached, after which the seal wire is removed. This arming wire is fastened to the bomb rack and pulls out of the vane when the bomb is dropped, leaving the fuze free to arm on the rotation of the vane as the bomb falls. The vane is attached to and turns with the outer ball race. The arming hub turns with the outer ball race and turning with it is a 56 tooth stationary gear. This gear turns a pinion which engages a movable 57 tooth gear, which is attached to the arming sleeve. The outside of this arming sleeve has a left hand thread. Therefore, every time the vane makes one complete revolution, the sleeve makes a 56th of a 57th turn. It will therefore be seen that it takes 57 complete revolutions of the vane to back the arming sleeve one complete thread (or turn) out of the hub. The two gears separate and the sleeve is drawn down in the body cavity toward the end plate. This draws the sleeve out of the safety block slots and leaves the blocks free to fly out. The fuze is then armed, as firing pin with striker is held away from the detonator by only the firing pin spring. This fuze will probably take the place of the old M 104.

Inspection Points on the M 111 Combination Bomb Fuze

The M 111 is a combination time and superquick fuze designed for use on flares. This fuze and the M 110 are the same except for the presence of the mechanical timing element in the M 111 hence the points that must be watched in the inspection of the M 111 must necessarily include all the inspection points in the M 110.

Striker:-

The surface on the under side of striker should be straight and of good finish to insure the free movement of the safety blocks. The radius adjacent to the smaller diameter must be as specified to prevent binding of the corner of the safety blocks. The firing pin hole must be concentric and straight.

Firing Pin:-

The surface must have a good finish with no taper. The point must be concentric with the body of the pin. The flat surface of the point end of pin must be held and be free of burrs. The dimension from center of shear wire hole to end of pin must also be held.

Safety Blocks:-

The top and bottom surfaces must be straight and parallel and with a good finish. The width of the groove should be checked closely for tightness in the bottom as this would cause binding on the arming sleeve. This groove must be free of burrs. The thickness of the blocks and the depth of the groove are important.

Nut:-

Care must be taken that the step on the bottom surface be the proper height and parallel with the top surface of the nut.

Upper Ball Race:-

The inside threads must be concentric with the axis of the race which must be of FF finish. The depth, diameter, and concentricity of the counter-bore must be held to prevent the race from binding. This surface must be of good finish. The shoulder on the top must be parallel and of the right height. The height and location of the pins are important for the assembly of the vane and vane lock.

Lower Ball Race:-

The locations of the dowel holes, screw holes, and recess for the drive gear must be inspected very carefully. The inside and top outside diameters must be concentric. The depth of this inside diameter must be held so that it will not be too deep. This piece, like all fuze parts, must be free of burrs.

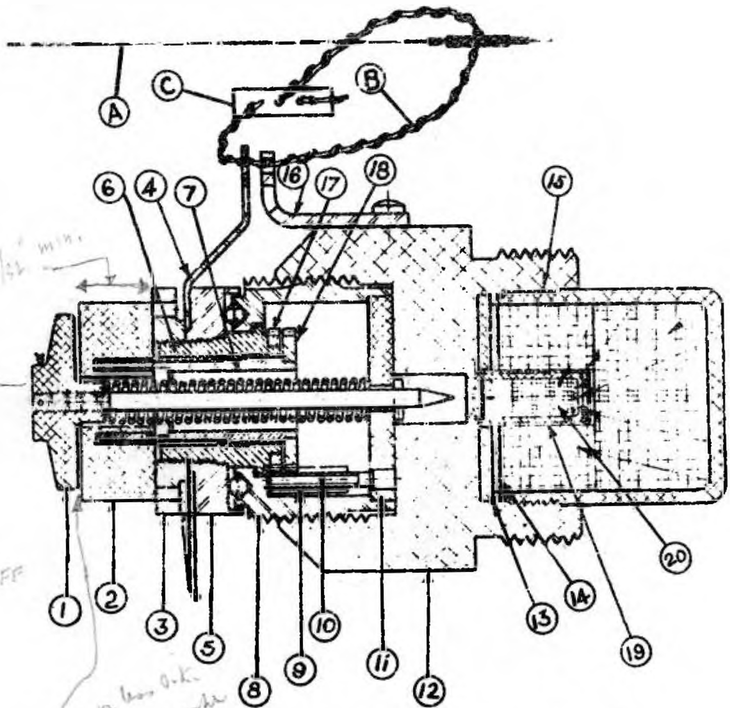
Arming Hub:-

The inside threads must be perpendicular to the axis of the hub and concentric with the outside threads. A close inspection of the length dimensions of the outside flange and shoulders must be made as the proper arming of the fuze greatly depends upon their accuracy. The outside diameters must be concentric with inside threads. Special care must be taken with the smallest outside diameter.

Arming Sleeve:-

The threads must be concentric and perpendicular to the axis of the sleeve and be free of any rough spots. The outside diameter for the gear seat must be held. Burrs on this diameter may distort the gear or prevent it from seating square with the axis of the sleeve.

The counter-bore in the end of the sleeve must be concentric and straight. The depth of the safety block cavity must be held. Burrs in this cavity or walls of uneven thickness may bind the safety discs.



1 7/32" min.

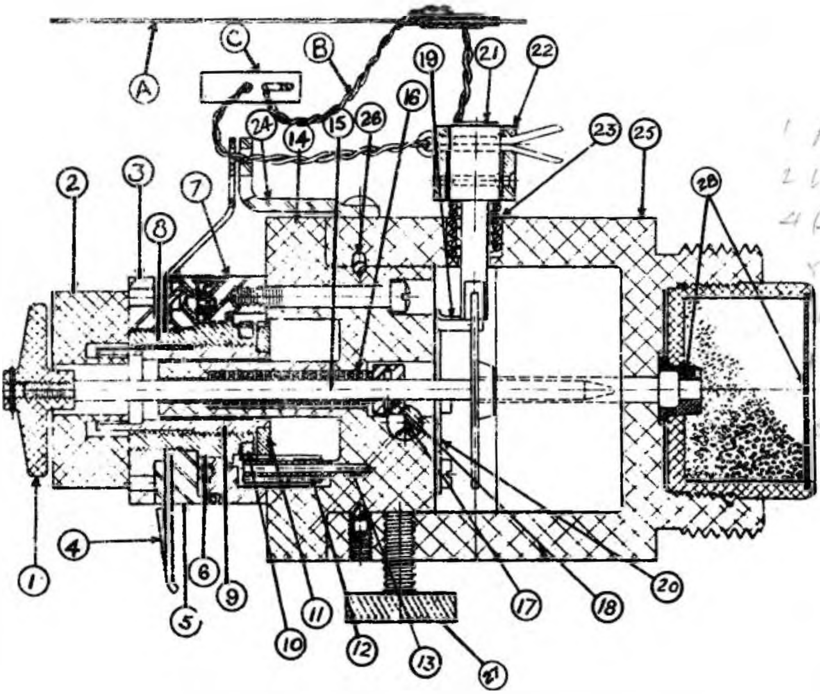
Test washer 40 lb. pull

8/3
1. STRIKER OFF
2. SAFETY BLKS OFF
3. PINION NOT ENGAGED

2 .050 or less O.K.
3 7.050 w/ washer .031" washer

M-110 NOZE BOMB FUZE 8/3/42

1 STRIKER	11 END PLATE
2. SAFETY BLOCKS	12 BODY
3. NUT	13 DETONATOR PLATE
4 VANE LOCK	14 FELT DISC
5 OUTTER BALL RACE	15 BOOSTER CUP
6 ARMING HUB	16 ARMING WIRE GUIDE
7 ARMING SLEEVE	17 STATIONARY GEAR
8 INNER BALL RACE	18 MOVABLE GEAR
9 PINION	19 DETONATOR HOLDER
10 PINION PIN	20 DETONATOR
A. SEAL TAG SIDE VIEW	C. CAR SEAL
B. SEALING WIRE	NOTE ARMING VANE SNAPS ONTO VANE LOCK



1 Regan
2 Warden
4 Hosking
Walters
Kluber
7 Rotge
8 Hottinger
8 Mountford

M-111 TIME AND SUPERQUICK FLARE FUZE

1. STRIKER
2. SAFETY BLOCK
3. NUT
4. VANE LOCK
5. UPPER BALL RACE
6. BALL (STEEL)
7. LOWER BALL RACE
8. ARMING HUB
9. ARMING SLEEVE
10. ARMING HUB GEAR (STATIONARY)
11. MOVABLE GEAR
12. PINION GEAR
13. PINION PIN
14. HEAD
15. FIRING PIN
16. FIRING PIN SPRING
17. COCKING PIN
18. FIRING PIN RING
19. TIMING DISC LEVER
20. FIRING LEVER
21. ARMING PIN
22. ARMING PIN BRACKET
23. ARMING PIN SPRING
24. ARMING WIRE GUIDE
25. BODY
26. RING COUPLING
27. LOCK SCREW
28. BOOSTER AND PRIMER

Head:-

The surface where the outer ball race is assembled on the head must be straight and thickness of the flange uniform. The dowel holes and screw holes must be aligned with the holes in the ball race. The drive gear cavity must align with gear cavity of ball race.

The small diameter stem that locates the arming sleeve must have a good finish, no taper and no shoulders, The concentricity between this diameter and the recess, and the center distance between the head and the drive gear cavity must be held to insure the proper meshing of the gears.

The gear and spindle cavity must be inspected very closely. Check for any shoulder or radius close to bottom of the large gear cavity. The firing pin hole must be perpendicular to the axis of the body and concentric with the stem diameter. The graduations must be readable and in proper relation with the set line.

The dimension from the flange to the locking wire groove must be held. The depth, radius, and angle of this groove are important. The outside diameter under flange is also important. When the cocking pin rolls into the armed position, it must clear the firing pin ring cavity. This cavity must be parallel with center line of the head and of the proper depth.

The cocking pin screw slot must be perpendicular to the pin cavity. The depth and width of this slot are important.

The concentricity and depth of the firing pin ring cavit are likewise important.

Particular care must be taken with the location and the threads in the firing lever and arming lever screw cavities. The depth and concentricity of the counter-bored screw holes must be such that the screw will draw the lower ball race tight to the head and not bind.

The bottom surface should be straight so that the firing lever and arming lever can function without binding.

The location and tightness of the stop pins must be checked closely.

Body:-

For the proper seating of the head in the body and for free movement for the setting of the time element, the following points of inspection must be made: top surface straight and with the specified radius; dimension from top of body to center of lock wire groove correct.

The bottom inside surface must be straight to insure no binding or twisting of the timing device when it is assembled in this cavity. The drive screw holes for the arming wire guide must be parallel with the top of the body.

The pins must not bulge on the inside of body when the guide is assembled to the body. Care must be taken with the location of the arming pin hole.

The dimension from the center of the body to the bottom of the arming pin cavity and the concentricity of both diameters are also important.

The firing pin hole must be concentric with the inside diameter of the booster and timing element cavities.

The screw holes for holding the time element must be in the proper relation to the arming pin hole. The counter-bore of these holes must be of the proper depth so that the heads of screws will be below the booster cavity surface. The bottom of the booster cavity must be straight and the primer recess concentric.

Booster Cup:-

The bottom must be straight inside and outside. The depth of the counter-bore and the length of the threads must be as specified for assembly. Care must be taken that the cup is not distorted while being worked on.

Primer Holder:-

The angle and outside diameters are important as this is a press fit in the booster cup. The inside diameter of the primer cavity must be held and must have a good finish. The primer cavity must be concentric with the outside diameter and the flange must be of even thickness to insure proper seating in the booster cup.

Vane Lock, Arming Wire Guide:-

Check for the location of the holes and see that the metal is not cracked from the forming operations. The arming wire hole in the guide and the vane lock must align when fuze is assembled.

Arming Pin Bracket:-

The holes for holding the bracket must match the holes in the body.

Arming Pin:-

The flat surface must be on the center of the body of the pin and at right angles with the arming wire hole.

The length of the pin must be held and diameters must not be tapered. This pin must be free of burrs to prevent binding in the timing element.

Vane:-

Check vane for cracked metal resulting from forming operations. The blades must be bent in the right direction.

Ring Coupling:-

This ring must be a true circle and have well rounded ends. The outside diameter and the diameter of the wire is important so that the ring will readily snap into the body groove.

Pinion Pin:-

This pin must be straight and free of burrs. Since the pin is a press fit, care must be taken that it is not kinked when inserting into the head.

Cocking Pin:-

This pin must be straight and free of burrs. A close inspection of the dimensions of this pin must be made. When the screw is assembled into the cocking pin it must be perpendicular to the firing pin slot.

The depth of the firing pin slot and the above inspection points are very important since, on arming, cocking pin must roll without binding and clear the firing pin hole.