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RESTRICTED

ORDNANCE PAMPHLET NO. 4

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AMMUNITION

INSTRUCTIONS FOR THE NAVAL SERVICE

DEPARTMENT OF THE NAVY BUREAU OF ORDNANCE

MAY 1943

RESTRICTED

ORDNANCE PAMPHLET NO. 4

AMMUNITION

INSTRUCTIONS FOR THE NAVAL SERVICE

This publication is RESTRICTED and will be handled in accordance with Article 76, United States Navy Regulations, 1920

MAY 1943

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INSTRUCTIONS GOVERNING THE CARE, PRESERVATION, STOWAGE, INSPECTION AND TEST OF AMMUNITION FOR THE NAVAL SERVICE

1. This revision which supersedes Ordnance Pamphlet No. 4, of September, 1923, is published in accordance with article 74, Navy Regulations, 1920, and covers instructions governing the care, preservation, stowage, inspection, and test of service explosives, and general information about ammunition. No attempt has been made to go deeply into the general subject of ammunition materials, as the subject is too broad for general consumption. Personnel seeking more detailed information should utilize standard works on explosives, consulting the list compiled under the direction of the National Research Council.

2. There are certain repetitions herein of matter contained in the Bureau of Ordnance Manual, but in most cases this pamphlet covers the subjects in greater detail than is appropriate for the Bureau Manual.

3. This publication should be given a free circulation under its restricted status to the end that all concerned with ammunition may have adequate information pertaining thereto.

4. In this revision the chapters on Pyrotechnics, Interior Ballistics, Erosion, and Dispersion have been omitted The first is thoroughly covered in Ordnance Pamphlet No. 725 of August 1937, and the remainder appear better suited to pamphlets on gun design or ballistics than to an ammunition manual.

5. The revision of Ordnance Pamphlet No. 5 which will follow this revision will constitute Part II of the Naval Ammunition Manual, and will contain matter pertaining only to ammunition depots, naval magazines, etc.

6. The inclusion in this pamphlet of matter pertaining to ordnance material which is obsolete or obsolescent so far as the Fleet is concerned, is dictated by the necessity for providing adequate information as to material issued in time of war to converted merchantmen, patrol craft, auxiliaries, and the like.

7. Shipments of explosives by freight or express must be packed and marked in accordance with the Interstate Commerce Commission Regulations for the Safe Transportation of Explosives, copies of which are on file at the various navy yards and stations, including naval ammunition depots. When it becomes necessary for a vessel to ship ammunition by freight or express, it is preferable to turn it in to an ammunition depot for proper packing, loading, and placarding, if such turning in is practicable, otherwise to the supply officer of a navy yard or station. Shipment of explosives by mail is positively FORBIDDEN.

AMMUNITION

NAVAL AMMUNITION MANUAL

Part I—1943

Chapter I. GENERAL INSTRUCTIONS

1–1. The instructions contained in this Ordnance Pamphlet, promulgated primarily for the service afloat, shall be followed at all naval ammunition depots, naval magazines, naval torpedo stations, naval ordnance plants, naval mine depots, and other naval stations on shore, insofar as they are applicable. **Instructions for ashore and afloat.**

1–2. The methods of caring for and handling ordnance material as set forth in— **Instructions for ordnance material.**

(*a*) United States Navy Regulations.
(*b*) Ordnance pamphlets.
(*c*) Ordnance manuals.

shall be closely followed.

1–3. Detailed instructions relative to any particular class of ordnance will be found in the following publications: **Detailed instructions.**

(*a*) Navy Regulations.
(*b*) Ordnance Pamphlets (OP's), Ordnance Data (OD's), and Ordnance Drawings.
(*c*) Ordnance Manuals.
(*d*) Gunnery Instructions.
(*e*) Ship and Gun Drills.
(*f*) Landing Force Manual.
(*g*) Navy Department General Orders.
(*h*) Ordnance circular letters.
(*i*) War Department circulars or technical regulations issued through the Bureau of Ordnance.

When in doubt as to the meaning of any regulation or instruction concerning ordnance, an interpretation should be requested from the Bureau of Ordnance.

1–4. Commanding officers shall have on file a complete and up-to-date set of ordnance publications covering all ordnance material and ammuntion on **File of ordnance publications.**

board the vessels under their command. Ordnance pamphlets may be obtained from the Bureau of Ordnance upon request, ascertaining the pamphlet number from the index published as Pamphlet No. 0.

Handling of explosives.

1–5. The exercise of the utmost care and prudence in handling, inspecting, testing, preparing, assembling, and transporting all kinds of ammunition and ammunition details is enjoined upon all officers and other persons whose duties require cognizance over or actual handling of explosives during any of the above operations. Subordinates are liable to become careless and indifferent when continually engaged in work with explosives and, as long as nothing occurs, are inclined to drift gradually into a neglect of necessary precautions. Nothing but constant vigilance on the part of officers and others in charge will insure the constant observance by subordinates of the rules and regulations which experience has taught to be necessary. Safety precautions, rules and regulations for handling explosives should be made the subject for frequent instruction, and the necessity for strict compliance therewith should be so firmly fixed on new men that they will invariably and subconsciously do the proper thing thereafter. Attention should be especially invited to the fact that in the earlier stages of the use of explosives the experience gained has been at a costly price. No relaxation of any regulation should be tolerated, as this tends to induce an idea that the rules are arbitrary.

Use of signs.

1–6. The use of placards and signs containing admonitory notices, serving as a constant reminder of the safety precautions, is sometimes condemned as having the effect of creating a fear of explosives, especially in new men. The use of signs is probably not so vitally required aboard ship as in shore plants, but their obvious advantages should not be overlooked.

Handling of ammunition.

1–7. Handling of ammunition shall be reduced to the minimum in order to prevent the occurrence of leaky containers, damaged tanks and cartridge cases, loosened projectiles, torn powder bags, etc., and in order to reduce the chances of accidents. The number of men allowed in the vicinity of explosives should, as far as practicable, depending on the requirements of the operation, be reduced to the minimum for properly performing the work in hand. It frequently happens that unnecessarily large working parties are assembled for handling live ammunition. Every effort and known precaution is taken to make ammunition safe in handling under all conditions, but this should not presuppose that an accident may not happen, and, therefore, unnecessarily subjecting the personnel to the effects of such is unwarranted.

Damage to containers.

1–8. Of equal importance to be considered in the handling of ammunition is the question of damage to containers. A study of smokeless powder shows how exposing it to the air affects its stability in a very injurious manner. Powder tanks are so constructed that they will remain airtight as long as the gaskets hold; hence, if care is observed in handling not to dent the body so as to open the seams, or to loosen the top or bottom rings or covers, and on periodic inspections to note that the gaskets are holding up, one may be assured that the powder is properly protected from the atmosphere. In handling powder tanks, dents are frequently caused by the use of cargo nets, by rolling the tanks along decks and over obstructions, by allowing the bodies or rings to strike projections when hoisting or lowering, or by dropping them. When powder tanks are opened for inspection, the gaskets and general airtight condition of the tank shall be observed. It is impossible to give a standard method of handling tanks, but, in general, they shall be hoisted and lowered with care, carried along decks by hand, or transported by truck.

Danger in damaged containers.

1–9. A vessel turned in her service allowance of ammunition to a depot for overhaul. While it was aboard the ship, the reports of surveillance tests ashore gave 50 days and on board ship about 60 days, showing that apparently the powder was entirely satisfactory for continued use afloat for a number of years. During the overhaul, a number of leaky tanks were discovered and the tests on powder taken from them gave less than 6 days surveillance test. The real danger to the safety of this ship and crew is apparent, but may be more fully realized when it is considered that the action of a deteriorating powder is progressive—that is, the presence of nitrous oxide fumes react to cause more molecules to break down. Carelessness on the part of the personnel resulted in the unsatisfactory condition of these tanks. Many instances are on file in the Bureau of Ordnance where sister ships have turned in their service allowances for overhaul, one requiring practically no repairs and the other requiring most extensive repairs and replacement of material. The investigation into the poor condition of one ship's outfit disclosed the fact that the powder tanks had been transferred from ship to lighter by dumping them down a chute. The only explanation for such utter disregard of existing instructions can be found in the failure of the personnel to appreciate the significance of their carelessness.

Damage to charges.

1–10. Aside from the danger of leaky powder tanks, there are other serious conditions which arise. The silk powder bag cloth is attacked by the nitrous oxide fumes. This would soon impair the serviceability of the charges for loading. The rotting bag would burst, scattering powder grains with the resulting danger and delay. Powder in leaky containers will not only give different ballistic results from those determined on proof, but will give erratic results, to the serious inconvenience of fire control. The seriousness of permitting ammunition to deteriorate so that it would not only be ineffective but dangerous and erratic in battle should be obvious to every person who participates in the teamwork which produces the correct answer in battle; namely, "hits per gun per minute." Smokeless powder in leaky containers shall be landed for replacement at the earliest practicable moment after discovery, unless a surveillance test shows it to be in normal condition, and the container can be repaired.

Handling projectiles.

1–11. The greatest care shall be exercised in handling loaded and fuzed projectiles. A projectile which has been dropped from a height exceeding 5 feet

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shall be set aside and turned in to an ammunition depot. Such a projectile shall be clearly marked to show its condition and shall be handled with the greatest care. Upon receipt at a naval ammunition depot it shall be unfuzed and the fuze scrapped. Fuzes are designed and manufactured so that a fuzed projectile may be dropped without causing the fuze to function, but additional drops or the shock of firing may cause a fuze action. Rotating bands on projectiles for separate or semifixed ammunition have nonfringing lips which are easily damaged. Particular care is required to prevent such band damage.

Empty containers.

1–12. Empty cartridge cases, tanks, boxes, and powder tanks shall be handled and stowed with care and shall be turned in to a naval ammunition depot at the earliest opportunity. To prevent deformation, cartridge cases which are still hot from firing should not be laid on their sides or roughly handled. Before restowing empty cartridge cases below they shall be freed from inflammable gases. Since these gases are lighter than air the clearing can best be accomplished by standing the empty cases on their bases in the open air for 10 minutes. Washing cases aboard ship is neither necessary nor desirable.

Powder charges.

1–13. Navy smokeless powder is manufactured to contain in the finished grain a definite percentage of "residual volatiles," which is as low as practical considerations will permit. Under normal conditions of storage the volatiles will not be reduced appreciably. Powder is packed at the factory, and charges and cartridges are made up at the naval ammunitions depots, as far as practicable, under normal atmospheric conditions to obtain a standard percentage of surface moisture. The charges in cartridges are effectually sealed by the cork mouth plug or by the projectile, and both cartridges and bag charges are issued in airtight tanks. The weights of charge having been established by the proof firing of the indexes under standard conditions of temperatures, etc., it is most important, for ballistic reasons, that powders undergo no change in service. To insure this freedom from change, personnel charged with the care of powder shall see that the airtightness of the containers is maintained. Powder exposed to the atmosphere will lose a portion of its residual volatiles, and on board ship will gain or lose surface moisture. While these changes may be counteractive, it is highly unlikely that they will exactly balance, and the importance of keeping powder containers airtight should, therefore, be rated as on a par with the upkeep of the director systems.

Temperature of charges.

1–14. The proof of powder is conducted under normal conditions as to volatiles and moisture, with the powder at a temperature of 90° F. Variations in storage temperatures do not affect the regularity of the powder, nor does loss of stability of itself affect ballistics unless it has gone so far as to preclude retaining the powder aboard ship.

Exposure to sun.

1–15. When smokeless powder is removed from magazines at naval ammunition depots or on board ship for any purpose, it shall not be exposed to the direct rays of the sun or subjected to other abnormal conditions of temperature.

This prohibition applies equally to powder in bulk, in tanks, cartridge cases, ammunition boxes, or other containers. Whenever it may be necessary to transport smokeless powder ammunition in boats, or to take it on shore, as for boat-gun or field-gun target practice, it must be effectively shaded from the rays of the sun.

1–16. Whenever, in particular cases, the terms of the previous paragraph have not been complied with, any ammunition which may have been exposed shall be segregated, and shall, for purposes of tests, inspections, and reports, be regarded as a separate index; and, if on board ship, it shall be landed at a naval ammunition depot at the first opportunity, should there be reason to believe it has deteriorated. **Procedure when exposed to sun.**

1–17. If at any time smokeless powder be exposed to a temperature higher than 100° F., a special report shall be made to the Bureau of Ordnance immediately, explaining the circumstances in detail and stating the temperature and the length of time the powder was so exposed. **Exposure to high temperatures.**

1–18. Smokeless powder that has been wet from any cause whatever must be regarded as dangerous for storage on board ship. Such powder must be completely immersed in distilled water (in which condition it is entirely safe), and must be turned in without delay to a naval ammunition depot. Each container of immersed powder must be clearly marked to indicate its gross weight and the condition of such powder. In handling powder charges which have been wet, the smokeless powder shall be removed from the powder bags or cartridge cases, the smokeless powder then being cleaned by washing in water to remove any black powder residue, before finally packing in water. The powder bags and ignition charges shall be thrown overboard. The condition to be avoided is shipping smokeless powder and black powder in a wet condition in the same container. **Wet powder.**

1–19. Where safety devices are provided for any form of ammunition, they shall always be used in order to preclude any possibility of accidental discharge. **Safety devices.**

1–20. Service ammunition is supplied to ships for use in battle only. It is not to be used for drill at the guns, instruction of the personnel that requires opening of charges or projectiles, for testing hoists or conveyors, or for similar purposes, except upon express authority from the Navy Department. It shall be regarded as part of a vessel's outfit, shall be kept distinct from the ammunition issued for gunnery exercises, and shall never be expended in gunnery exercises without the authorization of the orders for gunnery exercises or special instructions from the Bureau of Ordnance. Target practice ammunition may be stowed in the same magazine with service ammunition, but steps shall be taken to prevent the use of the latter in target practice. **Service ammunition.**

1–21. The inspector of ordnance in charge of the ammunition depot nearest the navy yard in which a ship is undergoing overhaul should be consulted and requested to have the service allowance of ammunition inspected to determine the requirements for overhaul and replacement, and to provide the **Inspection of service ammunition.**

data for a report on the condition to the Bureau of Ordnance, when requesting authority to turn it in for temporary stowage.

Periodic overhaul of service ammunition.

1–22. All service ammunition on board ship shall be overhauled periodically as follows:

(*a*) *Powder Charges* (other than black powder and small arms powder) for either bag guns or cartridge case guns:

(1) *Five years after assembly or reassembly.*—All powder charges and all cartridges that have been on board ship for 5 years after assembly or reassembly shall be turned in to a naval ammunition depot for examination, test and overhaul during the ship's next regular overhaul period at a navy yard In no case, however, shall powder charges be permitted to remain on board ship for more than 7 years after assembly or reassembly without having been overhauled at a depot

(2) *Three years after an overhaul.*—All powder charges and all cartridges that have been on board ship for 3 years after the overhaul mentioned in the preceding paragraph shall be turned in to a naval ammunition depot at the ship's next regular overhaul period for examination, test and overhaul. Powder charges shall not remain on board ship for a longer period than 4 years without overhaul, except in the case of new or reassembled ammunition, as provided for in the preceding paragraph.

(3) *Special overhaul.*—Whenever authorized by the Bureau of Ordnance, powder charges shall be given special overhauls because of having been subjected to unusually high temperatures, rough handling, water or moisture, storage in leaky tanks or cartridge cases, or other abnormal conditions; and as may be considered desirable as a result of the "Examinations and Tests of powder on Board Ship" (see ch. 6). Ammunition on destroyers, submarines and other vessels having similar storage conditions, and on vessels having long service in tropical waters will probably require Special Overhauls at more frequent intervals than the 5- and 3-year periods specified in the foregoing instructions. Commanding officers of such vessels should take the initiative in requesting examination and overhaul during the regular navy yard overhaul periods of the vessels.

(*b*) *Projectiles:*

(1) *Separate loading ammunition.*—Projectiles afloat for guns using bag charges or semifixed ammunition shall be kept in serviceable condition on board ship as prescribed in article 1–30, chapter 1, page 19. Projectiles loaded with black powder, mixed filler, explosive "D," granular TNT, and illuminating assemblies need not be turned in to an ammunition depot for overhaul unless required as a result of the inspection mentioned below. Five percent of projectiles loaded with cast TNT, chemical warfare or incendiary materials, or other special explosives or pyrotechnic materials, shall be turned in at every ammunition overhaul for such examination by the depot

as may be necessary to establish their serviceability and safety for continued stowage on board ship. The service allowance of projectiles shall be inspected by the Inspector of Ordnance in Charge of the ammunition depot, or his representative, in company with the Gunnery Officer of the ship prior to or during the period of the powder overhaul in order to determine what overhaul is required; and if considered necessary, shall be in to the depot without further reference to the Bureau.

(c) *Special ammunition, small arms, primers, unassembled fuzes, signalling and pyrotechnic materials, trench and chemical warfare munitions, etc.*—These materials shall be inspected by the Inspector of Ordnance in Charge or his representative and the Gunnery Officer at the time of the projectile inspection; and, if necessary, shall be turned in to the depot for such examination, test, grading, marking, overhaul, and replacement or completion of allowances as may be deemed desirable, having due regard for the nature of the materials and existing instructions for stowage, handling, testing, surveillance, preservation, replacement, and safety.

(d) *Responsibility and authority.*—

(1) The responsibility for the care, surveillance, testing, inspection, and overhaul of ammunition, explosives, and pyrotechnic materials, afloat, rests with the Commanding Officers of the ships who shall arrange for and request authority from the Bureau of Ordnance for the overhaul of ammunition at a depot during a regular navy yard overhaul of the ship. Advantage should be taken of the first opportunity for periodic ammunition overhaul, so that through unexpected changes of schedules or duties a ship will not be forced to retain ammunition on board for periods longer than the maximum given above. In no case, however, shall any bag charges or cartridges remain afloat in ships' service allowances for a period longer than 10 years (regardless of the number of inspections or partial overhauls) without break-down, complete overhaul, and reassembly at an ammunition depot. The dates of assembly or of reassembly as well as the dates of any subsequent overhauls will be printed by the depot on the "powder identification tags."

(2) The Bureau shall be informed of any inability of a ship to comply with the instructions for inspection, test and overhaul of ammunition and explosives.

(3) The regular forms for reporting powder, projectiles, small arms, pyrotechnics, bombs, warheads, etc., should be submitted by ships even though the materials are undergoing overhaul at a depot. Where necessary, the forms should be forwarded through the depot for filling in of test data.

(4) Ammunition depots shall submit to the Bureau a report (copy to the ship concerned) of inspections, examinations, tests and overhauls of

ammunition with complete details regarding the condition of containers and explosives, the results of tests and the extent of overhaul found to be necessary or desirable, with recommendations for filling shortages in or replacing allowances.

Operations prohibited aboard ship.

1–23. It is expressly forbidden for any ship to make additions to powder bags. All ammunition is issued to the service in such condition that no work, except possibly tightening bag lacings, is required to be done on it preparatory to firing. It is strictly forbidden to remove a fuze from a loaded projectile, as this is a very dangerous undertaking and shall be done only at ammunition depots under special regulation, unless ordered by the Bureau of Ordnance. Under no circumstances shall any person, except when carrying out explicit instructions from the Bureau of Ordnance, attempt to break down a fuze. Only regularly prescribed fuze setters shall be used for setting time fuzes, and regular tools for preparing saluting, signaling, and subcaliber charges, and in breaking down and assembling charges for testing powder

Target practice ammunition.

1–24. Special ammunition, called target practice or training ammunition, is put up and issued for gunnery exercises, or occasionally part of a ship's allowance of service ammunition is designated by the Bureau of Ordnance for that purpose. Such ammunition, provided it is not live ammunition, may, when in the discretion of the commanding officer it becomes necessary, be used for instructional purposes, for testing hoists and conveyors, but not for drill at the guns

Disposition of unexpended target practice ammunition.

1–25. The unexpended portion of such target practice ammunition as may have been issued for a specific gunnery exercise or experimental firing shall be turned in as soon as practicable, after such firing, to an ammunition depot, preferably the one where it was prepared, unless additional firings are immediately authorized by the Navy Department

Use of proper containers.

1–26. After opening containers and removing ammunition for firing, care shall be taken to return unexpended ammunition to the proper containers and not to obliterate the identification marks. The repacking of case ammunition in tanks or boxes other than those designated to take it will result in damage to the ammunition. A case is on record where a ship restowed some shrapnel in boxes not designed for it in such a manner that the time percussion fuzes were moved off safety, the watertight caps cut, and the ammunition rendered useless and dangerous

Primers.

1–27. The Bureau supplies to each ship an allowance of lock combination drill primers. This allowance is furnished on an annual basis and provides an adequate quantity for testing of firing circuits and for such training of primermen as cannot be obtained with fired primers. With the exception of these, primers in excess of an allowance of 10 per gun per year shall not be expended except in actual firing. Primers issued for drill are from the oldest lots of primers, Mark 15, mod. 1, on hand. The use of service primers for fire-control drills or other training is prohibited. Cases have occurred where ships have used up more than half of their service primers in preparation for target practice, thus rendering a part of their service ammunition worthless until the supply is replenished.

1–28.

1–29.

1–30. Projectiles comprising the service allowance of ammunition shall not be altered or disassembled on board ship, in any of their parts, without explicit instructions from the Navy Department. They shall be kept free from rust, and the paint and lacquer shall be renewed when necessary. The old paint shall be removed before painting in order that the dimensions may not be increased by constant addition to it, and care shall be exercised that no paint is placed on the bourrelet. Projectiles for separate loading ammunition in 5-inch guns and above are issued with grommets protecting the rotating bands. When projectiles are stowed horizontally grommets should be left in place until projectiles are removed for sending up the hoists. In base stowages grommets may be removed, but only if necessary to permit the designed stowage. When removed, grommets shall be returned to an ammunition depot. Slings fitted on 5-inch projectiles should be removed before sending up the hoists to avoid possible jambs. **Service projectiles.**

1–31. When ships turn in target ammunition, the following shall be done:

(*a*) All paint not required by chapter XVIII of this pamphlet will be removed before delivery of target projectiles to depots.

(*b*) All time fuze covers and safety wires and grommets removed for firing will be collected and delivered to depots for salvaging.

(*c*) Replace grommet if removed.

1–32. Illuminating projectiles assigned for target use are of the oldest manufacture available in the caliber concerned, thus retaining the most modern and improved projectiles for service use.

1–33. Empty cartridge cases, cartridge boxes and tanks, powder tanks, bomb crates, primer boxes and blocks, and all other containers and ammunition details including covers, gaskets, projectile grommets, metal stops, wood distance pieces and projectile nose blocks, fuze covers, etc., shall be returned to an ammunition depot (preferably the one from which issued) at the first convenient opportunity. Empty ammunition containers or boxes shall be closed with the same method and care as filled containers. Such materials shall be carefully saved and protected from damage and shall be invoiced to the depot. Invoices of materials turned in which are incomplete or damaged shall form separate items with notation as to the condition and reasons therefor. Ammunition, ammunition containers, and details which are missing or have been lost shall be covered by "missing surveys" as prescribed by the Navy Regulations. **Return of empty containers and ammunition details.**

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Chapter II. SAFETY PRECAUTIONS

2–1. The safety precautions are contained in article 972 of the Navy Regulations, 1920. They are revised from time to time as changed material conditions render existing precautions unnecessary or inadequate, or dictate the addition of further provisions.

2–2. It must be borne in mind in studying and carrying out the safety precautions that in the main they are derived from costly experience, and that the most serious casualties on record are attributable to neglect or violation of safety precautions then in effect. The attention of all concerned is invited to that chapter of the Gunnery Instructions which covers the history of safety precautions.

Extent of safety precautions.

2–3. The safety precautions are explicit and allow no recourse except positive compliance. It is difficult to cover every possible emergency which may arise and which, if improperly handled, may result seriously. An attempt should be made in carrying out the safety precautions to grasp the ideas on which they are based so that, under circumstances not known at the time of their promulgation, the proper action may instinctively be taken.

Forbidden articles.

2–4. As a matter of precaution, persons working with explosives shall have no iron, steel, or articles of a combustible nature about their persons. Matches or other flame producing articles are a source of great danger and shall never be permitted around explosives. Smoking shall not be permitted during firing or when magazines are open and powder exposed. Particular attention shall be paid to avoiding the making of sparks from contact of steel on steel, especially with black powder present. *Black powder is the most dangerous explosive used in the Navy, and the one most likely to cause accidents.*

Red flag.

2–5. A red flag (International B) shall be hoisted and kept flying whenever explosives are being handled. All lighters, boats, and vehicles carrying explosives, except artillery pieces, shall carry a red flag (International B).

2–6. A careful distinction must be made between safety devices and devices for increasing the celerity of service of a gun. The most common error is regarding a gas-ejector system as a safety device when it is merely a means of decreasing the time required for compliance with that safety precaution which requires that the bore be clear before powder is exposed at the breech of the gun.

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Chapter III. DEFINITIONS AND HISTORY OF EXPLOSIVES

3–1. The term explosion is very broadly used to define a bursting with great violence and loud noise, thus covering many occurrences resulting from the action of other substances than those known as explosives. The most important effect of an explosion is a rise in the pressure in the surrounding medium. Although an explosion results from the rupture of a cylinder filled with gas under pressure, the gas is not considered an explosive substance as the action produces a fall in pressure. An explosive substance, on the contrary, produces a rise in pressure. Marshall defines an explosive as follows:

Explosion and explosive.

> "A solid or liquid substance or mixture of substances which is liable on the application of heat or a blow to a small portion of the mass, to be converted in a very short interval of time into other and more stable substances largely or entirely gaseous. A considerable amount of heat is also invariably evolved, and consequently there is flame."

It is characteristic of an explosive that when the explosion occurs it is always accompanied by a chemical transformation. "Explosives have also been defined as substances whose atomic groups are in unstable equilibrium." ("Explosives," Brunswig, Munroe & Kibler.)

Conditions for an explosion.

3–2. There are three important conditions to be fulfilled by an explosive substance; first, to produce large quantities of gas; second, to liberate heat; and third, to accomplish these two conditions in a very short space of time. If gases are evolved slowly, they are dispersed without causing any noticeable increase in pressure, such as happens when oil, for instance, is consumed in the ordinary way. Yet petroleum has 30 times the latent power of fulminate of mercury. A chemical reaction may liberate large quantities of heat such as is the case with thermite, yet not evolve gaseous products. Hence it cannot be classed as an explosive substance. It is, therefore, essential that pressure result from the sudden decomposition of an explosive substance. The volume of gas evolved is so great compared with the original mass that a sudden pressure results, expending the energy released in the surrounding medium, manifesting itself in the disruptive phenomena accompanying an explosion.

Explosive reaction.

3–3. The chemical transformation taking place in an explosive reaction is an oxidation process of a kind which liberates heat, i.e., an exothermic reaction. If heat were not liberated, the absorption of energy due to the work done by the explosive would cool the explosive and slow down the reaction until it ceased, unless heat were supplied from without. Once the reaction is started the heat liberated tends to propagate the explosion. An explosive substance may be considered as containing a certain amount of latent chemical energy, which is released on decomposition in an almost instantaneous oxidation process. This means that the substance must contain sufficient oxygen to combine with the other elements to form the gaseous products. Carbon and hydrogen are the elements with which the oxygen reunites to form water, carbon dioxide and carbon monoxide, depending on the amount of oxygen present. The oxygen is not combined with the carbon and hydrogen until the reaction occurs, but is present either as a separate compound, as in the saltpeter in black powder, or combined in a single compound, as in a nitro explosive in which the nitro radicals act as the oxygen carriers. This distinction in the method of supplying the oxygen divides explosive substances into two classes:

Explosive mixture and compound.

Explosive mixtures: consisting of distinct substances mechanically mixed together, and

Explosive compounds: consisting of substances which are of definite homogeneous chemical constitution, each molecule having the elements necessary for combustion.

As a rule, few explosives have sufficient oxygen present to oxidize all the carbon to carbon dioxide, but when they do, a very high temperature results, as may be seen from the following. If 12 grams of carbon unite with 16 grams of oxygen to form 28 grams of carbon monoxide, 29 large calories of heat are liberated. If 12 grams of carbon unite with 32 grams of oxygen, then 97 large calories of heat are liberated. This influence of the products of combustion on the power of explosive substances is shown by the difference between nitroglycerin, which has an excess of oxygen (more than is required to convert all the carbon to carbon dioxide), and nitrocellulose, which has a deficiency of oxygen such that only small quantities of carbon dioxide are formed.

Heat of explosion.

3-4. It might be supposed that the quantity of heat given off by an explosive is large, but this is not the case, as is shown by the following table giving the relation of certain articles to each other with reference to the amount of heat given off in combustion.

Petroleum	30
Coal	20
Wood	8. 75
Nitroglycerin	4
Fulminate of mercury	1

Explosives appear to contain more energy for the reason that they have the property of releasing their energy in an extremely short space of time—that is, the velocity of explosion or the rate at which the effects of the reaction are transmitted from layer to layer is very great. Although the quantity of gas and heat evolved affect greatly the power of an explosive, the rate at which they are given off is of prime importance. This rate is measured by taking the time the explosive wave requires to travel a known distance in a tube in which the explosive has been packed.

3-5. The sensitivity of an explosive is an important property. The substance must be "safe" until the impulse is applied to start the reaction. If the atomic groups are in such an unstable equilibrium that the reaction starts spontaneously, or in response to a slight blow, the substance can have no practicable application. Explosives vary in the strength of the impulse required to cause them to explode. Some are exploded by the slightest touch; others, such as fulminate of mercury, require a moderate blow or a flame, and others require a very violent blow and cannot be exploded in the open by a flame. It was originally considered that the power of an explosive was measured by the sensitivity and that the most powerful explosives were quite sensitive; but now, in the light of modern investigation, it is found that insensitive explosives are quite powerful and that the *safest* explosives are those which under ordinary circumstances require a detonator to initiate the reaction. Of these, Explosive "D" and TNT are examples. **Sensitivity.**

3-6. Explosives cannot be classified definitely from their chemical constitution, by the gas evolved or the heat liberated. Consequently, they are classified by the speed of the chemical change. If the velocity of explosion can be controlled after the reaction starts, the explosive is classed as a propellant, i. e., for use in ejecting a projectile from a gun. One not in this class is termed a "high explosive." A propellant is sometimes termed a low explosive and is one which burns relatively slowly and permits of initiating the action by flame. When an explosive requires a powerful agent, such as fulminate of mercury, to start the reaction, but which when once started proceeds at a high rate, it is considered a "high explosive." The latter have a powerful disruptive action. The velocity of explosion for a smokeless powder is about a meter per second, for black powder about a few hundred meters per second, and for high explosives several thousand meters per second, depending on the conditions under which the reaction occurs. **Classification of explosives.**

3-7. From the above it may be judged that the difference between a propellant and a high explosive cannot be sharply drawn. In fact, until nitro-explosives came under investigation, there was no need of such a distinction, as black powder was the only well-known explosive substance and was used both for propellant and blasting purposes. It would be possible to use any explosive for propellant purposes if the velocity of explosion could be controlled. Investigations along this line caused the development of smokeless powder as we know it today, for nitro-cotton, when attempts were made to use it as a propellant charge, did considerable damage to the guns. However, when it was found that when this high explosive was dissolved in ether and alcohol the colloid resulting burned instead of detonated, a revolution in the propellant explosives industry began. The number of chemical compounds which can be so treated as to permit control of the velocity of explosion is very small, and **Propellant and high explosive.** **Requirements of an explosive.**

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is still more limited by the fact that the substance in its final state must not only be efficient ballistically, but must be safe in use, easy to handle, and stable under varying conditions of storage, and also remain in a stable condition for protracted periods of time. When selecting an explosive, it is necessary to consider the case and safety of manufacture and use, the cost, the sensitivity, the power, the stability, and the temperature of explosion.

Early history.

3-8. Various attempts have been made through search of the works of the fourteenth and fifteenth century writers to determine with some degree of certainty the early history of gunpowder and its use in military operations. Due to the inaccuracies of the manuscripts, to the fanciful style of many writers of that day, and to the errors in translation and loose use of terms, not only is it impossible to name the inventor, but it is also a matter of conjecture as to which nation belongs the credit for its invention. It seems most probable that gunpowder as used in the fourteenth century was the result of the gradual development of the substance known as "Greek fire" and "wildfire" by the addition of saltpeter when this substance was found to have the property of deflagrating with burning bodies.

Greek fire.

3-9. In 660 A. D., in the defense of Constantinople, a mixture thought to contain sulphur, pitch, resin, etc., was discharged from a tube or siphon somewhat after the manner of modern flame projectors. The tubes were mounted in the bows of the Greek ships and destroyed the enemy by directing a burning stream of liquid fire at them. The secret has not survived the ages, but a similar substance appeared at a later date, about the time of the sixth crusade, as "Wildfire." In this, sulphur, naphtha, pitch, and saltpeter, in a semisolid mass, was ignited and thrown by ballistae in land warfare.

First use of black powder.

3-10. From the best authorities it appears probable that the Arabs about 1280 A. D. used mixtures similar to gunpowder by substituting charcoal for the naphtha, and that about 1313 A. D. the gun for the use of black powder was invented by a German monk named Schwarz. The use of gunpowder was not extensive at first, as its employment was not in accord with the chivalrous sense of the times, but when it finally was adopted its use spread rapidly, resulting in improvements in manufacture and rapid development of powder-making machinery. It was restricted in use in the early stages, as it was prepared as a fine powder, and consequently was suitable only for use in small arms, but in the sixteenth century the French began to grain it and classify it according to size, so that it could be used in various sizes of guns. In the seventeenth century its use was adapted to the blasting of rock for getting out minerals.

Development of black powder.

3-11. Until a few years ago gunpowder was the only propellant in use for firearms. During the long period since its introduction it has changed but little in its ingredients, though many changes have been made in methods of manufacture and in its final form. By the introduction of rifled cannon and the increase in pressures for large ordnance the necessity for controlling the rate of combustion became apparent. General Rodman, United States Army, in 1860 inaugurated the method of pressing the powder into different size grains and later of controlling the rate of burning by perforating the grain, thereby improving the ballistic qualities. The next change was the introduction of charcoal from rye straw which resulted in the brown or cocoa powder, so named on account of its color. This improvement gave a denser grain, more suitable for heavy guns as it burned more progressively. In 1882 guns had increased to 16 inches in diameter in the British Navy.

3–12. During the nineteenth century a great development in explosives resulted from the discovery that when certain organic substances were treated with nitric acid easily combustible substances were obtained. In 1838 Pelouze discovered that an explosive could be made by treating cotton with nitric acid. Previous to this, in 1832, Braconnet found that starch, wood, and similar substances treated with nitric acid made explosive compounds. These discoveries were without practicable importance until Schoenbein in 1845 found that a mixture of nitric and sulphuric acids produced a better quality of explosive than nitric acid alone. Considerable interest was shown in this development by several European countries, resulting in the erection of several factories. Due to the fact that no one knew how to purify the nitrated cotton, and, as very little attention was paid to the purity of the ingredients, the stability was very low and many disastrous explosions occurred. In 1853 Von Lenk showed that the trouble lay in the purification and suggested that, instead of merely washing the nitrated cotton with water until neutral, an extended course of washings was necessary, including boiling with dilute potash solution. In spite of Von Lenk's improvements explosions still occurred. Meanwhile, Abel continued experiments and in 1865 found that there was great virtue in a pulping process, in that the treatment reduced the impurities and also permitted pressing the pulped material into blocks. In 1868 it was found that when wet it could be detonated by dry guncotton and that the dry guncotton could be detonated by fulminate of mercury. This resulted in its adoption for military purposes for explosive charges.

Nitrocompounds.

Guncotton.

3–13. In 1846 Sobrero discovered nitroglycerin. This substance, due to its dangerous nature and difficulty in causing it to explode, was not developed until Nobel in 1859 found that it could be detonated by fulminate of mercury. In 1867 he found that by allowing "keiselguhr" to absorb about three times its weight of nitroglycerine a satisfactory and fairly safe explosive resulted. This substance, known as dynamite, has become very popular and entirely replaced black powder as a blasting agent. In 1875 Nobel invented blasting gelatine, made by solidifying nitroglycerine by the addition of 8 percent of nitrocellulose.

Nitroglycerin.

3–14. As the new blasting powder replaced black powder in commercial uses, so the continued investigation of nitro compounds produced a substitute for it as a military bursting charge for projectiles. Picric acid or trinitrophenol was adopted by many countries for this purpose; by France in 1885, by Germany in 1888, and about the same time the British Government adopted

Other nitrocompounds.

molten picric acid as Lyddite. In 1905 the United States Navy adopted ammonium picrate, a more insensitive compound than picric acid. In 1905 the German Government adopted trinitrotoluol. Since that time numerous additional compounds have been investigated and adopted.

Substitute for black powder.

3–15. Inventions up to this time had developed suitable high explosives but these were not suitable for use in guns due to the violence of the explosion. Attention was directed to modifying the known explosives for use as propellants and to the development of smokeless powders. Black powder was considered unsuitable for several reasons, namely:

First, it left a large amount of residue, thus fouling the bore.
Second, made large quantities of black smoke.
Third, was very hygroscopic.
Fourth, caused considerable erosion by the high temperatures of combustion.

Early smokeless powders.

3–16. The first successful smokeless powder was made by Major Schultze, of the Prussian artillery, about 1864. It was made of nitrated wood impregnated with saltpeter. Later the substance was dissolved in ether and alcohol and was known as collodion. This powder burned at a fairly slow rate and, as it did not cause as much recoil as black powder and gave no smoke, it was very popular for sporting powders. In 1882 the Explosives Company of England patented the E. C. powders. These were made of nitrocellulose mixed with nitrates of potassium and barium and partially gelatinized by dissolving in ether and alcohol. This powder also is used as a sporting powder, for it is too quick for rifled guns.

Nitrocellulose and nitroglycerine powders.

3–17. Although Maynard in 1843 discovered that nitrated cotton was soluble in ether and alcohol mixed together, but not in either alone, this fact was used only for development of celluloid and collodion, the latter giving impetus to developments of photography. In 1884 the French engineer Vielle discovered that the fiber of the nitrocotton must be entirely destroyed in a complete gelatinizing process. He mixed nitrocellulose with ether and alcohol, then rolled the mixture into sheets and cut the sheets into cubes. When dried, a very satisfactory propellant powder resulted. This powder was called "Poudre B" after General Boulanger, a noted French ballistician. In 1888 Nobel produced a new propellant which was adopted by the British the same year under the name of cordite. It is a mixture of nitroglycerine and nitrocellulose dissolved in acetone. The improvements which have been made in smokeless powders since that time have been principally in the direction of better purification and other measures for insuring chemical stability.

3–18. In 1889 the German Government adopted a nitrocellulose powder and in 1893 the Austrian Government adopted a powder similar to cordite. In 1896 the United States adopted the nitrocellulose powder, but it was several years later before it had finally replaced the brown powder then in use.

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3–19. Every nation now uses as propellants substances obtained from nitrocellulose, alone or mixed with nitroglycerin, as such substances permit of controlling the rate of explosion, as, during combustion, the individual grains burn from the surface inward in successive layers. By altering the shape of the grain and changing the burning surface the time of the explosion can be modified so that the same composition may be used in any size firearm merely by a change in the finishing process. **Adoption of new propellants.**

3–20. The introduction of smokeless powder removed the objectionable features inherent in black powder. Research in smokeless powder has sought a reduction in the flash—producing the so-called flashless powders where a desirable red glow is accompanied by highly undesirable excess smoke—an improvement in stability, life, and resistance to hygroscopicity—leading to the nonhygroscopic powders—and a reduction of temperature to reduce erosion—an effort which so far has been futile unless a marked reduction in powder potential be accepted. **Further development.**

Chapter IV. BLACK POWDER

4–1. Saltpeter (sodium nitrate), sulphur, and charcoal have been the ingredients of black powder from the time of its first use as an explosive. The proportions have varied with the development of the manufacture, from a clearer knowledge of the properties of the different mixtures, so that eventually special proportions were used for making military, sporting, or blasting powders. The earliest mixtures had equal parts of saltpeter, sulphur, and charcoal. Experience obtained by testing different proportions caused a constant change until Berthelet found that 84 parts of saltpeter, 8 parts of sulphur, and 8 parts of charcoal were the theoretically correct proportions. Theoretical results, however, can not be obtained from the combustion of black powder, as it is a mechanical mixture and not a chemical compound, and consequently the combustion is affected by the degree of incorporation of the ingredients. It has been found that an increase in sulphur improves the keeping qualities and that as charcoal is never pure carbon its percentage must be increased. The proportions now used by all nations are practically the same—75 parts of saltpeter, 10 parts of sulphur, and 15 parts of charcoal—these proportions being used for all powders and the rate of combustion for different uses being regulated by the granulation. Composition.

4–2. Saltpeter is formed in nature by the decay of nitrogenous substances in the presence of air, moisture, and alkalies, more readily in warm climates, as the higher temperatures facilitate the decay. The most fruitful source was India, but European countries supplied considerable from stables, cattle sheds, etc., where stable dung accumulated. Frequent sprinkling with urine accelerated the decay. Saltpeter.

4–3. The material when gathered is placed in containers and sprinkled with water. The liquid flowing through the mass dissolves the saltpeter and carries it off to evaporating containers, where it crystallizes out. The result is a crude saltpeter, which is removed to refineries and treated in a similar process more subject to control. With the discovery of the sodium nitrate deposits in Chile another source was obtained. This salt is treated with potash or potassium chloride in the concentrated mother liquid from a previous operation, and sodium chloride or common salt crystallizes out at the high temperature of the reaction. When cooled the saltpeter which has been formed crystallizes out. Synthetic sodium nitrate is now obtainable commercially at reasonable cost. Sources of saltpeter.

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Sulphur.

4–4. Up to a few years ago sulphur was obtained from the Sicilian sulphur mines, which produced a limestone ore with about 25 percent sulphur. The ore is piled in heaps covered with moistened ashes and a fire started at the bottom. The combustion of some of the sulphur after the fire has started provides the necessary heat for melting the rest, and as the molten sulphur runs out the bottom it is collected in troughs, where it forms sulphur cakes when cool. More recently it has been obtained to some extent from coal gas, but by far the best and most abundant source is the sulphur fields of Louisiana. The sulphur is found there in a very pure state at a depth of about 500 feet. Due to the cheapness of the product obtained in Louisiana, Sicilian sulphur could not compete with it, and the mines would have been abandoned except for the action of the Italian Government in supporting the industry.

Source of sulphur.

Effect of sulphur.

4–5. Sulphur has the effect of making black powder burn more readily, as its ignition temperature is low. It also has the effect of flowing when under pressure of manufacture, so that it cements the charcoal and saltpeter together.

Charcoal.

4–6. Soft wood is usually burned to make charcoal for powder, as it is easier to ignite than if made from hard wood. A variety of woods have been used, such as the alder, dogwood, yew and willow. In the United States the willow has generally been used, and it is to be noted that blackpowder factories are now located where the willow trees grow in abundance. The wood is carefully selected, cut in the spring, and the bark removed. Then it is seasoned until the sap has run out. The wood is split up, placed in iron cylinders and heated uniformly in a furnace at a temperature of about 280° C. The volatiles are allowed to escape through holes in the cylinder and into the furnace where they burn. When the flame from the escaping gas becomes blue, the carbonization has proceeded far enough. The cylinder is removed, the contents kept from contact with air, as oxygen would cause the heated carbon to burn, and when cool the charcoal is removed, sorted, and ground. The charcoal for brown powders was made from rye straw, only slightly carbonized, resulting in a soft material with a large percentage of hydrogen and oxygen. Rye straw charcoal in the process of pressing had the effect of binding the other ingredients together and thus made a denser grain, giving better ballistic results in large guns, as the denser grain burned more slowly. Brown powders made from rye straw have been entirely replaced by smokeless powder, so that its manufacture has entirely ceased.

How prepared.

Manufacture of black powder.

4–7. The most important considerations in manufacturing black powder are to have the ingredients finely pulverized, intimately mixed together, and pressed to a high density. Manufacturing methods have changed considerably since the original process of pulverizing, mixing, and caking in one operation (which was discontinued due to dangers involved). At the present time they still differ a great deal in different countries. The saltpeter, sulphur, and charcoal are first ground separately to a very fine state in a mill without danger, as separately they are not explosive. This may be done either in separate operations

Pulverizing.

or by mixing them together in varying proportions before grinding. The French method is to grind 6 percent of the saltpeter with the charcoal and the rest with the sulphur, and then mix the compounds. Usually some saltpeter is added to the sulphur to prevent it caking during the pulverizing process. Any mill is suitable for the pulverizing operation, but the one in most general use consists of a steel cylinder in which bronze balls are placed with the materials, the balls, as they fall with the rotation of the drum, reducing the material. After pulverizing, the ingredients are weighed out in the proper proportions and given a preliminary mixing in a drum made of wood, leather lined, in which are placed lignum-vitae balls, or in a copper cylinder through which as axle passes carrying several rotating arms. The mixing is carried on by rotating the drum or cylinder for 5 minutes. **Mixing.**

4-8. At this stage in the manufacture, the black powder takes on its explosive character, and all further operations must be carried out most carefully to prevent friction or sparks igniting the material.

4-9. The incorporating is now usually done in incorporating mills, which consist of two heavy stone wheels running on a stone bed. They both may be made of iron, in which case the wheels are suspended from a cross head, so as not to touch the bedplate. As the cross head is revolved by means of a vertical shaft, the wheels travel round and crush and grind together the ingredients without exerting on them force sufficient to cause an explosion, provided the mill is properly operated. Scrapers are fitted to brush the charge under the wheels. The charge is spread over the bed evenly and wet down with about 3 percent of its weight in distilled water. The grinding is carried on for about 2 hours for cannon powder, and up to 5 hours for rifle powder, water being added periodically to keep it moistened. On completion of the incorporating process, the powder on the bed is in the form of mill cake. This must be carefully removed, and broken up by hand or by a break-down machine to reduce it to the powdered form for pressing. **Incorporation.**

4-10. In the pressing or caking operations, several layers or cakes are formed with copper, bronze, or ebonite plates between layers of powder, the latter being about ¾ inch thick. The built-up charge is then placed in a hydraulic press and a pressure of about 400 pounds per square inch applied and held for about 45 minutes. On removal the outer edges of the cakes formed are cut off and added to the next press charge, and the remainder are broken and passed through the granulating machine, which consists of three or four pairs of gun-metal rollers. A number of automatic sieves are fitted for sorting out the grains according to their size. After granulating, the powder is given a glazing treatment; that is, each grain is given a smooth finish, rough edges are rubbed off, and it gets a high polish. This operation consists of rotating the grains in a wooden barrel for about four hours, the time varying with the size of the grain. Large grains are frequently coated with graphite. The rubbing together of the grains produces the glaze. Glaz- **Pressing.** **Graining.** **Glazing.**

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ing stops up the pores, thus making the powder less sensitive to moisture, and also makes it less liable to deposit dust. The powder is then dried in canvas trays in houses heated by low-pressure steam at a temperature of 40° F., and is then "dusted" by rotating it in a canvas-covered reel, and finally it is blended.

Compressed grains.

4-11. The above description applies to rifle, cannon, and shell powder, which is made up of irregularly formed grains. When black powder was used as a propellant in heavy ordnance, the mill cake was cut into cakes, or it was powdered and formed into individual grains of a regular size. The sphero-hexagonal powder in use at present for certain torpedo impulse and depth charge throwers is made in this way.

Physical properties.

4-12. Black powder was originally used in the powdered forms, but when so used is very dangerous to transport. Black powder dust should always be avoided. A clean white handkerchief wrapped around the fingers and passed through black powder should come out clean, otherwise too much dust is present. Granulating the material makes it more inflammable, as the flame can travel more readily through the interstices. Compressing the powder into large grains, on the other hand, reduces the number of interstices and slows the burning. Perforating these grains permits speeding up the burning, for, as the compressed powder burns from layer to layer, the surface is increased by the enlargement of the perforations. General Rodman made disks the diameter of the bore and about 1 to 2 inches thick, with perforations, and obtained great success in controlling the rate of explosion.

Packing.

4-13. Black powder is packed in metal drums which have an interior cloth bag lining.

Uses.

4-14. The development of new chemical compounds has decreased the range of use of black powder, but it is still important for certain purposes. Its high inflammability makes it essential for ignition charges for smokeless powder and for primers for guns of all calibers. Its high stability at moderately high temperatures and its uniformity, when protected from moisture, make it suitable for the time trains of powder train time fuzes. Although it is being used (when mixed with equal parts of granular TNT) as a filler in minor caliber common and shrapnel projectiles, it is gradually being superseded by high explosive fillers in projectiles of new design. In the sphere-hexagonal granulation it is used for torpedo impulses and Y-gun charges. For the former it has been partially superseded by sodium-nitrate (SN) black powder (blasting) for those tube mounts requiring an exceptionally high velocity to insure the torpedo's clearing the side. Its most common use is in black charges for training, saluting, and signaling. In these uses it presents the paradox of a most hazardous explosive being loaded by the forces afloat. To preserve its qualities it requires protection from moisture.

4–15. The grades and uses of black powder in the United States Navy are:

BLACK POWDER

Type	Designation	Use
Meal	F. F. F. F. F. F. G	Fuze delay trains.
Fine grain	F. F. G. and F. F. F. G	Primers.
Granular	Cannon	Ignition charges (when broken down, for saluting charges, etc.).
Granular (smaller)	Shell	Projectile filler (for saluting charges when authorized.)
Grained	Sphere-hexagonal (SH)	Impulse charges.
Do	Sodium nitrate (SN)	Do.

Chapter V. SMOKELESS POWDER

5–1. The raw materials used in the manufacture of Navy Standard smokeless powder are cellulose, nitric and sulphuric acids, ether, ethyl alcohol, and diphenylamine. Cellulose is a celloidal substance, the molecule of which is thought to consist of the complex $(C_6H_{10}O_5)n$, although the exact chemical constitution and, in particular, the exact molecular structure, are not definitely known. Cotton represents the purest type of cellulose produced in nature. It contains about 90 percent of pure cellulose. Flax, ramie, hemp, and other fibers also contain a high proportion of pure cellulose. Wood and cereal straws are distinguished as containing smaller quantities of cellulose, and this cellulose is also intimately associated with lignin. There is considerable evidence to show that the pure cellulose isolated from these fibrous materials is identical. However, it is probable that pure celluloses isolated from various sources will always differ in some of their properties, due to the modification of the molecular structure during extraction. **Cellulose.** **Cotton.**

5–2. Raw cotton contains about 90 percent of pure cellulose, natural coloring matters, 8 percent of moisture, 0.2 to 0.4 percent of nitrogen, 0.5 percent of wax, fat, and resin, and 1 percent of mineral matter. The actual amounts of these substances are determined largely by the type of cotton, its origin of growth, and the stage of its maturity. By ordinary methods of determination the density of cotton is accepted as 1.50–1.53. The structure of the cotton hairs is distinguished as containing an outer primary wall known as the cuticle; a secondary thickening; and a central canal, or lumen. The secondary thickening is made up of a number of concentric layers of cellulose, similar to the growth rings in trees. The cuticle may or may not be composed of the same cellulose, but contains fatty matters. There are minute pits in the walls of the hair, which extend from the outside surface to the lumen. Linters is the type of cotton normally used by the Navy for the manufacture of nitrocellulose. It is known that Germany used wood cellulose for powder during World War I. In World War II large amounts of wood cellulose are used by the United States Army in the manufacture of smokeless powder.

5–3. Cotton to be used for manufacture of powder is given a very careful purification treatment, as this has a direct bearing on the manufacturing process and on the stability of the finished product. The raw cotton is first cleaned to remove seeds and other visible impurities. It is then boiled under steam pressure in a 3-percent solution of sodium hydroxide. It is then washed **Purification of cotton.**

and bleached cold in open tubs or vats with a hypochlorite or chlorine gas. It is then thoroughly washed to remove purifying reagents, dried and baled.

5-4. The finished cotton must be clean, contain not more than 7 percent moisture; not more than 3.5 percent of material soluble in 7.14 percent sodium hydroxide solution, not more than traces of lime, chlorides, sulphates, or hypochlorites, not more than 0.4 percent of other extractive matter, not more than 0.5 percent ash content, be in such physical form that it will readily absorb the mixed acid used in nitration, and have a viscosity of from 12 to 40 poises when in cuprammonium solution at 25° C.

Cellulose nitrates.

5-5. When nitric acid is brought into contact with cellulose, a cellulose nitrate is formed by the displacement of an OH radical in the cellulose molecule by an NO_3 radical. The number of OH radicals so displaced depends on the strength of the acid and the temperature and duration of the reaction. Extensive investigation has been made concerning this reaction. The action of numerous mixtures of nitric acid and other chemicals has been accurately recorded. A mixture of nitric and sulphuric acids and water has been found to be the best mixture for nitration of cellulose. All percentages of nitration from 6 to 13.9 have been obtained in the laboratory. The theoretical maximum is 14.14 percent. The percentage of nitrogen in a nitrocellulose is the principal factor in determining the amount of energy that will become available when it explodes.

5-6. The nitrocellulose prepared for manufacture of powder is converted into a dense colloid by treatment with a solvent, whereby the original fibrous structure of the cellulose is destroyed. The properties of this colloid and the solubility of the nitrocellulose are dependent upon the degree of nitration, the solvent employed, and the temperature of solution. Below 9 percent nitrogen the nitration is generally incomplete and the solubility in ether alcohol is from zero to 10 percent; from 9 percent to 12 percent nitrogen the solubility in ether alcohol normally increases gradually to 100 percent; and from 12 percent to 12.70 percent the solubility may be 100 percent, from which point to 13.5 percent nitrogen the solubility in ether alcohol gradually decreases from 100 to 0 percent. The higher percent nitrogen product is soluble in acetone and many other solvents. The standard nitrocellulose used by the Navy for the manufacture of smokeless powder has 12.60 percent nitration and is 100 percent soluble in a mixture of two volumes of ether and one volume of alcohol at 15.5° C.

5-7. The percentage of water in the mixed acid is the principal factor in controlling solubility. Apparently, in order to get a product perfectly soluble in ether alcohol, it is necessary to have enough water not only to convert all the sulphuric acid into $H_2SO_4 \cdot H_2O$, but also all the nitric acid into $HNO_3 \cdot H_2O$. As a molecule of water is formed for every molecule of nitric acid used up, the percent of nitration, and in turn solubility, is affected to some extent by the proportion of acid to cotton. If the proportion of acid to cotton be very great, the ratio alters only slightly during nitration. This is the reason for the use of an approximate ratio of 50 to 1, acids to cotton, as is done in practice. The Navy nitrocellulose has a nitration of 12.60 percent plus or minus 0.1 percent. This value may be arrived at by blending nitrocelluloses which contain from 12.45 percent to 12.75 percent nitrogen and have at least 95 percent solubility.

Sulphuric acid.

5–8. The raw materials used in the manufacture of sulphuric acid at the Naval Powder Factory are sulphur and a platinum mass catalyzer, which induces the reaction but is not consumed; the same mass being used continuously without appreciable loss. The sulphur used shall be free from chlorides and arsenic, and the total impurities shall not exceed 0.5 percent. Arsenic compounds will "poison" the platinum mass and prevent catalytic action. Contact platinum mass is commercial magnesium sulfate carrying approximately 0.2 percent finely divided metallic platinum.

Manufacture of sulphuric acid.

5–9. Navy sulphuric acid is produced by burning sulphur in a sulphur burner (fig. 1), which consists of a horizontal cylinder arranged to rotate about one and one-half turns per minute. At one end is a hopper which feeds sulphur through the cylinder by means of a worm feed. The other end of the cylinder is connected to a stationary combustion chamber, from which the gas line leads. As the sulphur burns in the presence of excess air, SO_2 is formed, with some SO_3. For purification, this gas is drawn by a suction blower through the combustion chamber, gas lines, coolers, scrubbers, and filters. The gas

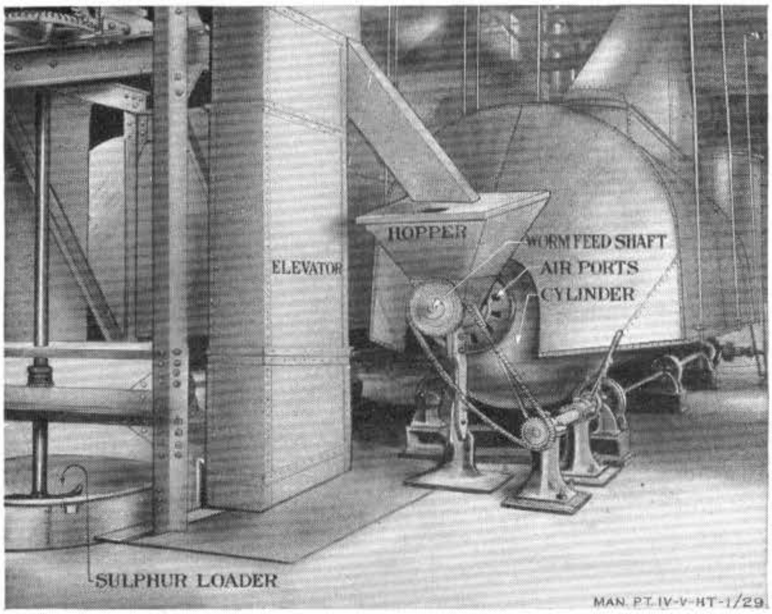

FIGURE 1.—Sulphur burner.

is then forced through a coal-fired preheater which heats the gas to 400° C., and then through the converter, which contains the catalyst and wherein the gas is converted to SO_3. This gas is then passed, after cooling, through shower towers. Sulphuric acid is run through the towers in a continuous shower. The SO_3 combines with the water in the sulphuric acid to form a stronger acid, which is finally built up to a fuming acid of about 110 percent. The fuming acid is withdrawn, mixed with 5- to 7-percent nitric acid to prevent freezing and stored for use.

Manufacture of nitric acid.

5–10. Nitrogen products are obtained as a byproduct from coke ovens. They may also be obtained from the nitrogen in the air by one of several ways. In the cyanamide process, lime and powdered coke are burned in an electric oven, and calcium carbide obtained. This is nitrified in iron vessels into which is forced nitrogen made by distilling liquefied air, and cyanamide is formed from which ammonia is obtained by treating it with steam. In another method, the Haber process, nitrogen and hydrogen are combined directly under very high pressures. The hydrogen is obtained by injecting steam into a furnace containing red-hot coke, removing the CO formed and leaving the hydrogen. The nitrogen is obtained by the distillation of liquefied air. In these methods, ammonia is obtained and nitric acid is made by oxidizing the ammonia. In the arc process nitrogen monoxide (NO) is obtained directly from the atmosphere by using very high temperatures which are obtained from an electric arc. Decomposition is prevented by very rapid cooling; when the gas is finally cooled it becomes nitrogen dioxide (NO_2), and it is then converted into HNO_3 by passing it through water in absorption towers. During World War I, extraction of nitrogen from the air received a great impetus due to the fact that nitrogenous substances had to be imported into this country.

5–11. The most modern type of nitric acid plant is one in which ammonia is oxidized by platinum, a catalyst in the presence of air. The operation is at a high temperature and 100 pounds pressure. Less pressure will serve but is not so efficient.

The nitric gases resulting from the oxidation are cooled but maintained at 100 pounds pressure while being absorbed in a tower to which water is fed. The resulting acid is about 63 percent HNO_3 and can be readily strengthened to 95 percent by the usual manufacturing practice by distillation with sulphuric acid.

Any kind of ammonia can be used but ordinarily anhydrous liquid ammonia is the starting point. The apparatus used is of noncorrosive high-chrome iron and stainless steel.

5–12. The first operation in the manufacture of nitrocellulose is the purification treatment of the raw cotton. Due to the large demand for purified cotton in the rayon, pyroxylin paint and enamel, and other similar industries, the cotton purification process is more economically done by large concerns equipped for the process than if each plant of these related industries were to purify its own raw cotton.

5–13. The purified cotton is received at powder factories in bales. These bales are broken apart and the cotton is fed into a machine called the picking machine (fig. 2), which fluffs the cotton. It is more easily nitrated in this form. The picking machine consists of a frame arranged with a traveling table, on which the cotton is spread by hand. The traveling table feeds the cotton on to a small spiked cylinder, which in turn passes it to a large spider frame

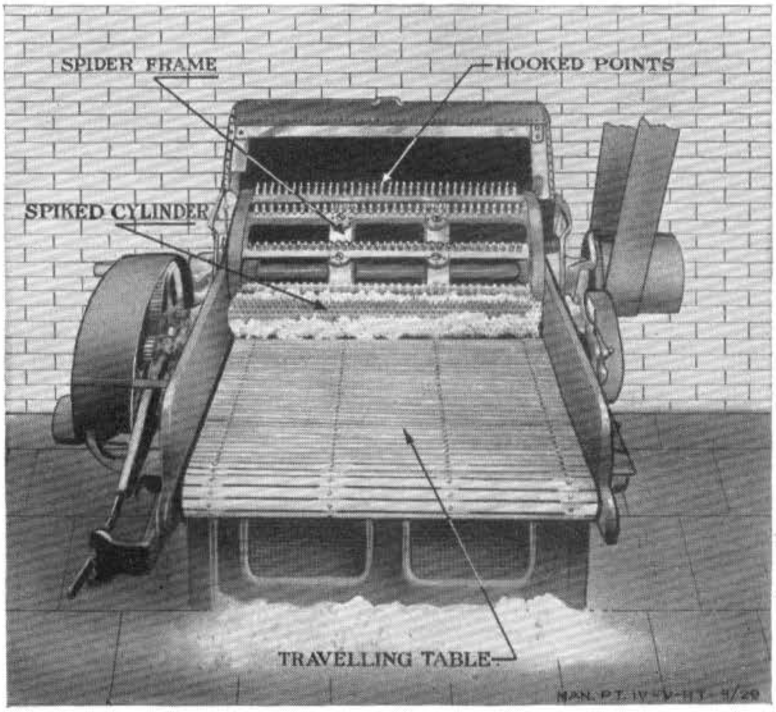

FIGURE 2.—Cotton picking machine.

covered with hooked points. This frame seizes the cotton, shreds it and then passes it out through an opening in the back of the machine into the cotton dryer.

5–14. Cotton in air will absorb about 7 percent moisture. This must be reduced to about 0.5 percent, as excess moisture in the cotton will affect the nitration process. Formerly cotton was dried in bins in a house, the bins being so arranged that a free circulation of heated air was permitted. The present method is to use a continuous drying machine (fig. 3). The cotton enters the dryer from the picker through a chute. A wire mesh belt carries the cotton through a heated chamber. Steam coils supply the heat, and ventilating fans drive the heated air around the conveyor belt. The temperature should not exceed 110°C. The cotton is discharged at the end of the dryer where it is placed in covered cans for transportation to the nitrating house.

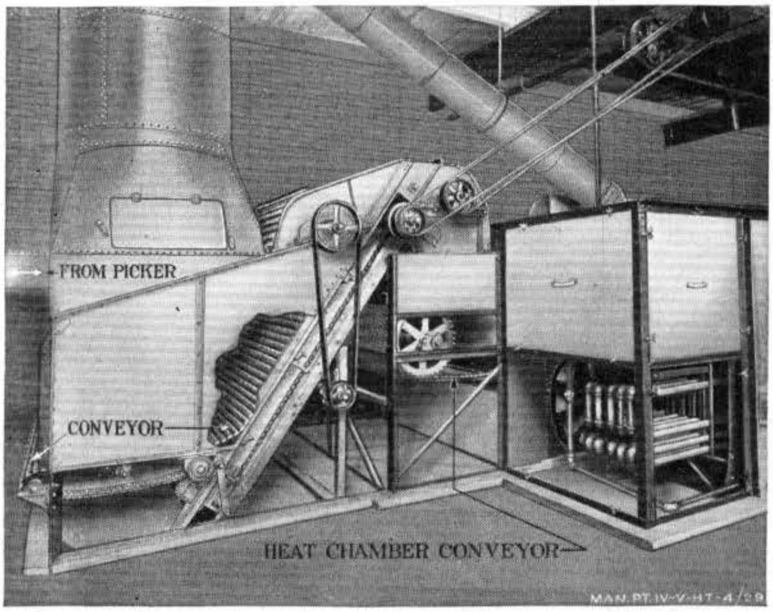

FIGURE 3.—Cotton dryer.

5–15. Four different systems have been in use for the nitrating process: the pot system; the displacement system; the centrifugal system; and the Du Pont mechanical dipper system. The first was the original method used and consisted in steeping the cotton in earthenware pots. In the displacement system shallow pans are used. After nitration of the cotton, water is run slowly into the pans over the mixture of acids and cotton, and the acids are thereby displaced by the water. In the centrifugal system the cotton is nitrated in centrifugal wringers, then wrung out in the same wringer in which it was nitrated. The Du Pont system is most used in this country. The following description applies to this system.

5–16. A diagrammatic sketch of the nitrating house, plate 1, shows three floors. The top floor has four nitrators in each unit, with a mixed acid measuring tank and suitable piping and valves for handling the acid and nitric oxide fumes. The second floor has a centrifugal wringer directly below the outlets of the four nitrating pots. The lower floor has a flume through which the nitrated cotton is washed to the boiling tubs, and also a fume pipe for carrying the nitric oxide fumes from the nitrators and wringer to an outside vent stack where a considerable quantity of weak nitric acid is condensed and collected.

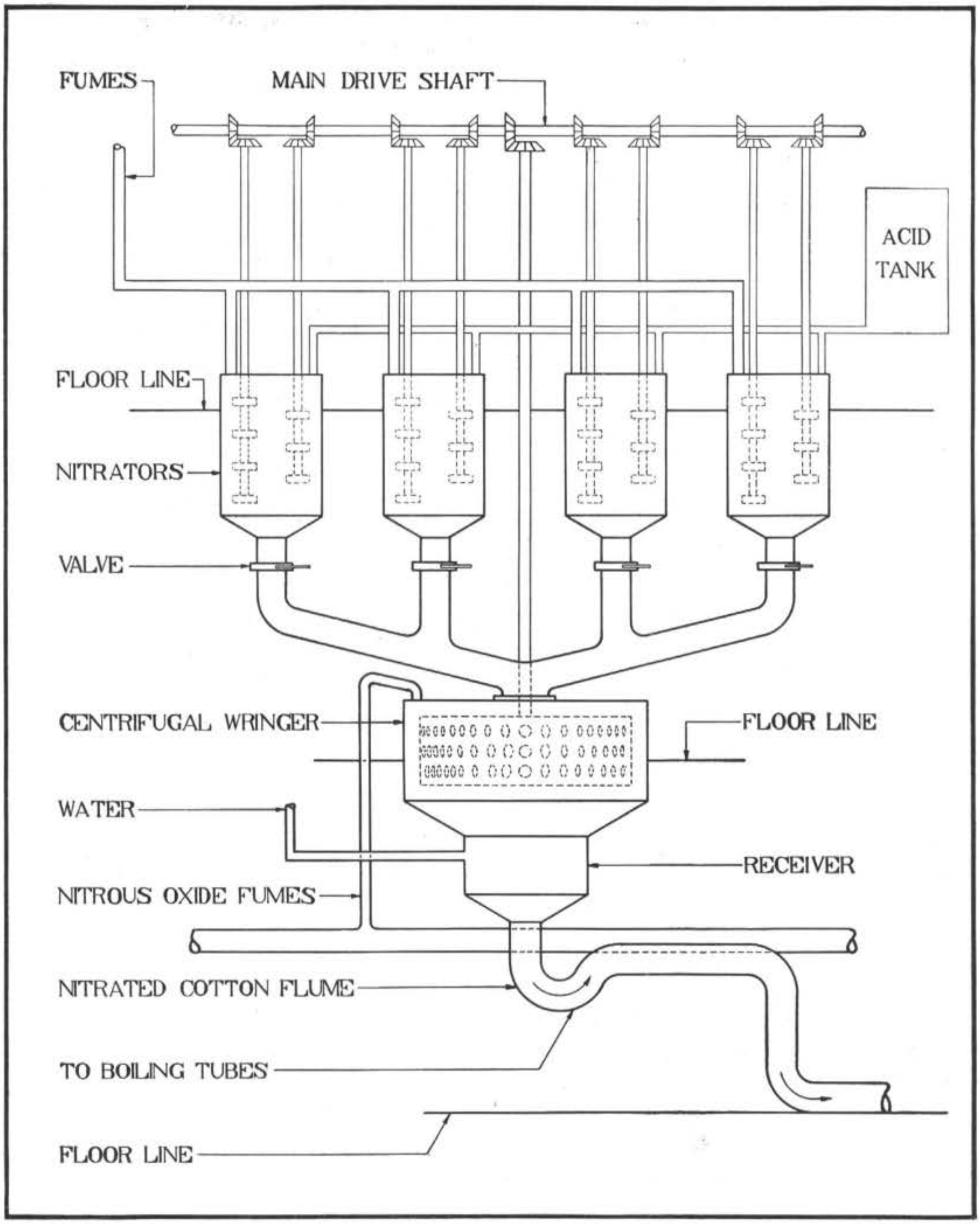

Plate 1.—Diagrammatic arrangement of nitrating process.

5–17. In operating the mechanical dipper system 32 pounds of cotton are dumped into a nitrating pot (fig. 4) and 1,600 pounds of mixed acid at a

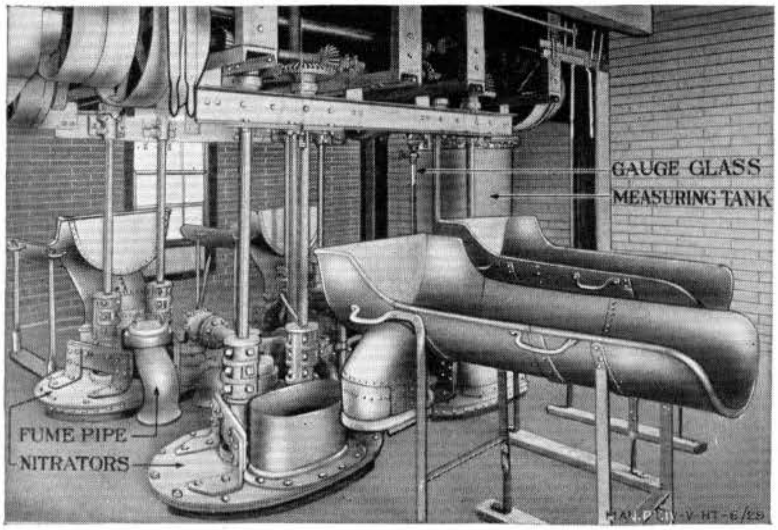

FIGURE 4.—Cotton nitraters.

temperature of 30° C. are run in. The agitator, made up of stainless steel paddles, keeps the charge agitated to prevent local deterioration of the cotton and to mix cotton and acids thoroughly. The charge remains in the nitrator 20 minutes, which is the time found suitable for making soluble nitrocellulose with the particular mixture of acids used. A longer time in the nitrator is of no advantage.

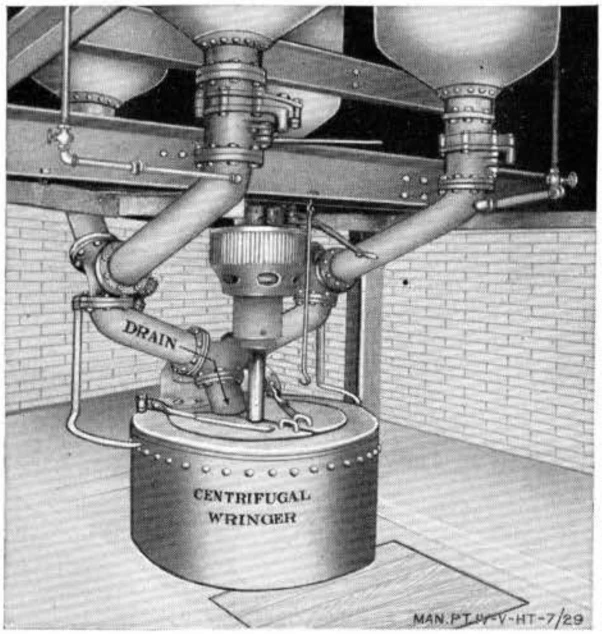

FIGURE 5.—Centrifugal wringer.

5–18. At the end of this time the charge is run into the centrifugal wringer (fig. 5). It removes a large percentage of the mixed acids, which drain into a spent acid tank. The wringer is operated for 5 minutes and is then stopped. At this point the nitrocellulose is about 25 percent saturated with free acids and is unstable in air, being liable to "fire," which is a spectacular reaction giving off dense oxides of nitrogen fumes, accompanied by a total loss of the charge of nitrocellulose. For this reason it is necessary to drown the product in water, which also is a convenient medium for transportation of the nitrocellulose to other processing equipment. The bottom of the wringer is opened and the nitrocellulose is rapidly forked down by a manual operation into the receiver on the first floor (fig. 6) where it is drowned in water and washed into the flume which carries it to boiling tubs. A suction blower system removed the nitric oxide fumes at all points where they are formed and discharges them to the outside vent stack. Special materials, such as steel, stainless steel, duriron or stoneware must be used in all equipment in the nitrating house.

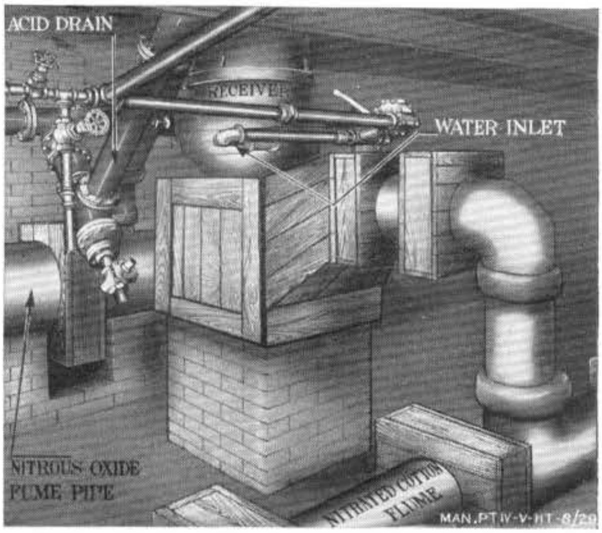

FIGURE 6.—Pyro discharge to boiling tubs.

5–19. The product is now a cellulose nitrate, usually called "pyrocellulose," or "pyro." It contains an excess of acids, cellulose sulphates, and other impurities, which are detrimental to the stability of the final product. It is impracticable to control the nitration process commercially so that the product will be a cellulose of a definite degree of nitration throughout the product. It is a mixture of nitrates of different percentages of nitrogen. The variation, however, can be controlled within limits, giving a product of the desired average nitration: 12.6 percent for Navy standard pyrocellulose.

5–20. The flume from the nitrating house (fig. 7) conducts the pyro by gravity to large wooden boiling tubs. These tubs are fitted with false bottoms to allow drainage of water while retaining pyro and with suitable steam heating apparatus for boiling the pyro. A tub is charged with pyro, sufficient water is run in to cover the material completely, and the temperature is raised to 80° C. The tub is then drained, refilled, and boiled for 40 hours with at least 4 changes of water to insure removal of a large percent of impurities in the cotton fibers. It is important that the water used be of such purity that no additional impurities are added to the pyro. On the conclusion of this treatment, the pyro is water-borne in a flume to bins located over each pulper in

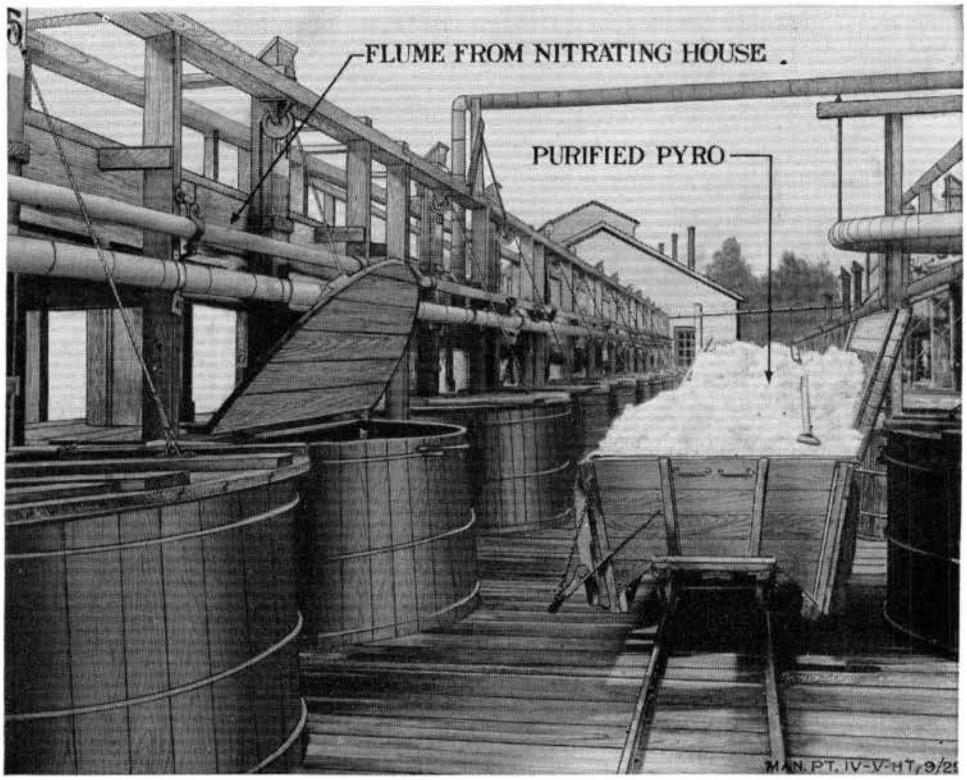

FIGURE 7.—Boiling tubs.

the pulping and poaching house. These bins have false bottoms for drainage of water from the pyro.

5–21. The treatment of the pyro up to this point has removed free acids and impurities principally from the surface of the pyro fibers. As these fibers are still in the same physical form as they were before nitration, the central lumen has absorbed free acids which are not all removed by simple boiling. Elimination of these free acids and other impurities in the center of each fiber is necessary to insure stability of the powder. This important fact was discovered by Abel as a result of his work in determining the causes of instability of gun cotton as originally made. The fibers must be cut up into smaller particles, which is called pulping. Two methods of pulping are commonly used: the Jordan engine and the Miller Duplex beater. A Jordan engine consists of a rotating shaft fitted with sharp knives, surrounded by a cone-shaped cylinder carrying knives. The pyro is fed slowly into the small end, thrown out between moving and fixed knives by centrifugal forces, and gradually worked out through the large end. It is customary to work these engines in multiple, with varying degrees of fineness: the pyro is discharged from the last engine in the required state of fineness for further purification.

5–22. The Miller Duplex beater (fig. 8), consists of a long tank as shown. A revolving drum, fitted with longitudinal knives, works between an upper and

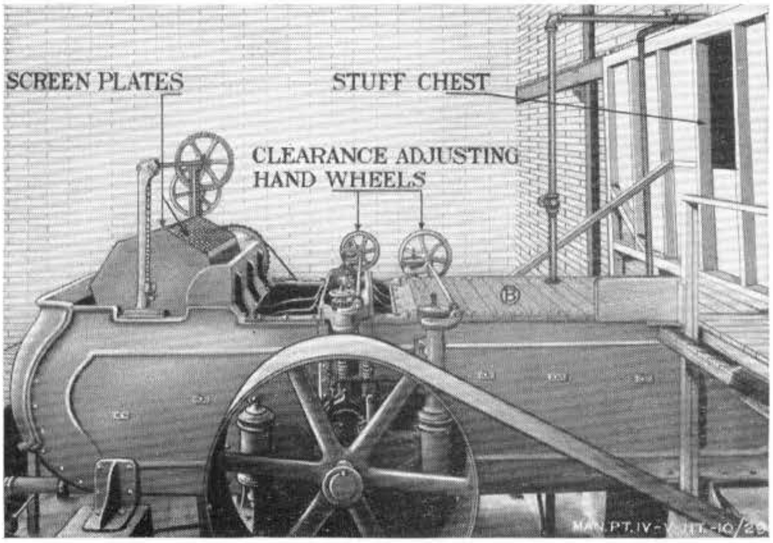

FIGURE 8.—Duplex beater, pulping machine.

lower set of fixed knives, each of which cover 20 degrees of the arc of the drum. The pyro is dumped into the beater through the top. As the drum revolves, the pyro, suspended in water, circulates, and the fibers are cut as they pass between the fixed knives and those on the drum. Hand adjustment of clearances is provided. An octagonal slotted screen is provided for withdrawal of water when the water is changed. The pyro will not pass through this screen. After sufficient pulping the pyro is waterborne to large wooden poacher tubs (fig. 9) where it is given treatment by boiling and washing while being agitated with large rotating paddles. It is boiled for 6 hours, then

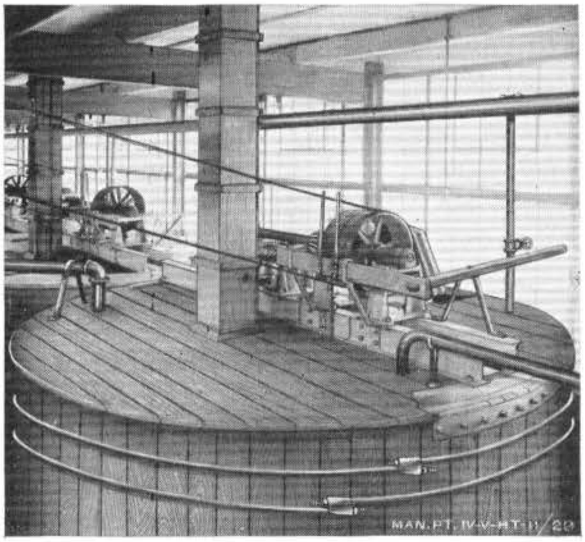

FIGURE 9.—Poaching tubs.

2 hours, then four times for 1 hour. The water is changed for each boiling. It is then washed with cold water 10 times. A sample is then removed and given the required tests.

5–23. The specifications require a heat test at 65.5° C. in the presence of potassium iodide starch paper for at least 35 minutes; a heat test at 135° C. with normal methyl violet paper for at least 25 minutes; a test for percent nitration and percent of insoluble pyrocellulose.

5–24. The pyro must not contain alkali, mercuric chloride, or other substances which might mask the heat tests in any way. If the pyro passes these tests it is run through a Reynolds, or equivalent pyro screen (fig. 10). Pyro which is retained by these screens is repulped and repoached. Pyro which passes these screens is water-borne to the dehydrating house, where it is delivered to large wooden stock tubs.

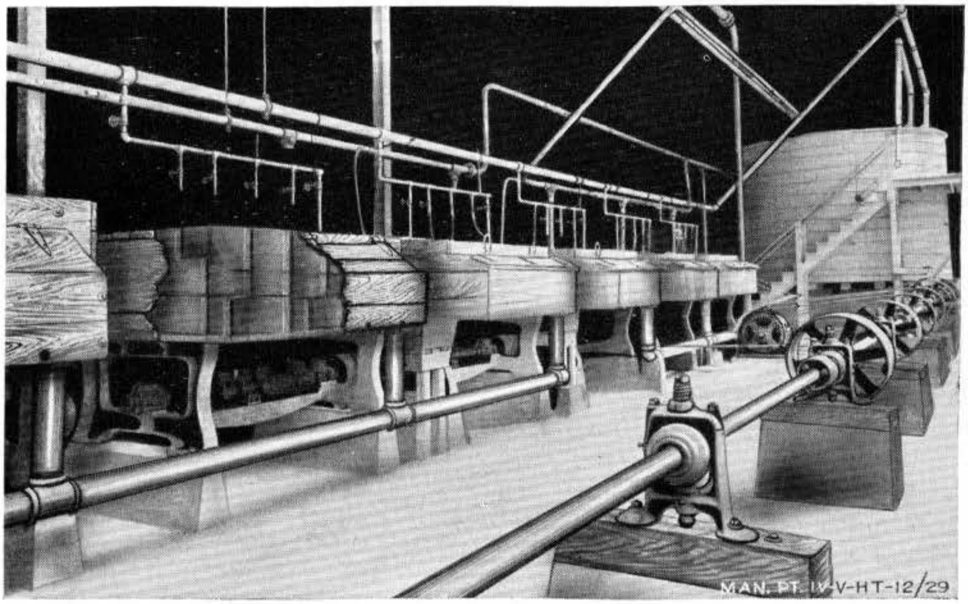

FIGURE 10.—Pyro screens.

5–25. Before being mixed with the ether-alcohol solvent to form a colloid it is necessary to remove all water from the pyro. The first operation is dewatering. Large rotary filters, or dewatering machines (fig. 11) extracts part of the water. This is done by pumping the pyro and water mixture from a particular stock tub to the shell partially surrounding the rotary filter. Water is separated by a wet vacuum pump as the filter slowly rotates. The pyro that remains on the filter is removed mechanically and returned to the stock tub from which it came.

5–26. This continuous operation gradually thickens the mixture of water and pyro in a stock tub. When the water content has been reduced considerably by the dewaterer the pyro is pumped to and wrung out in a centrifugal wringer (fig. 11) and delivered in large pyro cars to the dehydrating press room. At this point the pyro has a moisture content of about 28 percent. The water separated in the above operations is allowed to settle. The pyro carried over with the water is recovered.

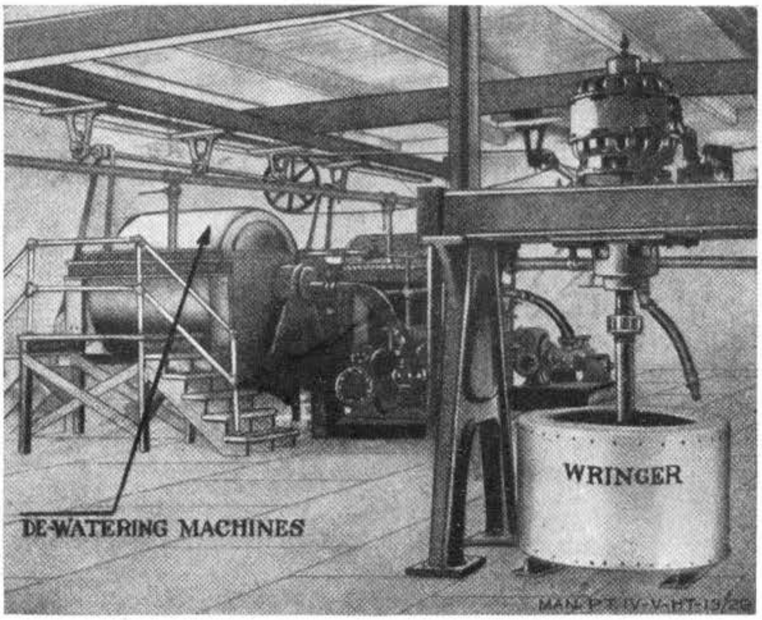

FIGURE 11.—Dewatering machine.

5–27. The final step in removing water is done in the dehydrating press (fig. 12). This press is provided with an upper and lower hydraulic ram. These two rams work in conjunction with the compression cylinder. A charge of moist pyro is weighed and dumped into this cylinder. A pressure of about 200 pounds is then applied. This forces part of the water through a screen in the lower ram. Alcohol is then drawn from a measuring tank by a steam pump and forced through the pyro, by a pressure of about 600 pounds. The alcohol gradually displaces the water. A hydraulic pressure of 3,500 pounds is then applied to the rams. A finished block of pyro containing practically no moisture and a definite percentage of alcohol is formed (fig. 12).

5–28. These blocks are transported in cans to the "block breaker" which reduces the blocks to a coarse, fluffy mass which is weighed out in cans and

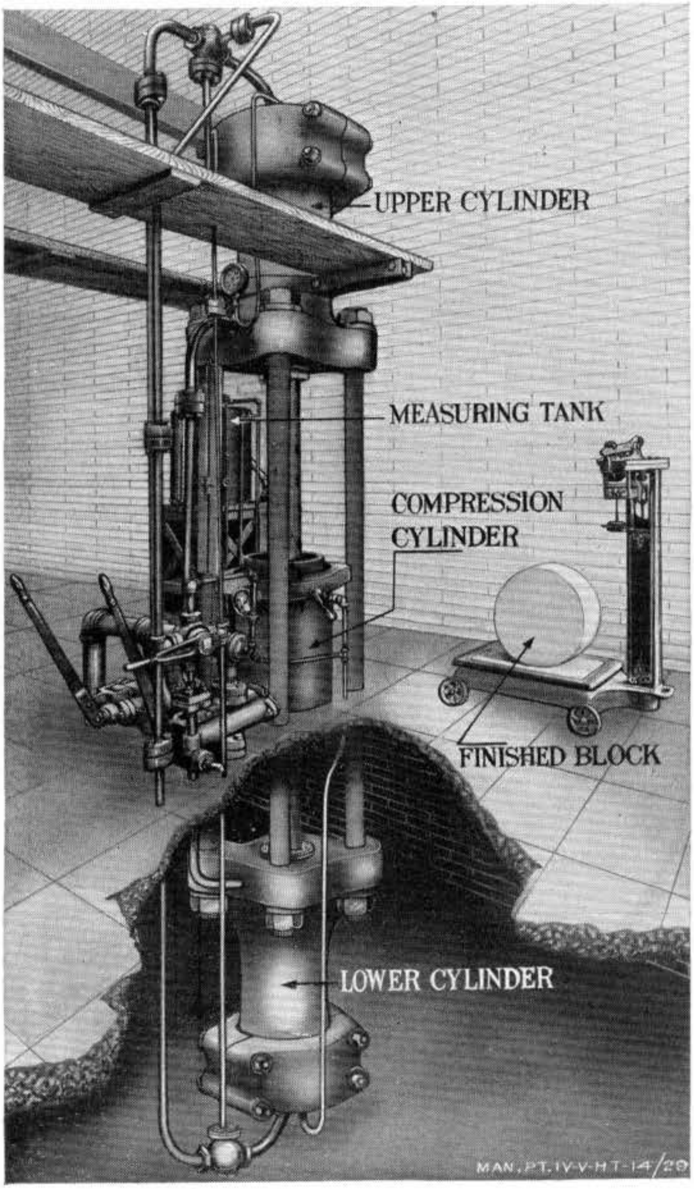

FIGURE 12.—Dehydrating press.

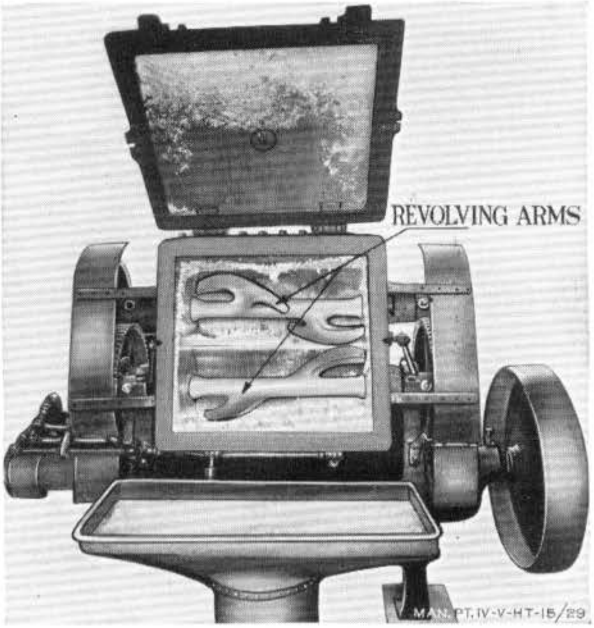

FIGURE 13.—Mixing machine.

transferred to mixing machines (fig. 13), similar to dough mixers. A charge is placed in the machine, the cover is secured, and the revolving arms are set in motion. Ether containing the powder stabilizer, diphenylamine, in solution, is added from a measuring tank. The amount of stabilizer added depends on the web of the powder. Powders up to about 5-inch contain 1 percent, and larger caliber powders contain one-half percent of the weight of the finished powder.

5–29. After the charge is thoroughly mixed it is dumped into cans and transferred to the block press (fig. 14), where the mixture is subjected to 1,600 pounds pressure in a cylinder with a removable head. It is removed from the blocking press as a plastic colloid in the form of cylindrical blocks, and transferred in cars to the die press house. In order to insure a thoroughly mixed,

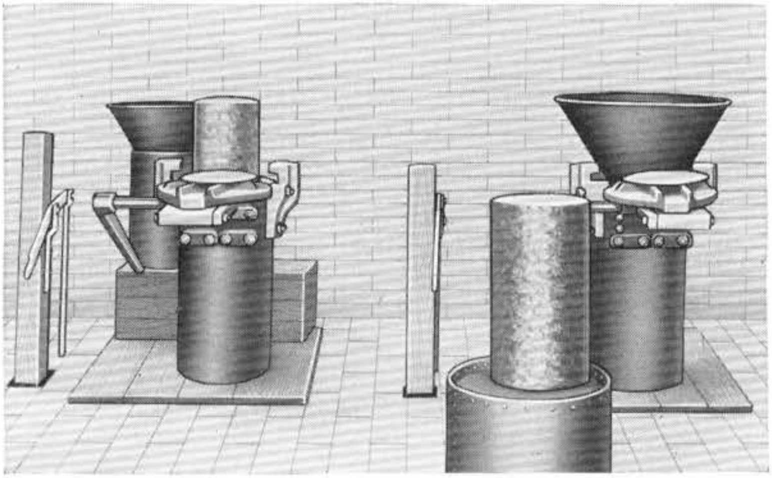

FIGURE 14.—Blocking press.

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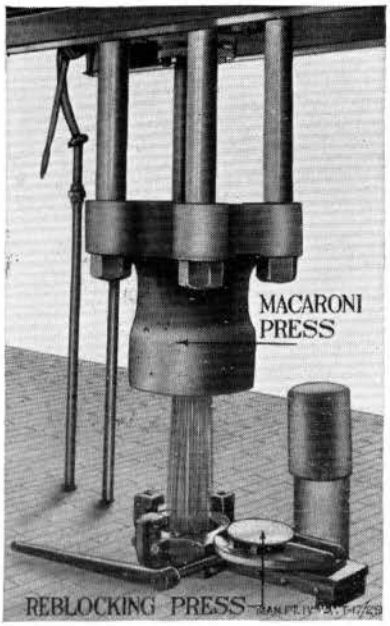

FIGURE 15.—Macaroni press.

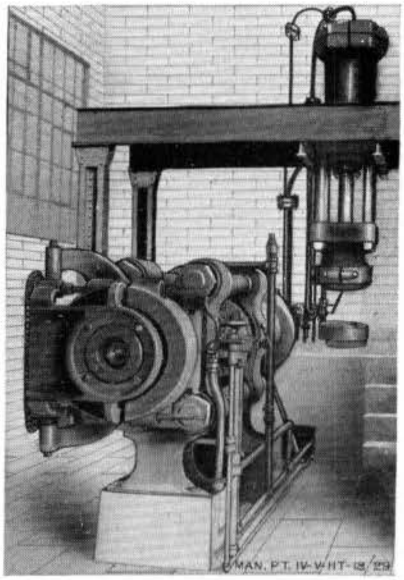

FIGURE 16.—Graining press.

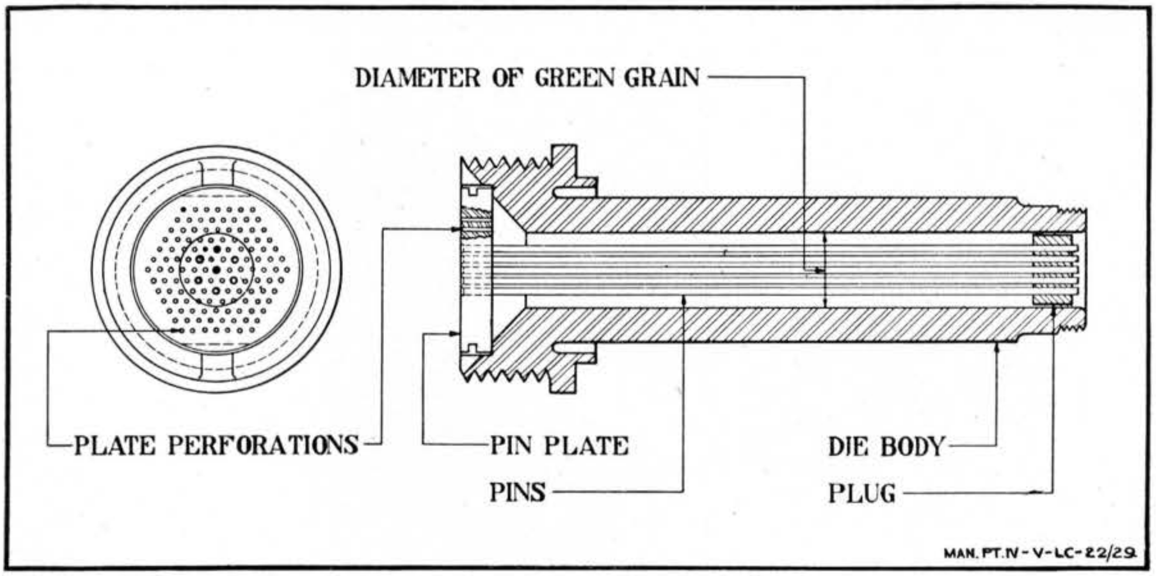

FIGURE 17.—Powder die for multiperforated grains.

uniform colloid, and to eliminate lumps and foreign matter, the blocks are pressed through the macaroni press (fig. 15). This press has a screen head, containing a large number of small holes. The powder is forced through this

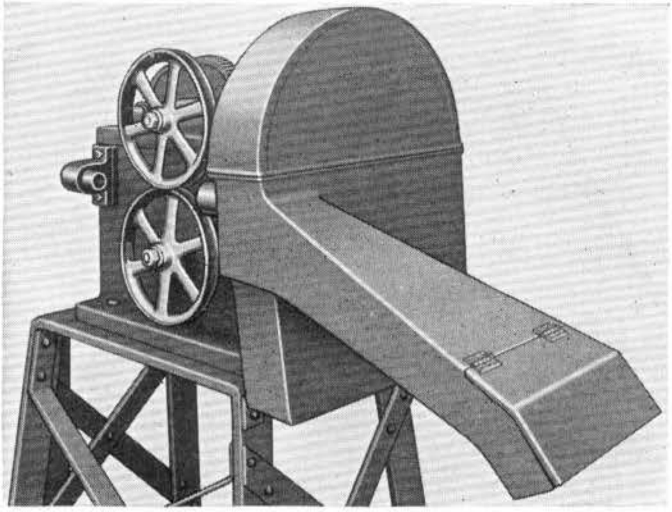

FIGURE 18.—Grain cutter (cover in place).

screen, and forms long solid threads, which are collected in the cylinder of a reblocking press similar to the blocking press. The powder is reblocked and taken to the graining press (fig. 16). It is forced through the die, (fig. 17) in this

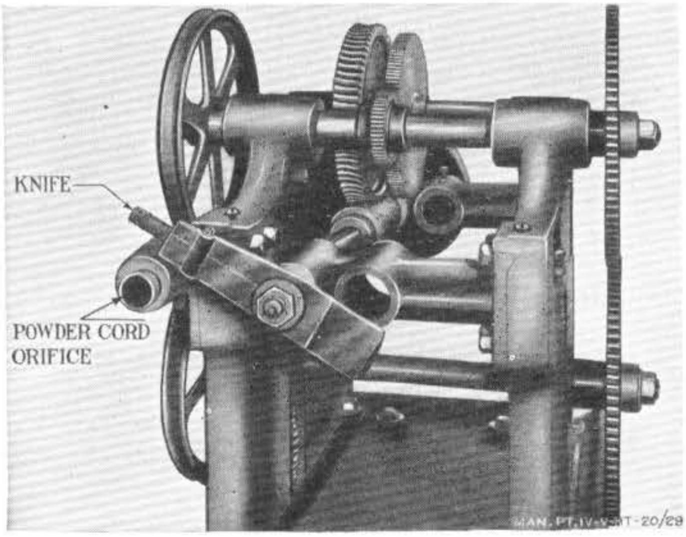

FIGURE 19.—Grain cutter (cover removed).

press coming out as a long cord with the perforations made in it and is immediately passed through the grain cutters (figs. 18–19). The grains in the form shown in figure 20 are transported to the solvent recovery plant for removal and recovery of excess solvents. After solvent recovery the grains are removed to dry houses where the solvent content is reduced to the desired value.

5–30. Certain powders have other ingredients added to make them moisture-repellant forming "NH" powders. Such materials include dibutylphthalate and/or dinitrotoluene. Since these materials do not have the decomposition power of "pyro" a higher nitration, 13.17 percent N is required. These additional materials are added in the mixer. Since the composition is water-repellant, the excess solvent can be removed with water instead of air as is the case for "pyro" powders. Water drying is a much more rapid process.

FIGURE 20.—Sorting table.

5–31. Pyro and "NH" powders often produce "muzzle flash," due to the high temperature of the gases liberated. Flash may be reduced or eliminated by the presence of inert, difficultly volatile materials in the guns at the time of firing. The chief one used is potassium sulfate. This substance may either be incorporated in the powder, in the mixers, or added to the charge in the form of pellets. In either case there is a marked increase in smoke.

5–32. Smokeless powders containing nitroglycerine in addition to nitrocellulose are use as propellants by many nations. The United States Navy uses these only as the propelling charge for various types of rockets.

Chapter VI. EXAMINATION AND TESTS OF POWDER ABOARD SHIP

Assignment to lots.

6–1. The details of manufacture of smokeless powder are discussed in chapter 5. The powder is manufactured in lots for the purpose of test and issue, the lots varying in weight from 25,000 to 500,000 pounds, depending on the granulation. For lots over 125,000 pounds manufacture is in sections of 125,000 pounds each. After proof and acceptance a lot, or a blend of several lots, is given an index number and assigned to one or more specific guns with a definite weight of charge for each combination of gun, projectile and muzzle velocity. Normally a powder is designed for but one caliber, but if it be suitable for other calibers it may be so assigned.

Designation of lots; unstabilized.

6–2. Index numbers are assigned serially—number 1 having been the first smokeless powder accepted, and, except for the class designation shown in the letters preceding the number, they tell nothing about the powder beyond an approximate indication of its age. The designating letters are—

SP—Smokeless powder, made without stabilizer or indicator, none now in service.

SPR—Smokeless powder with rosaniline indicator. Reddish in color. None now in service.

SPD—Smokeless powder stabilized by addition of diphenylamine. All powders since SPD 883 have been stabilized.

SPDW—Reworked powder, made from ground stabilized smokeless powders. Generally manufactured for target practice use. A few indexes are still used as service ammunition.

SPDB—A blend of stabilized smokeless powders. The blend may be made to provide an index of ample size for a ship's service allowance, or to utilize small remnants for target practice purposes. A blend of large and small web powders may be made to produce an equivalent intermediate web.

SPDN—Nonhygroscopic powder; stabilized smokeless powder with the further addition of certain nonvolatile materials to reduce hygroscopicity and increase service life. Now in service only in webs for 5-inch, .38 caliber and below.

SPDX—Stabilized smokeless powder, water-dried. In this process the long period in the dry house is replaced by a shorter time in tanks of warm water followed by a short air drying. At the present time X powders are all of wartime manufacture and are being reworked as opportunity offers and are to be replaced with new powders.

SPDF—Flashless powders—made so by the addition of certain compounds which reduce muzzle flash.

Stability.

6–3. Smokeless powder, containing as it does the volatile substances, ether, and alcohol, cannot be held to possess unlimited chemical stability and the length of its life depends very largely on the conditions under which it is stored. At temperatures approaching 100° F. the period during which it will retain stability sufficient to warrant its retention in service is relatively short. Although chemical tests give an indication as to the probable life of powder, no satisfactory method has been devised of foretelling with certainty its length of life. The only safeguard is, therefore, to discover loss of stability by frequent tests, and such tests shall be made with increasing care and vigilance as the powder becomes older.

Care in carrying out tests.

6–4. Officers charged with the care of magazines and the examination and tests of smokeless powder shall thoroughly familiarize themselves with the practical methods of making such examination and tests, and they shall be held responsible for the accuracy thereof and for the correctness of the official reports thereon. In order that the tests may be of value and indicative of the stability of powder it is essential that the methods in all details shall be uniform, and those charged with this duty must follow strictly the prescribed methods. The apparatus and methods to be used are described in detail later on. Commanding officers may take advantage of visits to navy yards to send officers whose duties require supervision over powder tests to the ammunition depot in the vicinity for the purpose of obtaining special instruction in surveillance test work and for checking methods and results.

Record of tests.

6–5. The Bureau of Ordnance records all tests reported from the various sources and keeps careful records of the disposition and condition of each index, in order that proper steps may be taken, without delay, to dispose of any index which develops low stability. In the case of powder on the Asiatic Station, including Guam, this duty has been delegated to the Inspector of Ordnance in Charge of the Naval Ammunition Depot, Cavite, P. I. In order, therefore, that the system may be carried out care is enjoined to submit correct and complete routine reports of ammunition on hand, stability tests, etc. More complete information regarding these reports is continued in chapter 23.

Prescribed tests.

6–6. The following examination and tests shall be made of smokeless powder on board ship:

(1) For all service powders except 20-mm., 40-mm., 1″1-inch and 5″/25 calibers and powder for small guns assembled in crimped cartridges:

(*a*) *Daily.*—Visual examination of samples and test for local heating in magazines. Examination of violet paper.

(*b*) *Fortnightly.*—Visual examination of each replacement sample.

(*c*) *Monthly.*—Visual examination of one or more charges of each index; 65.5° C. surveillance tests on samples from broken-down charges on all indexes that give a test of less than 30 days.

(*d*) *Bimonthly.*—65.5° surveillance test from replacement samples on all indexes giving 30 to 39 days' test.

(*e*) *Quarterly.*—65.5° surveillance test from replacement samples on all indexes giving 40 to 59 days' test.

(*f*) *Semiannually.*—65.5° surveillance test from broken down charges on all indexes on board.

(2) For service powders assembled in crimped cartridges the same tests and examinations are required, but ships not furnished with special tools for breaking down and reassembling such cartridges shall request the assistance of vessels in company having such facilities or shall send the necessary cartridges to an ammunition depot for break-down, test, reassembly, and return. A sufficient quantity of the replacement sample(s) shall accompany the cartridge(s). The ship or depot conducting the test shall be furnished with the appropriate Smokeless Powder Test Card with all data except the time of test. On completion of the test the cards shall be completed and forwarded to the Bureau, a copy being returned to the ship concerned.

(3) The peculiar nature of the heavy machine gun cartridge assembly makes a departure from the above instructions desirable. The visual examination of broken down charges and the surveillance tests are replaced by the following procedure:

(*a*) In order to avoid possible damage to the details of the assembly, if cartridges were broken down to comply with the above instructions, the Bureau authorizes at other than ammunition depots the omission of the monthly examination of charges, but not of prescribed visual examinations of the exterior of cartridges for heavy machine-gun cartridges issued for either service or target purposes, until such time as surveillance tests indicate a stability of less than 60 days for the powder indexes involved.

(*b*) Instructions for surveillance tests are modified to the extent that instead of breaking down a heavy machine-gun cartridge to obtain the powder, the test sample shall be taken from powder of the corresponding index stowed in a sealed bottle in the magazine with the ammunition requiring test. Where no surveillance oven is available on board ship or at the activity requiring the test, the sample shall be forwarded in the original bottle, without breaking the seal, to the activity conducting the test. Depots shall supply with future deliveries of service and target ammunition a sufficient number of 100-gram powder samples in 8-ounce sealed magazine sample bottles to provide for surveillance tests over a period of 4 years for service ammunition, and for the balance of the gunnery year for which issued for target ammunition. A dated strip of tenth normal violet paper shall be added to each sample and the bottles shall be sealed by coating the seated glass stopper and the neck with molten paraffin. Each bottle shall be labeled "Special surveillance test sample for U. S. S. __________________, SPDN ______________, Prepared __________ (Date), by Naval Ammunition Depot ____________________." These are in addition to the regular magazine samples. Provision for stowage of the special surveillance samples is considered within the capacity of the ship's force.

(*c*) In lieu of the monthly examinations, it requested that upon each visit of a ship carrying heavy machine-gun ammunition to the vicinity of a naval ammunition depot, but not more often than once in 9 months, the commanding Officer request the Inspector of Ordnance in Charge to select a total of 36 rounds from each magazine in which 1″1-inch and 40-mm. ammunition is stowed. The 36 rounds shall be selected from at least 18 boxes but should be transported to the depot in one box. The ship's replacement samples of the indexes concerned shall be turned in at the same time that the cartridges are turned in for inspection. The cartridges in the box so selected shall be broken down, the powder examined, and, if found in satisfactory condition, the cartridges shall be reassembled using cases and primers from stock, and returned to the vessel. 20-mm. ammunition shall be treated as prescribed for small arms. On the occasion of a ship's regular navy yard overhaul surveillance test samples from the powder in the cartridges and a test sample from the replacement sample shall be selected by and tests started at the depot during the inspection of broken-down cartridges in order that a comparison of test results of powder in cartridges and the special samples in the ship may be made. Necessary hand crimpers and gages will be furnished depots not already so supplied.

Magazine samples.

6–7. When ammunition containing smokeless powder is issued to a ship by an ammunition depot, there shall be supplied with each issue "magazine samples" contained in a glass bottle with a tight glass stopper, one for each index and magazine in which the index is to be stowed, and a "replacement sample" in an airtight glass or metal container for use in bringing up to weight a charge which has been drawn on for surveillance test; one of the latter for each index issued. When ammunition is transferred, these samples shall accompany it. In case ammunition is expended, the magazine sample bottles and the replacement samples shall be returned to an ammunition depot. Ammunition depots keep on hand for observation small amounts of each index issued, these samples being known as "retained samples."

Stowage of magazine samples.

6–8. The different magazine samples shall be stored in the racks provided, in the same magazine with the indexes which they represent and shall not be opened except for the purpose of changing the violet paper, as provided for below. Magazine sample bottles shall not be used in surveillance ovens, nor shall "nonsol" bottles, especially prescribed for making surveillance tests, be used for magazine samples. Each magazine sample, when received, will have a strip of N/10 violet paper in it bearing a date showing when the test was started.

6–9. The daily examination shall be made as part of the daily magazine inspection, which shall be made of all magazines and ammunition spaces, and shall consist of a visual examination of each magazine sample in a good light, without removing the stopper, to note whether the powder retains its normal appearance and any change in the color of the violet paper. The presence, at any time, of reddish brown or orange colored fumes in the bottle will indicate decomposition of the powder. **Daily examination.**

6–10. The result of the decomposition of nitrocellulose powder is the emanation of oxides of nitrogen, which, if not immediately absorbed by the stabilizers, will be given off in the form of gases. These gases are strongly acid and will attack material like metal or powder-bag cloth. They also possess oxidizing properties, and this fact is taken advantage of in the violet paper test, as the coloring material of the paper, methyl violet, is decolorized by the oxides of nitrogen. The strips of violet paper issued are of standard size and contain a definite amount of the coloring material. The paper strips, when exposed to the gases given off by the decomposition of a standard sample powder, are attacked and will absorb a definite amount of oxides of nitrogen, and the coloring material in the paper will be changed from violet to white. The time required for this change in color is an indication of the relative rate of decomposition of the powder. For this reason only one strip shall be exposed to a sample at one time. **Principle of violet paper test.**

6–11. Two kinds of methyl violet paper are made for use in conducting test of smokeless powder. One, known as normal violet paper, has a deep tint and is used only in the laboratory for making the "German test at 135° C.," required by the powder specifications. The other is known as one-tenth (N/10) normal violet paper, and has a paler tint. The latter is issued to ships and ammunition depots for testing smokeless powder at normal atmospheric temperatures. The Naval Powder Factory, at which the paper is manufactured in the laboratory, is the source of supply for replenishment of depot stocks. When received, the paper shall be transferred to tight glass-stoppered bottles, if the shipping bottles are not satisfactorily tight, and stored in a dark place. It is not affected by ordinary handling, but should be kept clean and dry, and it is used dry. It is not affected by acids other than oxides of nitrogen, and is only slightly affected by light, but it is better to subject all tests to as little light as possible. Deteriorating paper will show up by a whitening around the edges and when this occurs a fresh supply should be obtained. Ships should draw N/10 normal violet paper from ammunition depots in quantities sufficient for about 1 year's use in order to avoid accumulating stocks on board ship and to insure fresh paper's being available for tests. It is not considered desirable to have supply officers keep violet test paper on hand, as technical supervision is required to insure the use of a suitable quality. **Kinds of violet paper.**

6–12. The object of the violet paper test is to provide a continuous visual indication of the condition of the powder index represented by the sample. It **Object of violet paper test.**

supplements the surveillance test. It cannot be regarded as a definite quantitative test to the same extent as the surveillance test. All indexes aboard ships shall be continuously subjected to violet paper tests by means of the magazine samples, and ships not equipped with surveillance test ovens shall have three samples, each representing a different charge of all powders on board continuously subjected to this test. The extra samples required shall be supplied by the ammunition depot issuing the original outfit. If not on hand they shall be made up by a depot conducting an inspection or overhaul. Doubtful powder should be given special attention on violet paper tests.

Method of conducting violet paper test.

6-13. To test powder from rounds, charges, or bulk powder, a sample of 12 ounces of the powder for calibers larger than 8-inch shall be placed in a 16-ounce glass stoppered bottle, and a sample of 6 to 8 ounces for calibers 8-inch or smaller in an 8-ounce glass stoppered bottle. Fruit jars or 8-ounce bottles partly full will permit of carrying on a satisfactory test, as the quantity does not change the test, but it is better to have a standard procedure. ONE strip of DRY violet paper, marked in lead pencil with the date of starting the test, is dropped into the bottle on the powder and the bottle is then closed tightly. It is preferable to stow the bottle in the warmest part of the magazine, but as a rule special racks are provided. The bottle should be carefully protected from bright sunlight. The change in color due to the oxides of nitrogen, if any are present, causes a gradual fading to a faint violet, then a change to blue, and finally total loss of color, leaving a white paper. The duration of the test is the number of days required for the paper to become white, and the bottle should not be opened during this time. In submitting reports of tests always show the total number of days from date on paper that the strip has been in the bottle, omitting the (+) sign to show that the paper has not turned white. The paper will not become white in two months at ordinary temperatures. The same paper can remain in a sample bottle indefinitely, so long as it does not turn white. Cases have occurred where this test has run continuously for several years. If a noticeable change in color occurs in 2 months, another sample bottle should be started.

Influence of temperature.

6-14. As the decomposition of nitrocellulose powder depends to a very large degree on the temperatures to which the powder is subjected, so the duration of the violet paper test is dependent on the temperatures existing during the test. The violet paper test of two months specified for serviceable powders above is intended as a minimum under the average temperature conditions obtaining aboard ship.

6-15. The following table presents some useful comparisons between results of violet paper tests and surveillance tests of the same powders.

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COMPARISON OF SURVEILLANCE AND VIOLET PAPER TESTS

Powder samples	Surveillance test at 150° F. in days	Violet paper test				
		At 64° F. in days	At 70° F. in days	At 100° F. in days	At 110° F. in days	At 150° F. in days
6-pounder	7	217	67	12	3	2
Do	21	400+	252+	39	13	2
5-inch, 51-caliber	19	81	21	5	2	2
Do	48	334	220	12	7	3

6–16. The total loss of color by violet paper should be checked by examination in good light and comparison with prepared standards as furnished by the Naval Powder Factory. *Standard of color of violet paper.*

6–17. Fortnightly, the powder in each replacement sample shall be visually examined for signs of decomposition or change in appearance. After making this examination, particular pains shall be taken to see that the replacement sample containers, the contents of which are to be exposed for as short a time as possible, are restored to their former airtight condition. In the event no replacement sample is furnished, one charge shall be used for this purpose and be plainly marked as such. The lack of a replacement sample shall be immediately brought to the attention of the depot issuing the ammunition, and, if none be furnished then, to the attention of the Bureau. *Fortnightly test.*

6–18. Monthly, the powder in one or more charges of each index shall be visually examined for signs of decomposition or change in appearance and test samples removed for 65.5° surveillance test on all indexes which gave a test of less than 30 days on the last surveillance test. Different charges shall be selected each time for this examination, and care shall be exercised to expose the charge for as short a time as will permit a thorough examination and to restore the tanks or cartridge cases to their former airtight condition. *Monthly test.*

6–19. When a charge of powder decomposes, nitrous fumes are given off. These fumes have a pungent, characteristic odor which can be detected by smell when the package is first opened. To make this of value it is necessary that the nostrils be applied to the charge immediately after opening the case and that the officer making the examination be familiar with the odor of such nitrous acid or nitrous fumes. They must not be confused with the odor of ether or alcohol, which is normal, or with acetic acid odors, which are sometimes present in old ammunition. If decomposition has proceeded very far, the metal container may show signs of attack by formation of a green or white rust on the inside. Only in the very worst cases are there likely to be present orange colored fumes of nitrous acid, and this would be accompanied by very strong corrosion of the case and an overpowering acid odor. *Nitrous fumes.*

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Visual examination.

6–20. The examination of powder for physical appearance should be made in a good light and by comparison with the magazine bottled sample. So long as the sample in the bottle maintains a reasonably good violet paper test, this sample may be considered representative of the index. In examination of the charges the idea is to note a change from its original condition by comparison with the sample. Powder in service is of various colors, ranging from buff color to amber and black. Stabilized powders may become black with only very slight decomposition, so that any darkening of the grain is not a criterion of its stability, as such a grain may be dead black and still have present 90 percent of the stabilizer.

Change in appearance.

6–21. When a grain of powder has considerably decomposed there is always set free nitrous acid which attacks the alcohol present in the grain and the tough qualities are in a measure lost. Fine hairline cracks develop on the edge of the grain where there is the greatest loss of volatiles. Here the grain becomes brittle and the structure may be crumbled and broken off much like sugar, while the balance of the grain is still tough and hornlike. Finally the whole of the grain may be involved in this brittle condition. Grains which have developed even the first stages of such brittleness will show a very low violet paper test and surveillance test, and such tests should be made to confirm the first diagnosis.

Surveillance tests.

6–22. Periodic surveillance tests shall be conducted on every index on board in accordance with the table in paragraph 6–6(1).

Special surveillance tests shall be made at such times as the officer responsible for the same considers necessary or proper, due to abnormal or unusual conditions, such as undue heating of magazines, etc. Wherever an index indicates loss of stability in the daily or fortnightly examinations or in the violet paper test, it shall be subjected to the surveillance test at once.

Target practice, training, or experimental firing ammunition afloat need not be broken down for surveillance test within six months of its issue from a naval ammunition depot, but thereafter ammunition of this type shall be tested the same as service ammunition, using powder from the magazine samples for the surveillance test. Small arms powder in rounds afloat need not be tested.

Principle of test.

6–23. Any nitrocellulose powder will gradually decompose at high temperatures. For stabilized powders, as the temperature increases above 90° F., the rate of decomposition rises rapidly. At ordinary atmospheric temperatures, however, such as are found in the magazines aboard ship, the rate of decomposition of serviceable powder is slow, and it is difficult to obtain quantitative data regarding the stability of a given powder subjected only to normal temperatures, owing to the time required for the completion of a test. The violet paper test may be expected to show up a "bad" powder which is rapidly decomposing, but it cannot be expected to give quantitative data regarding the stability and rate of decomposition of powders which are still serviceable.

6–24. This quantitative data is absolutely necessary for all powders afloat and ashore, not only for the protection of the ships, shore depots, and personnel concerned in their handling and storage, but also for the guidance of the Bureau of Ordnance in withdrawing powders from service when their stability begins to show progressive deterioration. **Necessity for test.**

6–25. To obtain the necessary quantitative data regarding the stability of a given powder, advantage is taken of the fact that the rate of decomposition of smokeless powder is much greater at elevated temperatures than at normal atmospheric temperatures. The decomposition of the powder to be tested is "forced" by subjecting it to a constant artificial temperature of 65.5° C. (150° F.), and the time required by a standard sample of the powder to give off a standard visible amount of nitrous oxides (products of decomposition) is noted. This test is known as the surveillance test, and the result expressed in "days" serves to give a definite measure of the stability of the powder. Successive surveillance tests show the rate of decomposition of the powder and form the basis of the data on which powders are condemned and withdrawn from service. **Results from test.**

6–26. In the surveillance test a fixed quantity of the powder to be tested is inclosed in a *special*, tight, glass-stoppered, "non-sol" bottle and exposed to a constant temperature of 65.5° C. in an electrically heated constant temperature surveillance oven supplied for the purpose to all battleships, carriers, cruisers, tenders, and large gunboats. The sample under test is examined once daily until red fumes appear; which marks the end of the test. The record to be made is the number of days it has taken to develop these fumes. The surveillance oven is described in chapter VII. **How made.**

6–27. The results of the surveillance test shall be reported to the Bureau of Ordnance on the Smokeless Powder Test Card (Ord. Form No. 67 and 67A). At the end of 60 days the test shall be discontinued, unless for particular reasons it is desirable to run it longer, and any index which does not give red fumes within this period is to be reported as "60 days +." **Reports of results.**

6–28. On board ship when a powder gives a surveillance test of or below the limits given in the following table, a special report shall be made to the Bureau of Ordnance immediately and three samples shall be immediately forwarded to the nearest naval ammunition depot with a notation of the circumstances. The naval ammunition depot receiving the samples shall immediately make surveillance tests and shall report the results of each as soon as completed. **Danger point.**

Caliber:	*Days*
16″/14″/12″/50	23
8″/55	19
6″/53; 7″/45	18
6″/47; 6″/50	17
5″/51; 4″/50; Mark 9	17
5″/25; 5″/38; 5″/51; 4″/50; Mark 7	16
3″/50	15
All others	15

Action to be taken when below danger point.

6–29. Smokeless powder indexes or parts thereof at naval ammunition depots giving less than two-thirds the limits fixed in the above table, will be segregated pending instruction from the Bureau of Ordnance regarding their disposition.

Surveillance test bottles.

6–30. Before making a surveillance test, the required number of 8-ounce, salt-mouth, glass-stoppered surveillance sample bottles should be thoroughly washed and dried. Stoppers for these bottles are ground to fit individual bottles and should be attached loosely to their respective bottles with twine. The twine must not be used to tie the stopper down during a test. Sealing wax shall not be used to seal bottles during a test. Surveillance sample bottles shall not be used for violet paper tests. Surveillance sample bottles may readily be identified by the ground or etched space about 2 inches by 1 inch on the side of the bottle near the bottom. This space is to be used for pencil markings showing the index number and date of commencing and ending the test.

Selection of samples.

6–31. Samples for additional surveillance tests may be selected at the discretion of the gunnery officer, but the samples for the surveillance tests required by paragraph 6–22 must be selected as provided therein. The powder shall be exposed to the air as short a time as possible. Five whole grains shall be used for large grained powders—12″/50 and above; 45 grams in whole grains shall be used for all other powders. The data necessary to identify each sample shall be entered in pencil in the etched area on the bottle, and the stoppers fitted snugly. The bottles shall then be placed in the surveillance oven, empty spaces being filled with empty stoppered bottles to insure a more even distribution of heat. The room containing the oven should be maintained at as even a temperature as practicable. The test requires that the temperature within the oven be maintained at 65.5° C. plus or minus 1° C. While the thermostat may be expected to regulate the heat within these limits, the ship's organization should provide for a frequent check on the temperature of the oven in order that neither too low a temperature vitiate the test nor too high a one cause an explosion of one or more sample bottles. It must be borne in mind that the basis of the test is the accelerated breaking down of the molecules of nitrocelullose by the application of heat and that the greater the heat applied the earlier the nitrous oxide fumes will appear. As it is impossible to predict just when the nitrous oxide fumes will appear, each bottle containing a sample shall be examined daily. The examination will consist of comparing the bottle with the fume tube against a white background to detect the appearance of the characteristic red fumes. With each oven there is supplied a fume tube prepared at the Naval Powder Factory and containing nitrous oxide fumes generated according to the fixed standards. The bottles must not be opened while the test is in progress, and the time out of the oven shall be as short as possible.

Completion of test.

6–32. When the red fumes appear in a bottle the test is completed, and a record is made of the number of days which have elapsed since the test was started, this being the measure of the stability of the powder. Should there be any doubt as to the presence of fumes at a daily examination, the appearance should be carefully noted and a close examination made on the following day, when the additional 24 hours' exposure should have considerably increased the depth of color. The standard fume tube should always be used for comparison. When unmistakable signs of red fumes have appeared, or when the test has run for 60 days, the bottle shall be promptly removed from the oven and the sample thrown overboard. After a test the bottles are thoroughly washed and dried and another test started, or else they are reserved for future use. With small caliber powders not in good condition, the fumes develop quite rapidly, and the powder might explode if the test is carried too far. This is due to the fact that the rate of decomposition is increased by the presence of the oxide fumes, but no case of this sort has occurred with large caliber powders, where the proper temperature has been maintained constantly.

Care in carrying out tests.

6–33. To have results of any value, it is most essential that personnel strictly comply with the instructions for carrying out the surveilance test. If conditions are constant, the results obtained are practically duplicated on tests at different times, unless some change has taken place in the powder sample. An increase in moisture content, or decrease in solvent content of a powder, or actual decomposition in the powder will all affect results by reducing the time of test.

Procedure if no oven is available.

6–34. If no surveillance oven is furnished, or if for any reason the one on board is not available for use, the prescribed tests should be made at an ammunition depot or on board another vessel. The responsibility for carrying out the prescribed tests rests with the commanding officer, and he is empowered to arrange for having these tests conducted as called for above. Such arrangements shall be made without reference to the Bureau of Ordnance, except, when on detached duty, information regarding the most suitable place or ship to which samples may be forwarded may readily be obtained from the Bureau. Vessels of the Navy and ammunition depots will conduct tests for Coast Guard vessels or stations in the same manner as for naval vessels. In case it becomes necessary to ship a sample by transport or rail (shipments by mail are absolutely forbidden) the instructions regarding such shipments contained in circulars issued by the Interstate Commerce Commission should be consulted. The test sample, suitably marked, shall be placed in a clean, airtight glass bottle, sealed with paraffin or wax, and the stopper secured by a cloth covering and twine seizing. A test sample shall consist of four ounces. Samples shall be properly packed and boxed to minimize breakage during transportation.

Transportation regulations for explosives.

6–35. The following abstracts from the Interstate Commerce Commission regulations for "The Safe Transportation of Explosives and Other Dangerous Articles by Express" are quoted as applicable to shipments of smokeless powder samples:

1. The only samples of explosives that can lawfully be shipped by express are those intended for examination in a laboratory.

2. Samples of explosives for laboratory examination when properly packed and not exceeding a net weight of one-half pound for each sample, and not exceeding 20 such samples at one time in a single vessel or vehicle.

3. Samples of explosives for laboratory examination must be placed in well secured metal cans or glass bottles or in strong waterproof paper or cardboard packages containing not more than one-half pound each, and the interior package must be placed in dry sawdust or similar cushioning material at least 2 inches thick in a strong and tight wooden box, with ends not less than 1 inch thick, and top, bottom, and sides not less than one-half inch thick when a nailed box is used, or with ends, top, bottom, and sides not less than one-half inch thick when of lockcornered construction. Whenever these samples of explosives for laboratory examination are contained in a metal envelope or receptacle, this receptacle must be properly cushioned with sawdust or similar cushioning material in a strong wooden box, and this interior box must be placed in a wooden box, with at least 2 inches of cushioning material separating the boxes.

4. Not more than 20 half-pound samples of explosives for laboratory examination may be placed in one outside box or transported at one time. The net weight of the explosive contents must be plainly marked by the shipper on the outside of each box offered for transportation.

5. Each outside package containing samples of explosives for laboratory examination must have securely and conspicuously attached to it a square red certificate label measuring 4 inches on each side and bearing in black letters the following:

Red Label for Samples of Explosives
(Reduced Size)
EXPLOSIVES
Sample for Laboratory
Examination

Handle Carefully
Keep fire away

This is to certify that the above articles are properly described by name and are packed and marked and are in a proper condition for transportation, according to the regulations prescribed by the Interstate Commerce Commission.

(Shipper's Name)

6. The following explosives may be accepted for transportation by express, when offered in compliance with regulations contained in Bureau of Explosives Pamphlet No. 9:

(*a*) Small arms ammunition.
(*b*) Small arm primers or percussion caps.
(*c*) Cannon primers.
(*d*) Percussion fuzes.
(*e*) Time or combination fuzes.
(*f*) Tracer fuzes.
(*g*) Cordeau detonant.
(*h*) Safety squibs.
(*i*) Fireworks, except when forbidden.

(*j*) Instantaneous fuze.
(*k*) Fuze lighters.
(*l*) Fuze igniters.
(*m*) Electric squibs.
(*n*) Delay electric igniters.
(*o*) Smokeless powder for small arms.

6–36. Containers which have been opened for examination of contents or for the removal of powders for test are to be restored to their former airtight condition. Cartridge cases will have projectiles or mouth plugs replaced and will be made airtight as follows: With fixed case ammunition the joint between the end of the cartridge case and the rotating band of the projectile shall be covered with adhesive tape and given a coat of clear shellac; with separate case ammunition closed with a cork mouth plug, the plug shall be shellacked on the periphery below the shoulder, the interior of the mouth of the case shall be shellacked for a depth of about 1 inch, and the plug shall be replaced. If there be any doubt as to the serviceability of the plug a new plug from spares provided should be used. **Resealing containers.**

6–37. Powder shall not be destroyed unless it shows unmistakable signs of advanced decomposition. In the event of such deterioration, every charge of the index on board shall be examined, and only such charges as contain the decomposing powder will be destroyed. Decomposition in the sense here used is evidenced by— **Powder not to be destroyed.**

(*a*) The grains being friable and easily crumbled;
(*b*) Unmistakable odor of nitrous fumes; and
(*c*) Very low violet paper and surveillance tests.

Powder found in a soft or mushy condition will be thrown overboard immediately. However, occasion requiring such action should arise only under the most unusual circumstances as constant observation and strict compliance with these instructions for powder tests will show loss of stability long before a powder becomes decomposed. In case it should be necessary to destroy or land smokeless powder for loss of stability, samples of each index shall be preserved and forwarded to the Naval Powder Factory, Indian Head, Md., for examination, and the Bureau of Ordnance notified at once of the shipment and the reasons therefor.

6–38. The foregoing instructions pertain to the care, preservation, and stability of smokeless powder. Quite apart from the safety of the ship and the preservation of her ammunition, these precautions are necessary to avoid variations in the ballistic performance of the powder. For a satisfactory performance there must be no unknown variations from the condition of the powder at the time of the proof which fixed the weight of charge assigned. Such variations may be— **Ballistic errors of powder.**

(*a*) A slowing of the powder due to absorption of moisture which decreases the muzzle velocity for a given weight of charge.

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(*b*) A quickening of the powder due to excessive heat which drives off part of the residual volatiles and increases the muzzle velocity.

(*c*) An irregularity in velocity due to varying effects of both (*a*) and (*b*) on individual charges.

Neither (*a*) nor (*b*) can occur unless one or more charge containers be not airtight. The importance of keeping powder containers airtight must be rated on a par with proper maintenance of the director system.

It should be noted that loss of stability, so long as it does not make the powder actually unserviceable, will not of itself affect ballistics appreciably.

Salvage of ammunition.

6–39. In case of shipwreck, flooding of magazines, or other casualty whereby ammunition is wet or damaged, the damaged ammunition shall be forwarded to an ammunition depot for salvage as soon as practicable. In no case should such damaged ammunition be thrown overboard or abandoned if it can be recovered, and every reasonable care should be taken in handling to avoid damage to containers. If shipment is materially delayed for any cause, smokeless powder which has been wet should be shipped completely immersed in distilled water. The ammunition so treated shall always be suitably marked to show its condition, and the complete history forwarded to the Bureau so that intelligent action may be taken regarding the disposition. The Government has suffered material loss in the past due to the failure of officers to carry out these instructions.

Chapter VII. SURVEILLANCE OVENS

7–1. The Washington Navy Yard is designated as the central source of supply for all types of surveillance ovens, and all ovens to be furnished ships and stations will be supplied from that yard. Spare parts for all types of surveillance ovens will be kept in store at the Washington Navy Yard. The source of supply for fume tubes and "non-sol" bottles for surveillance ovens is as follows: **Source of supply.**

East coast, Naval Powder Factory.
West coast, N. A. D., Mare Island.

The Washington Navy Yard will make out ship's allowance lists for all surveillance ovens, including spare parts. Surveillance ovens will be assigned serial numbers by the Washington Navy Yard, and a record of their disposition will be kept on file there. All surveys of surveillance ovens and all requisitions for parts of ovens should, in every case, give full information as to the make (or mark), number, voltage, etc., of the oven affected by the survey or requisition. When a surveillance oven has been damaged so that the estimated cost of repairs exceeds 50 percent of its invoice value, it shall be transferred to the Navy Yard, Washington, D. C., and a new oven requested. **Purpose.**

7–2. The purpose of these ovens is to conduct surveillance tests of smokeless powder described in chapter VI. These tests consist of the determination of the time which smokeless powder requires under the prescribed standard conditions of test to produce visible red oxides of nitrogen. The standard conditions and methods of conducting the test are fully described in the previous chapter. The surveillance oven is designed to maintain a constant temperature of 65.5° C. (±1° C.). **Purpose.**

7–3. No surveillance ovens prior to the Mark 2, Mod. 2 are in service. A description of surveillance ovens Mark 2, Mods. 2 and 3, is included in this pamphlet, but these ovens are to be modified to Mark 2, Mod. 4 or 7 eventually. **Types of ovens in service.**

7–4. Surveillance ovens Mark 2, Mods. 2 to 7 will be described as a group and features peculiar to certain of the modifications will be pointed out. The following plates pertain to this description: **Description.**

Plate 2—Surveillance oven, Mark 2, Mod. 2—General arrangement (Dr. 96855).

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Plate 3—Surveillance oven, Mark 2, Mod. 2—Wiring diagrams (Dr. 96833).

Plate 4—Surveillance oven, Mark 2, Mod. 2, Relay—General arrangement (Dr. 96828).

Plate 5—Surveillance oven, Mark 2, Mod. 2—Method of installing Boyce Moto-meter (Sk. 11734).

Plate 6—Surveillance oven, Mark 2, Mod. 2—Heat unit details (Dr. 96851).

Plate 7—Surveillance oven, Mark 2, Mod. 3—General arrangement (Dr. 133691).

Plate 8—Surveillance oven, Mark 2, Mod. 3—Wiring diagram (Dr. 133692).

Plate 9—Surveillance oven, Mark 2, Mods. 4 and 7—General arrangement (Dr. 133694).

Plate 10—Surveillance oven, Mark 2, Mods. 4 and 7—Wiring diagram (Dr. 133695).

Plate 11—Surveillance oven, Mark 2, Mod. 5—General arrangement and wiring diagram (Dr. 133602).

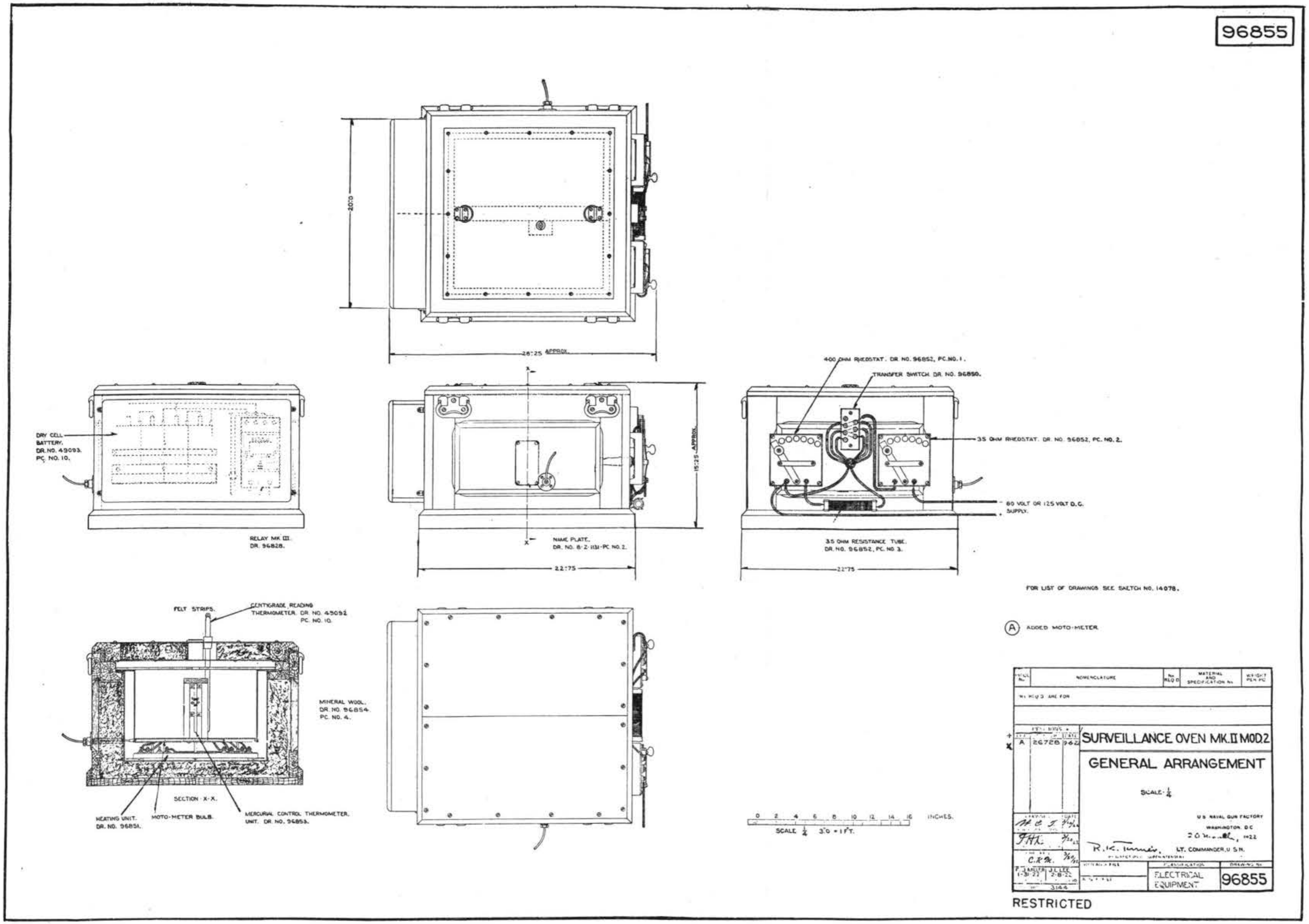
Plate 12—Surveillance oven, Mark 2, Mod. 4—Relay—Front view (N. G. F. Neg. 12841).

Plate 13—Surveillance oven, Mark 2, Mod. 5—Side elevation (N. G. F. Neg. 9694).

7–5. *General.*—The equipment consists of the following principal parts: Heat insulated box and cover, copper oven, temperature controlling device, heating element, relay, rheostats, bottles, fume tube, mercury centigrade thermometer, and wiring.

7–6. *Body.*—The body of the oven is made up of three boxes assembled one within the other. The outer box, made of seasoned hardwood, serves as a protective enclosure for the other parts. The second box, made of sheet steel, is supported in the wooden box and the space between the two is filled with a heat insulating material such as mineral wool. The third box, made of polished sheet copper, comprises the powder testing compartment. It is also supported in a recess in the top of the wooden box and is separated from the sheet steel box by an air space. The cover consists of a wooden frame with two sheet steel plates, the space between the plates being filled with the material used to insulate the body of the oven.

7–7. *Heating element.*—The heating unit is located under the powder testing compartment and rests in the bottom of the sheet steel box. The heating element consists of four spiral coils of nichrome resistance wire supported in and completely encased by an asbestos-lined sheet steel pan. The pan is made in two parts and is held together by a center bolt. The heating



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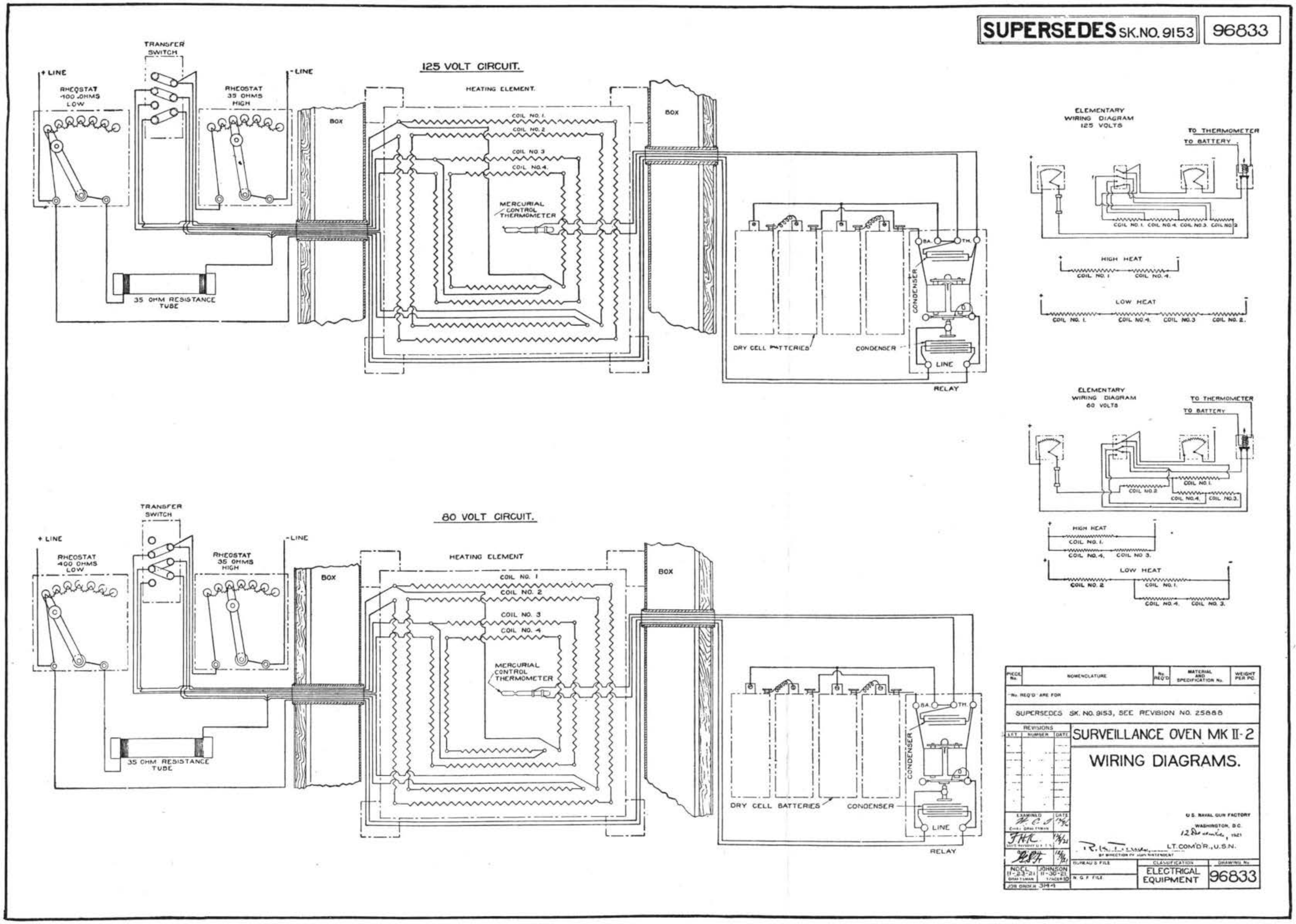
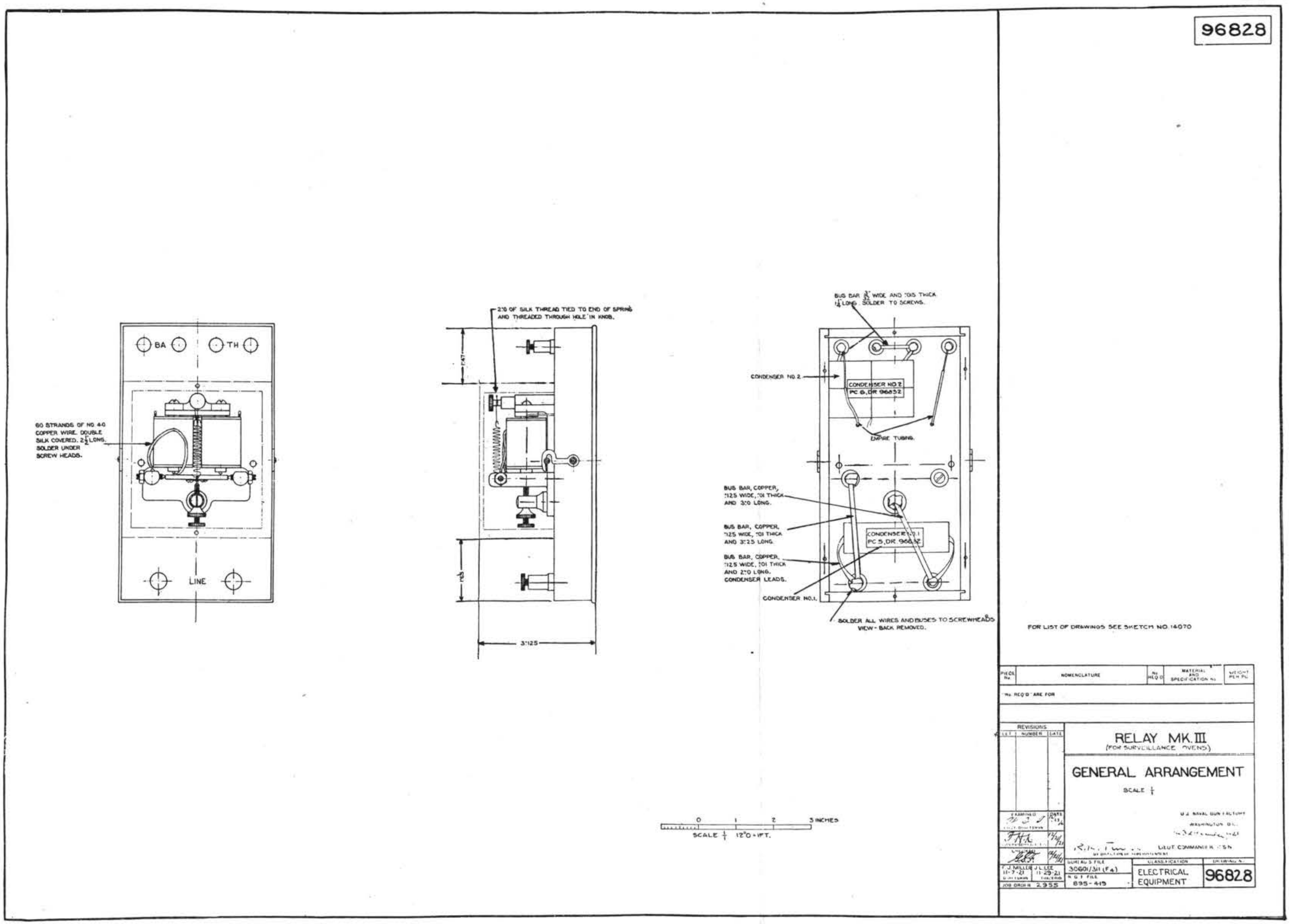

SUPERSEDES SK. NO. 9153
96833
125 VOLT CIRCUIT.
TRANSFER SWITCH
+ LINE
- LINE
RHEOSTAT 400 OHMS LOW
RHEOSTAT 35 OHMS HIGH
BOX
HEATING ELEMENT.
COIL NO. 1.
COIL NO. 2
COIL NO. 3
COIL NO. 4.
MERCURIAL CONTROL THERMOMETER
35 OHM RESISTANCE TUBE
DRY CELL BATTERIES
CONDENSER
LINE
RELAY
ELEMENTARY WIRING DIAGRAM 125 VOLTS
TO THERMOMETER
TO BATTERY
HIGH HEAT
LOW HEAT
80 VOLT CIRCUIT.
ELEMENTARY WIRING DIAGRAM 80 VOLTS
SUPERSEDES SK. NO. 9153, SEE REVISION NO. 25888
SURVEILLANCE OVEN MK II-2
WIRING DIAGRAMS.
U.S. NAVAL GUN FACTORY
WASHINGTON, D.C.
12 December, 1921
LT. COMD'R., U.S.N.
ELECTRICAL EQUIPMENT
96833



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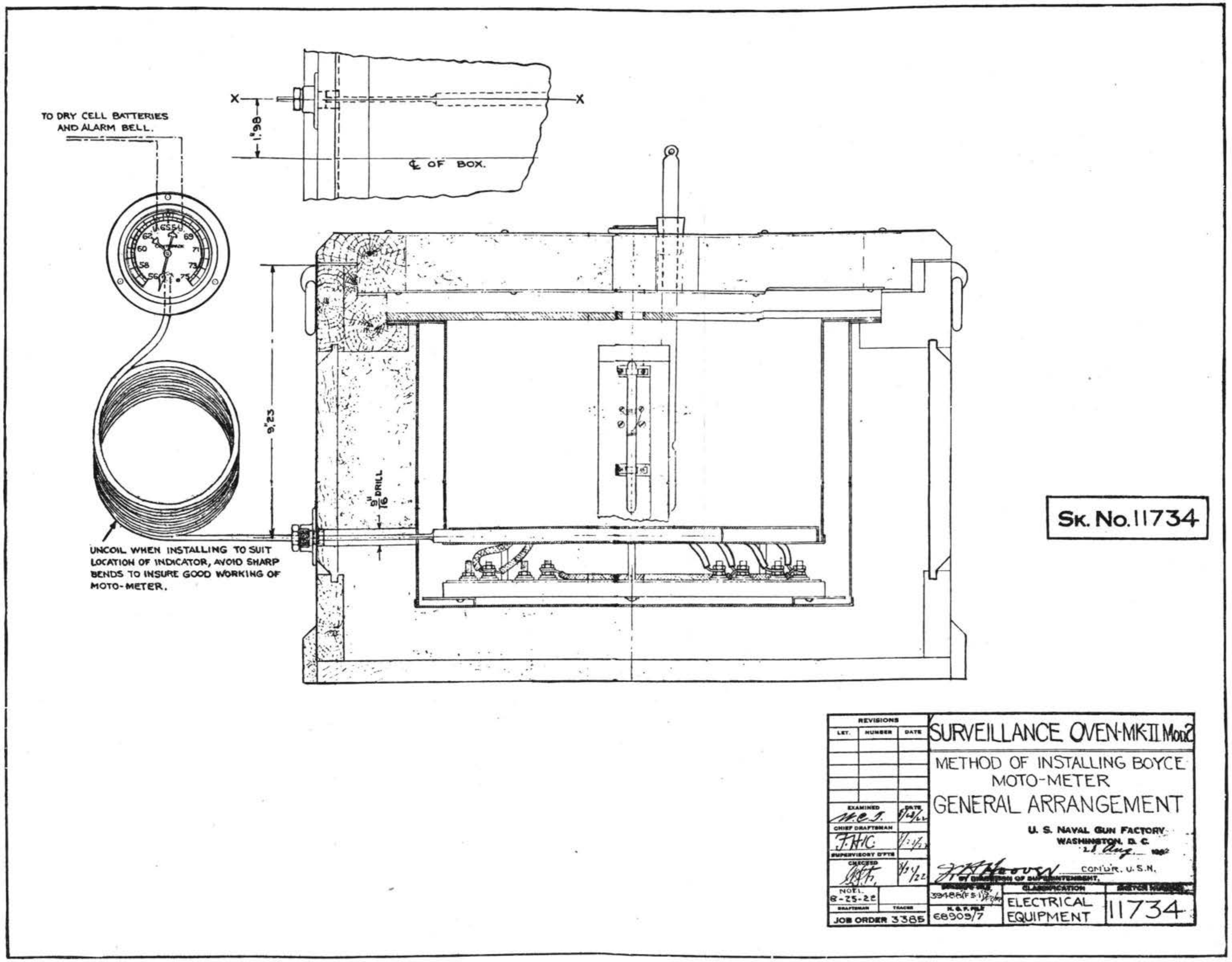

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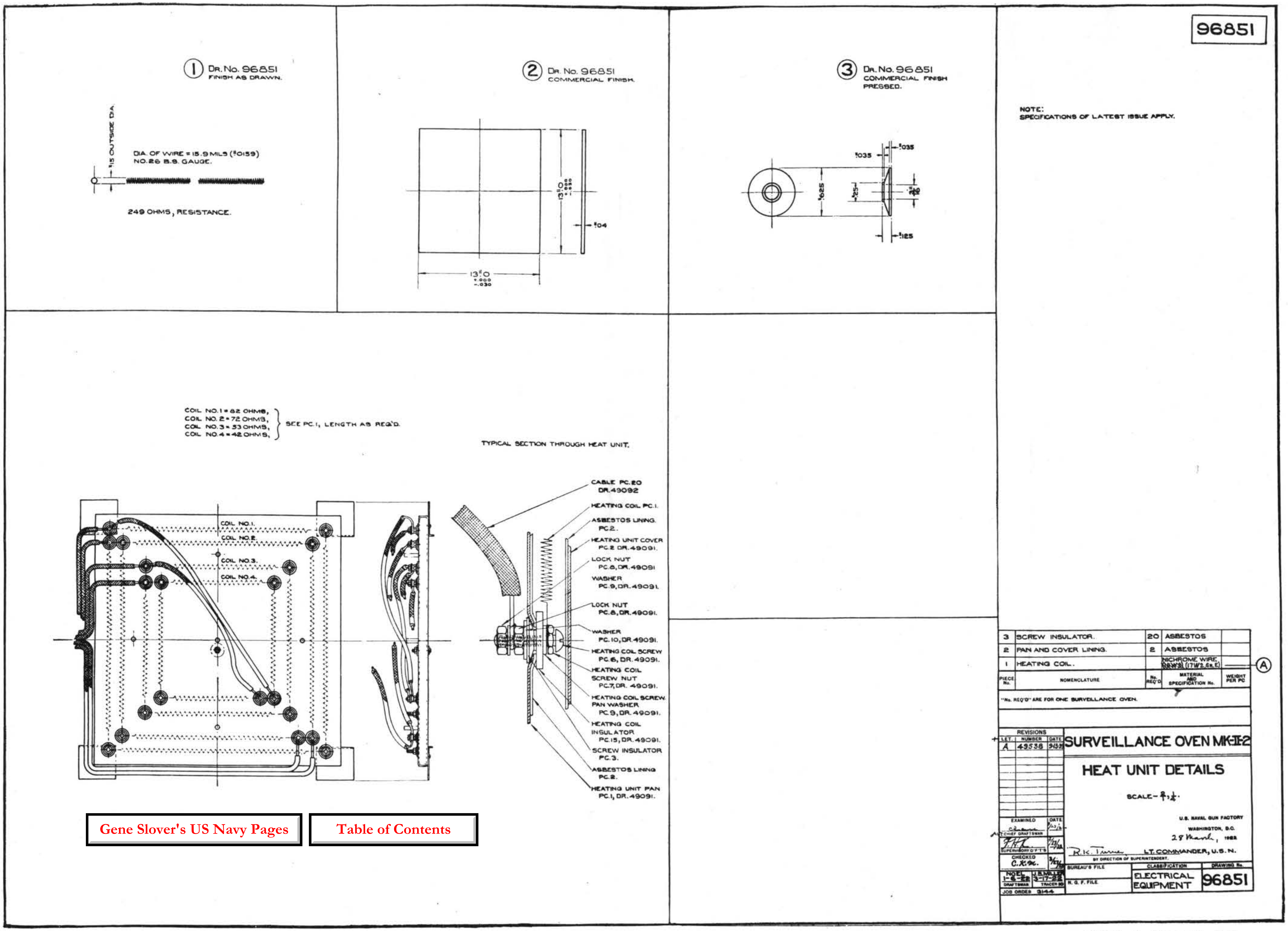

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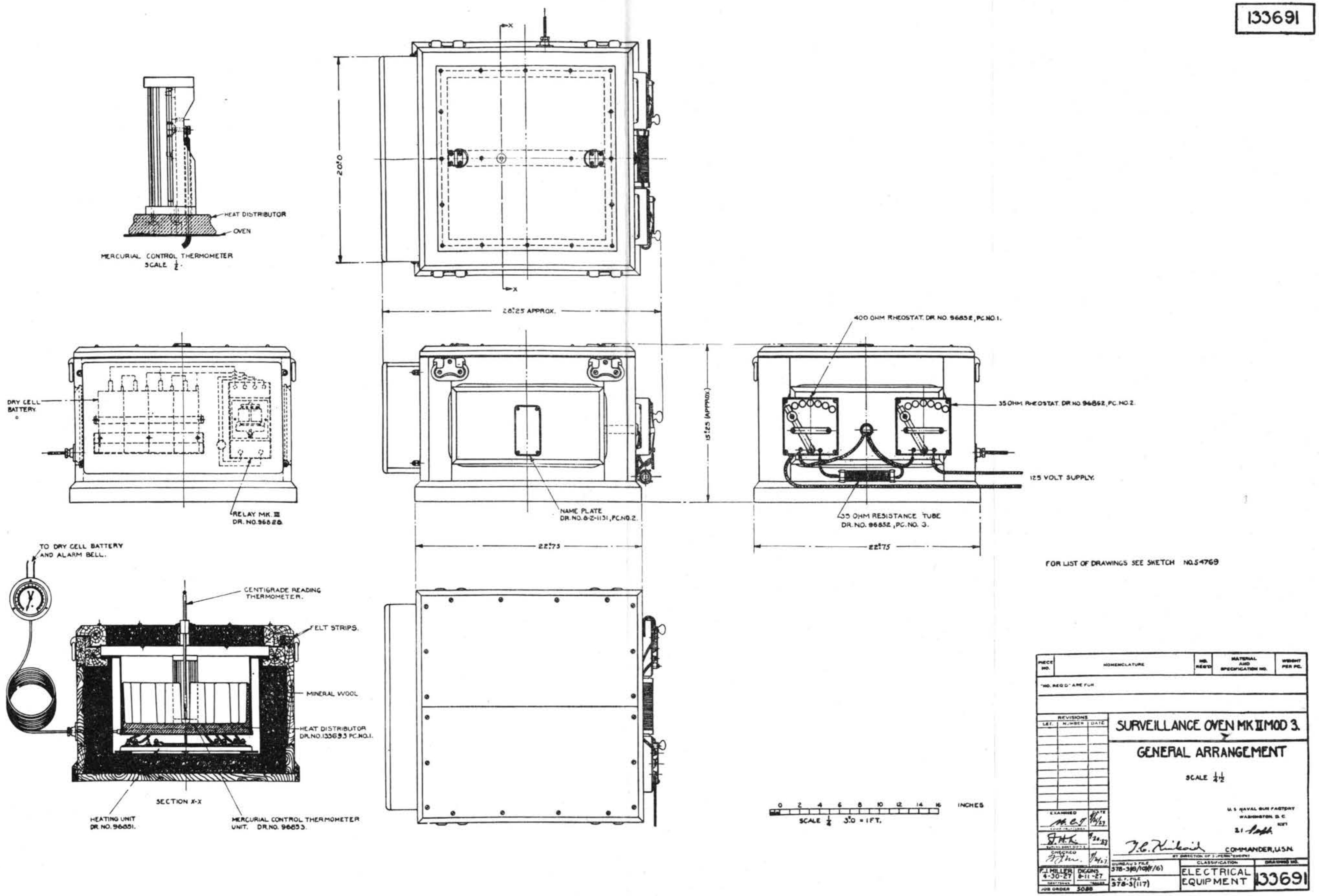

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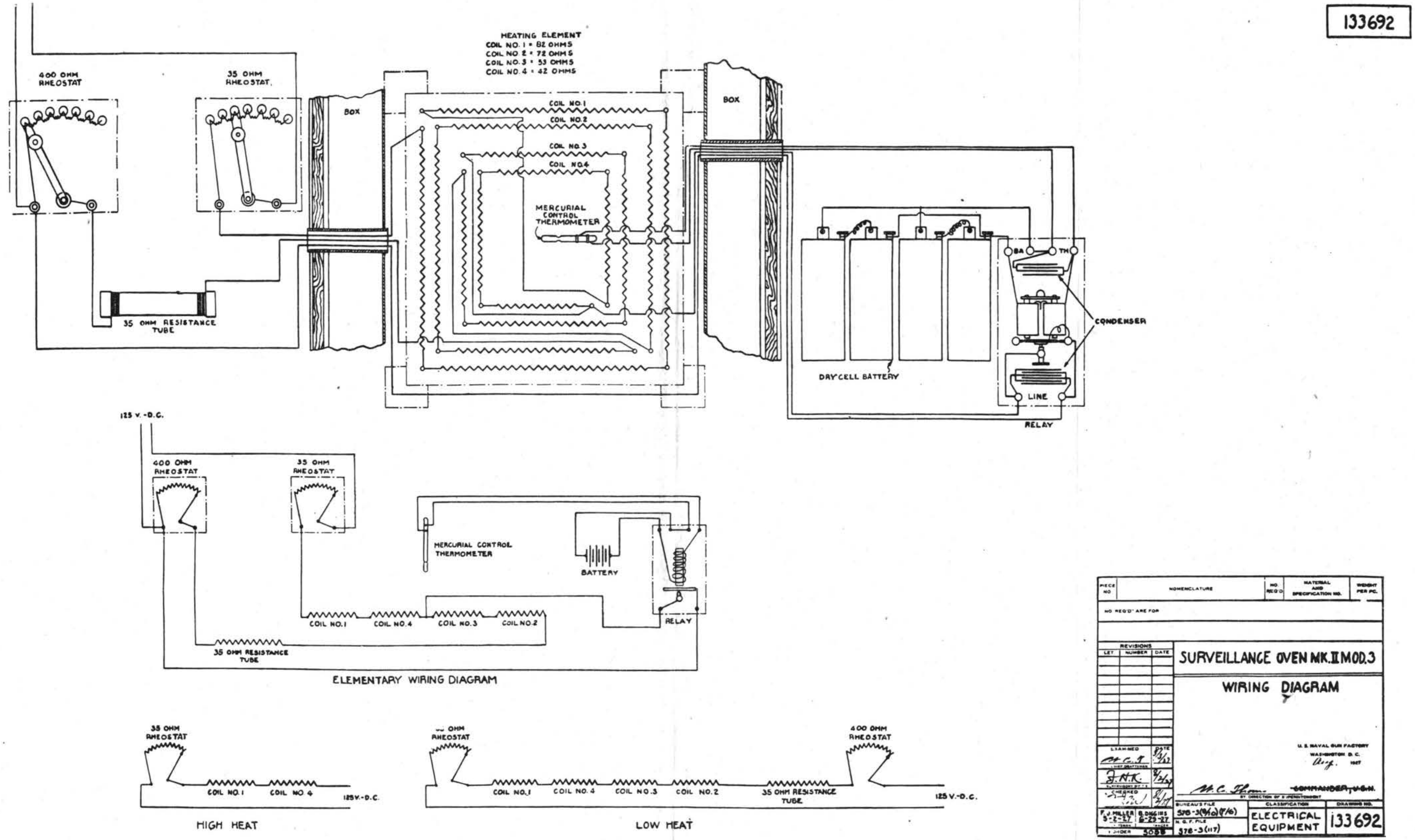

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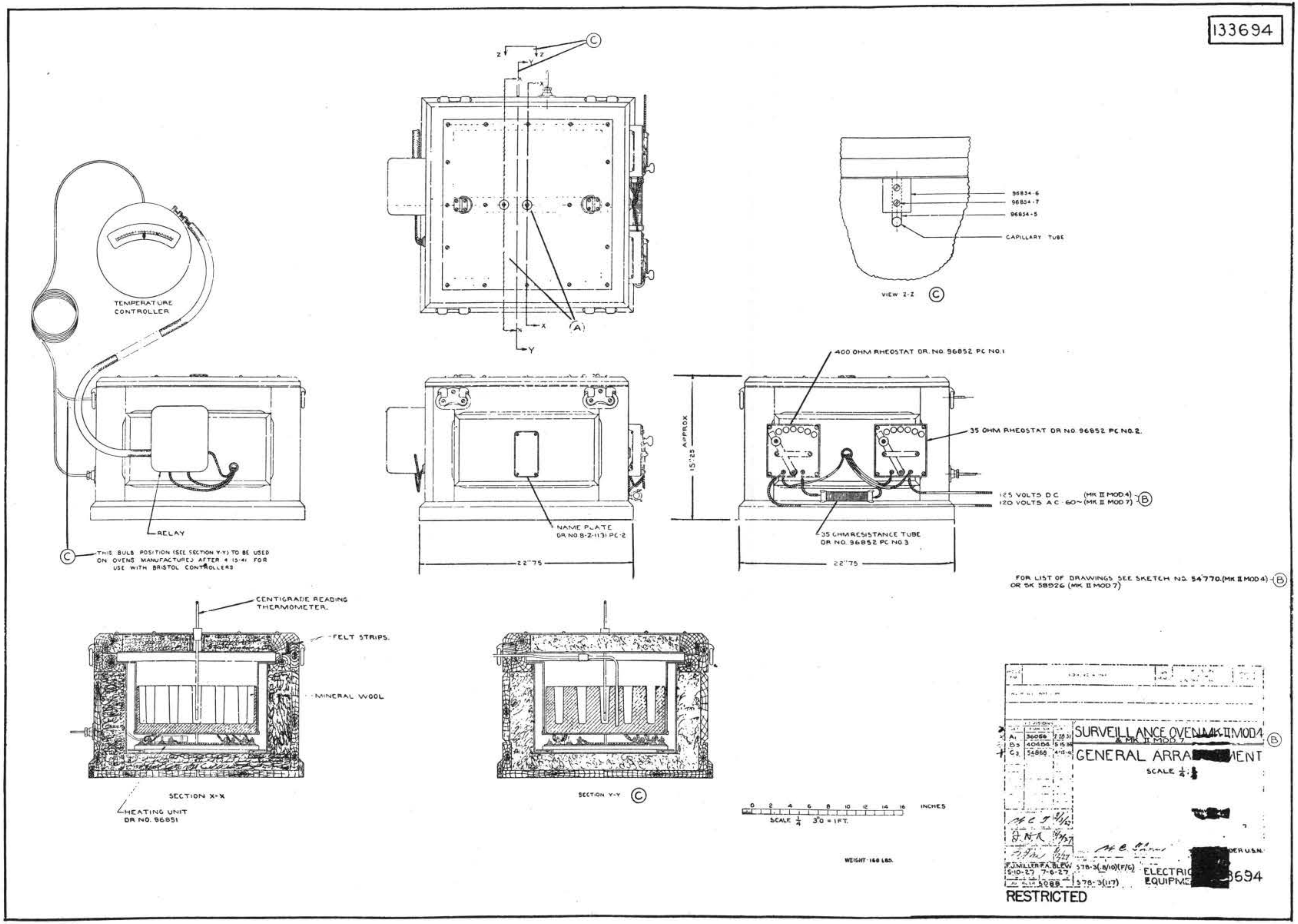
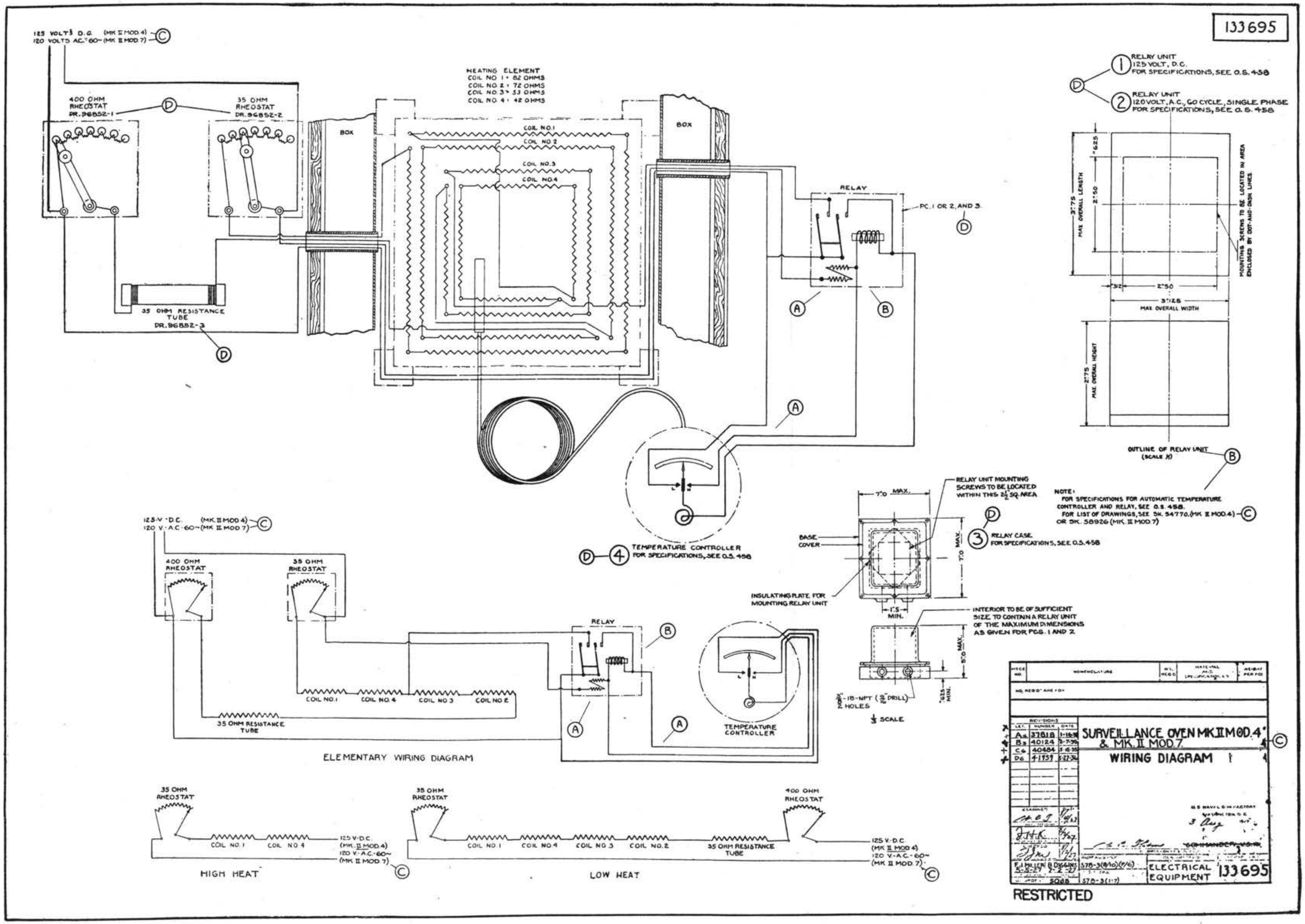

133694
VIEW Z-Z
96834-6
96834-7
96834-5
CAPILLARY TUBE
TEMPERATURE CONTROLLER
400 OHM RHEOSTAT DR. NO. 96852 PC NO.1
35 OHM RHEOSTAT DR NO 96852 PC NO.2
APPROX 15"25
125 VOLTS D C (MK II MOD 4)
120 VOLTS A C 60~ (MK II MOD 7)
RELAY
NAME PLATE DR NO B-2-1131 PC-2
35 OHM RESISTANCE TUBE DR NO. 96852 PC NO 3
22"75
22"75
THIS BULB POSITION (SEE SECTION Y-Y) TO BE USED ON OVENS MANUFACTURED AFTER 4-15-41 FOR USE WITH BRISTOL CONTROLLERS
FOR LIST OF DRAWINGS SEE SKETCH NO. 54770 (MK II MOD 4) OR SK 58926 (MK II MOD 7)
CENTIGRADE READING THERMOMETER
FELT STRIPS
MINERAL WOOL
SECTION X-X
HEATING UNIT DR NO. 96851
SECTION Y-Y
INCHES
SCALE 1/4 3"0 = 1 FT.
WEIGHT 168 LBS.
SURVEILLANCE OVEN MK II MOD 4 & MK II MOD 7
GENERAL ARRA[redacted]MENT
SCALE 1/4
F.J.MILLER F.A.BLEW
5-10-27 7-6-27
ELECTRIC
EQUIPM
[redacted]
3694
RESTRICTED



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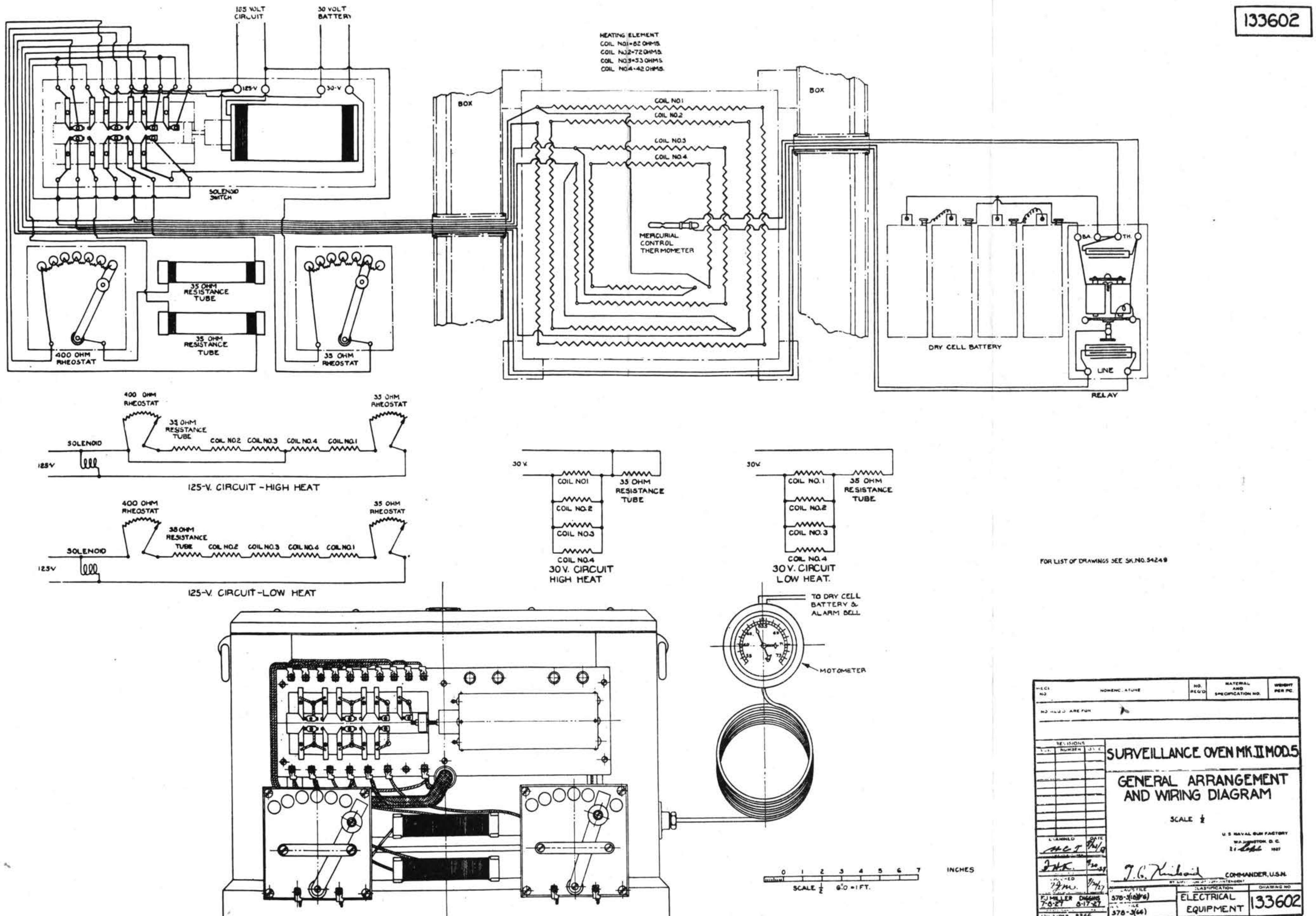

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element pan used on surveillance ovens Mark 2, Mods. 4 and 7, has asbestos supports for the bulb of the indicating control thermometer.

7–8. *Temperature controlling device.*—The function of this device is to close an electrical circuit which operates the relay when the temperature in the powder testing compartment has reached 65.5° C.

Surveillance ovens Mark 2, Mods. 2, 3, 5, 6, are equipped with a mercurial control thermometer for regulating the heat in the powder testing compartment. Fused in the capillary column of the thermometer are two wires, the highest of which is at 65.5° C. The thermometer is mounted on a semi-cylindrical hardwood holder located in the center of the powder testing compartment. The wooden holder is provided with two terminals to receive the ends of the wires from the two points on the thermometer. Wires are run from the binding posts on the holder through a ferrule in the side of the box and are connected to the relay. When the temperature in the powder testing compartment rises to 65.5° C., the mercury in the thermometer closes the battery circuit and causes the relay to function.

For a description of the temperature controlling device on surveillance ovens Mark 2, Mods. 4 and 7, see paragraph 17.

7–9. *Relay.*—Surveillance ovens Mark 2, Mods. 2, 3, 5, and 6 are equipped with a simple relay as shown on figure 21. This relay is mounted on the

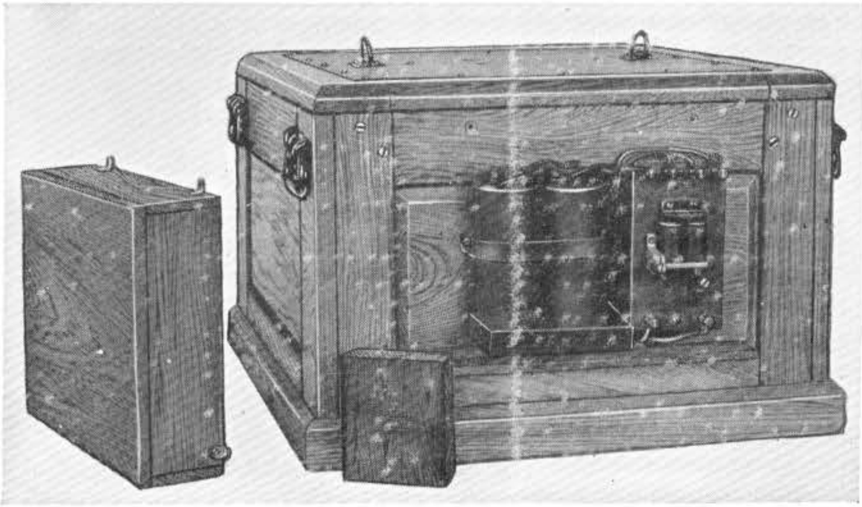

FIGURE 21.—Mark 2 oven showing relay.

exterior of the oven on the side opposite to that on which the rheostats are located. The relay is mounted on a hard wood base which contains two condensers. One condenser is connected in the thermometer circuit and the other in the circuit controlling the heating unit. The condensers are installed for

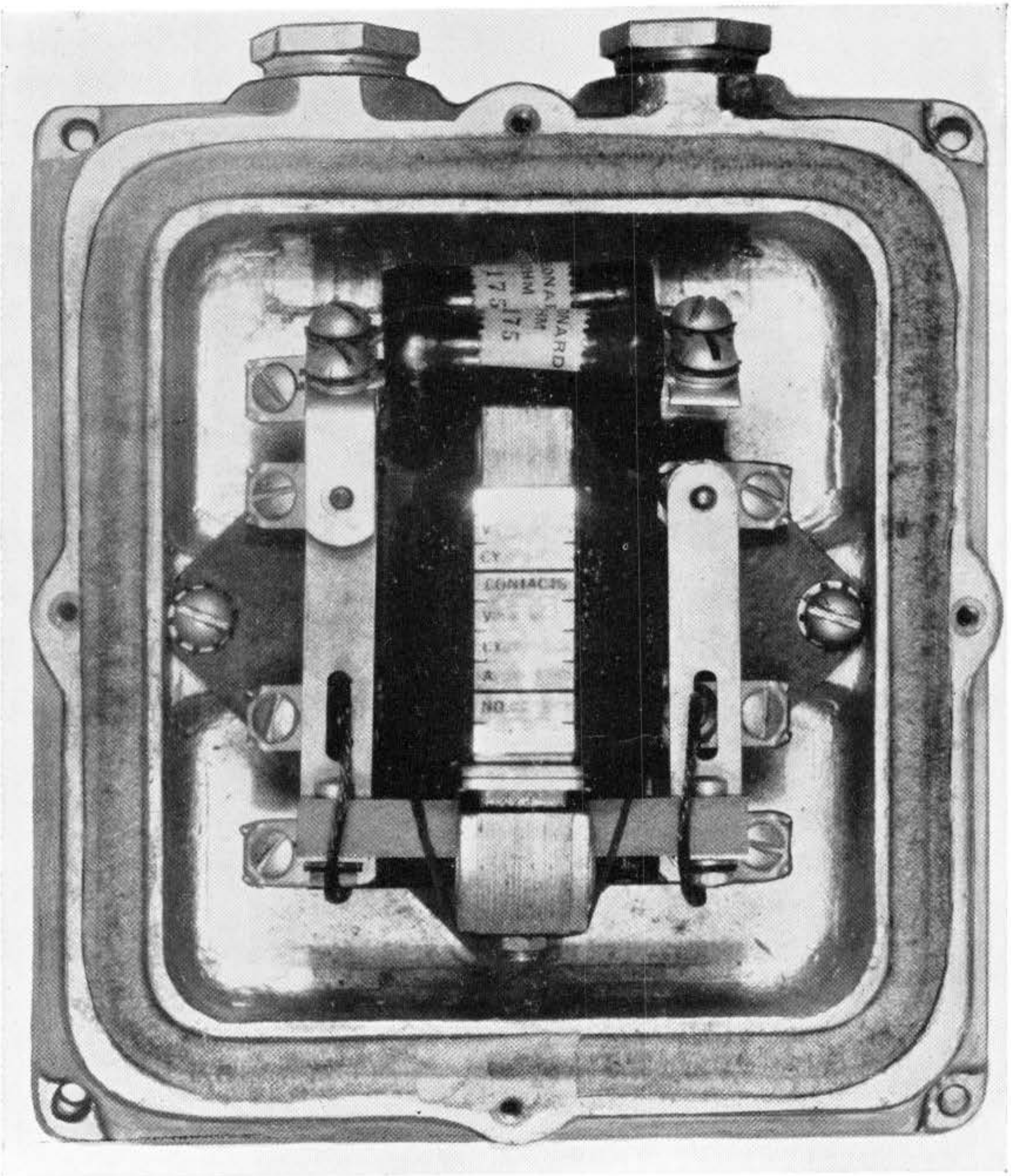

PLATE 12.—Surveillance oven, Mark 2, Mod. 4. Relay, and front view.

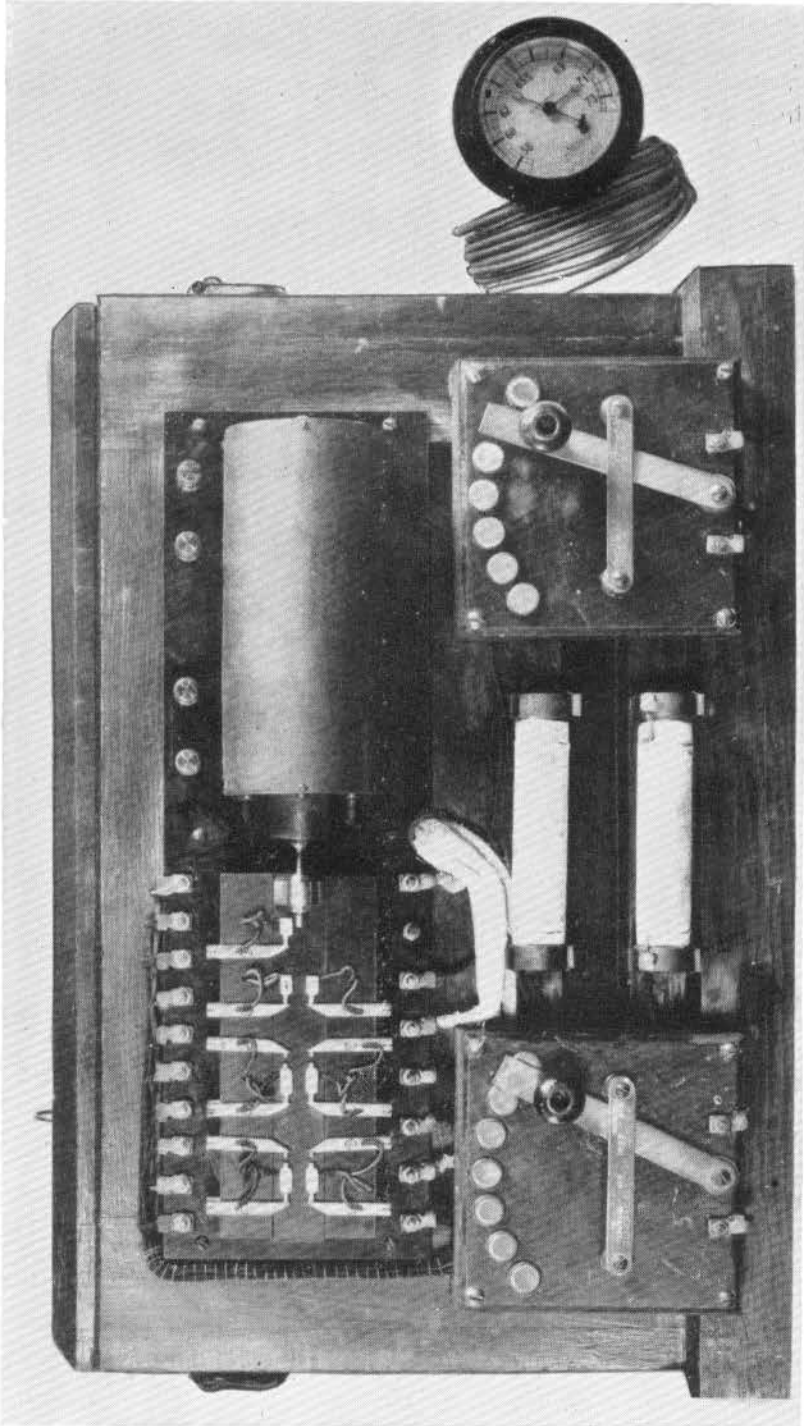

PLATE 13.—Surveillance oven, Mark 2, Mod. 5. Side elevation.

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the purpose of protecting from injury the circuit-breaking contact in the mercurial thermometer and that on the armature of the relay. The relay is protected by a hard wood cover. The binding posts provided for connection to line, battery and control thermometer are exposed and are marked "LINE", "BA," and "TH." When the control thermometer circuit is open the relay

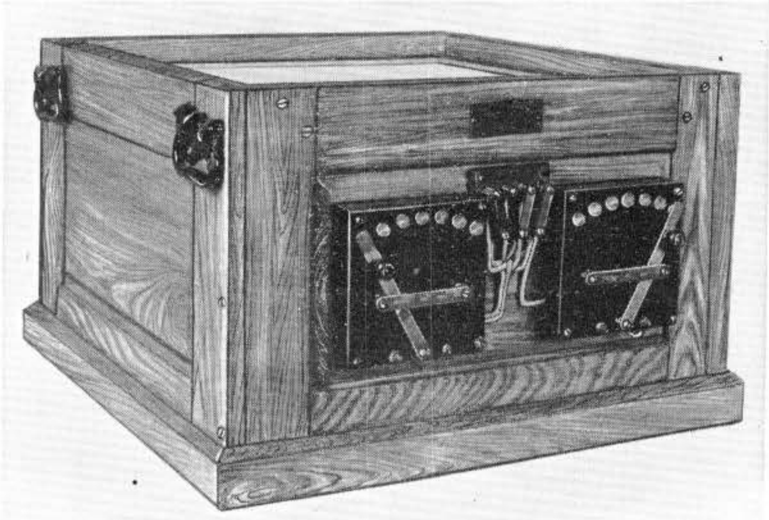

FIGURE 22.—Mark 2 oven showing rheostat.

armature short circuits the low heat coils. When the control thermometer circuit is closed, the relay armature is drawn away from its contact and the short circuit is removed, thus putting the low heat coils in the circuit.

For a description of the relay used on surveillance ovens, Mark 2, Mods. 4 and 7, see paragraph 17.

7–10. *Battery.*—Surveillance ovens, Mark 2, Mods. 2, 3, 5, and 6 have a dry-cell battery for operating the relay described in paragraph 9. The dry cells are supported in a sheet steel box located adjacent to the relay. A wooden cover protects battery, relay, and wiring. The cells are about 2.75 inches in diameter and 6 inches high. Each cell should give at least 1.5 volts and show about 30 amperes on short circuit. These cells deteriorate and must be inspected regularly.

7–11. *Rheostats.*—Two rheostats are mounted on one side of the oven. They have a spiral form of resistance enclosed in a moisture and fireproof base. Each rheostat is provided with a contact regulating arm and 7 contact points for varying the resistance. One rheostat has a resistance of 35 ohms; the other has a resistance of 400 ohms. In each case the low resistance rheostat controls the high heat circuit (see par. 16), and the high resistance rheostat controls the low heat circuit.

7–12. *Bottles.*—Each oven is provided with 24 standard 8-ounce salt-mouth, glass-stoppered, nonsoluble bottles. The stoppers should be loosely attached to the bottles by strings or chains. In case of doubt as to the tightness of a stopper in a bottle, the stopper should be ground in by hand, using fine emery and a solution of camphor in turpentine. The bottles must be thoroughly washed and dried before using. Near the bottom of each bottle is an etched space for noting, in pencil, the designation of the powder and the date when put in the oven.

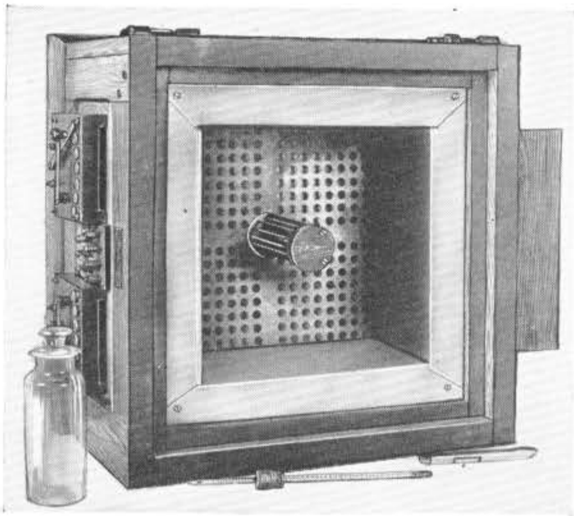

FIGURE 23.—Mark 2 oven interior.

7–13. *Fume tube.*—This is a tube about 6.5 inches long by 0.625 inch in diameter, containing peroxide of nitrogen gas and is used for comparison with the powder under test.

7–14. *Mercury centigrade stem thermometer.*—This thermometer is used to check the accuracy of the control thermometer. It is graduated in such a manner that the temperature inside the oven may be read without removing the thermometer. This thermometer stem is supported by a cork stopper in a hole in the oven cover.

7–15. *Alarm and indicating device* (*Boyce Moto-Meter, or equal*).—This instrument consists of a dial indicator which will show temperature ranging from 56° to 75° C. Its pointer is provided with a contact arm which will close a low voltage circuit to ring an alarm bell when the pointer indicates a temperature of 68° C.

A bulb about 10 inches long is placed in the bottom of the oven under the bottle holder and is connected to a small metal tubing about 15 inches long which passes out through the side of the box to the indicator.

On the back of the indicator are two terminals to which the wires in the alarm circuit are connected. The indicator is mounted on a bulkhead near the oven.

If, for any reason, the temperature within the oven is increased above 65.5° C., due to the relay failing to cut in the coils which were shorted for high heat, and if the temperature reaches 68° C., the instrument will close the alarm circuit, ringing an alarm bell. Immediate attention should be given to the oven to ascertain the cause of the excessive rise in temperature. The alarm circuit consisting of a bell or buzzer and battery is conveniently located to suit the wishes of the parties installing the oven. These instruments are installed on surveillance ovens, Mark 2, Mods. 2, 3, 5, and 6.

7-16. *Operation.*—In operation the oven is heated to 65.5° C. with the heating coils so connected that they give "high heat." When this temperature in the oven is reached, the temperature controlling device automatically closes the relay circuit. The relay operates and adds resistance to the heating coil circuit and produces "low heat." The heat then gradually decreases until the oven temperature falls below 65.5° C., when the temperature controlling device opens the relay circuit and releases the relay armature to its original position, thus short-circuiting the added resistance and producing "high heat" again. The functioning of the relay and the temperature controlling device is slightly different for surveillance ovens, Mark 2, Mods. 4 and 7—see paragraph 17.

Before proceeding with the test proper, always run the oven, containing the 24 empty bottles, at least 24 hours at approximately the correct temperature, 65.5° C., to dry the oven and to obtain constant conditions. The wattage can then be adjusted by means of the rheostats, so that the variation in temperature will not exceed one degree from normal. Although the ovens are designed to take care of fluctuation of room temperature, it is best to adjust the rheostats so that the low heat coil will supply almost enough heat to maintain the required temperature. Otherwise the relay will be called upon to operate often and this should be avoided as much as possible. Sufficient time must elapse between each adjustment to insure a constant temperature throughout the oven.

Full instructions and precautions regarding conducting the surveillance test of smokeless powder are given in the previous chapter and these must be carefully observed.

Classification of ovens.

7-17. *Mark 2, Mod. 2.*—For use on either 80- or 125-volt D. C. circuit. A transfer switch to change from one voltage to the other is mounted between the two rheostats. A 35-ohm resistance tube is connected in the low heat circuit.

Mark 2, Mod. 3.—This oven is for use on a 125-volt D. C. circuit only. A 35-ohm resistance tube is connected in the low heat circuit. An aluminum alloy casting, or heat distributor, holds the bottles in the oven.

Mark 2, Mod. 4.—This oven is for use on a 125-volt D. C. circuit only. A 35-ohm resistance tube is connected in the low heat circuit. An aluminum alloy heat distributor, holds the bottles in the oven.

This oven is equipped with an indicating temperature controller which is to be located on a bulkhead near the oven. The controller is of the fluid expansion type with a liquid-filled bulb connected to the instrument by a long flexible armored tube. In the body of the instrument is an electrical contact mechanism for controlling the operation of the relay. The sensitive element or bulb is inserted through the side of the oven body and is held above the heating element by small asbestos supports.

The relay has two sets of contacts. Referring to Dr. 133695, the operation is as follows: Assume that the temperature in the oven is between the high and low limits and that the relay contacts are open. All of the heating coils will be in the circuit and the oven temperature will fall until the temperature controlled contact in the temperature controller touches the low limit contact "L". This causes the relay coil to be energized, closing the relay contacts. One set of relay contacts short circuits part of the heating circuit, causing heat to be supplied to the oven at a greater rate. The other set of relay contacts connects the relay coil across the line independently of the temperature controller contacts, so that, as the temperature in the oven increases, the relay coil remains energized after the temperature controlled contact in the controller leaves the low heat contact. The oven temperature increases until the temperature controlled contact in the controller touches the high limit contact "H". This short circuits the relay coil, causing the relay contacts to open, and thus completes the cycle of operations. The circuit through the relay coil is made at the temperature controller contacts, but is always broken by the relay contacts. A series resistor in the relay limits the current through the temperature controller to ½ ampere or less.

The relay and the control thermometer are designed for operation on 125 volts D. C., therefore no dry cells are used on this oven.

Mark 2, Mod. 5.—This oven is intended for use on a 125-volt D. C. circuit. It is also connected to a 30-volt battery for emergency use in case of failure of the 125-volt supply. If the 125-volt supply fails, a solenoid switch turns on the 30-volt current and rearranges connections to the heating coils to give approximately the same wattage as was obtained with 125 volts. When the 125-volt supply is on again, the solenoid switch disconnects the 30-volt battery and rearranges the heating coil connections to suit the higher voltage. The test of powder is not interrupted because of failure of the 125-volt ships circuit. This oven is provided with two 35-ohm resistance tubes and solenoid-operated switch. With the exceptions mentioned above this oven has the same parts as the Mark 2, Mod. 3 oven. The solenoid switch, rheostats, and wiring are protected by a wooden cover. The rheostat knobs project through the cover which is marked to show positions for which resistance is "in" or "out."

This oven was made especially for the U. S. S. *Vestal*, only one being made.

Mark 2, Mod. 6.—This oven is the same as the Mark 2, Mod. 3, except that it was made to operate on 220 volts D. C. One oven of this type was made for the Naval Station, Tutuila, American Samoa.

Mark 2, Mod. 7.—This oven is identical with the Mark 2, Mod. 4 in all respects, except that it has a relay designed for operation on 120 volts, A. C., 60 cycle.

Chapter VIII. HIGH EXPLOSIVES

8–1. In chapter III it was pointed out that explosives cannot be definitely classified by their chemical composition, but that they are classified, by the speed of the chemical change, into propellants and high explosives. A high explosive for military use as a burster charge has two distinguishing features. It is, first, relatively insensitive to mechanical shock, friction, flame, etc., and, even when exploded by such means, does not give full explosive effect; second, the whole charge decomposes almost instantaneously when subjected to the proper impulse. The list of substances which can be grouped under the term "high explosives" is a long one, but this list is materially reduced when those not suited for military purposes are eliminated.

Requirements of high explosives.

8–2. The following conditions must be fulfilled by a military high explosive. It must—

(*a*) Have the proper insensitivity to withstand—
- (1) Shock of gunfire;
- (2) Shock of impact against armor, if used for projectile filler;
- (3) Shock of handling.

(*b*) Have maximum power.

(*c*) Have stability to withstand adverse storage conditions due to heat, moisture, etc.

(*d*) Be easy to handle, load, and manufacture.

(*e*) Produce proper fragmentation.

(*f*) Be cheap and available in sufficient quantity.

All these conditions must be considered, and the substance most nearly fulfilling them all is the best high explosive. However, the uses to which the high explosive is to be put must be considered, for a projectile filler must fulfill all these conditions while a mine or depth charge filler, for instance, need not be so insensitive as to withstand armor impact.

Sensitivity.

8–3. The sensitivity to shock is measured by the so-called impact test, wherein a given weight is dropped on measured quantities of the explosive under test, and the height of the drop causing an explosion is taken as a measure of the sensitivity. This test gives a relative measure and is of value only so long as the conditions are the same. The amount used, the degree of pulverization, the hardness of the face of the apparatus, the density, the mixture with other substances, will all affect the test. Some explosive substances can be compressed so that they become practically inert, this condition being called "dead pressed." Sensitivity to friction is measured by subjecting samples to the friction due to sliding impact of a shock pendulum across the face of an anvil upon which the sample rests. The arc of the swing of the pendulum gives the standard of measure. Sensitivity to heat is determined by measuring the flash point of the explosive.

Power.

8–4. It is very difficult to get an absolute measure of the power of an explosive. Although the temperature, pressure, and volume of the products of combustion can be determined, the behavior of the products at the high temperatures and pressures makes it difficult to determine an expression for power. Approximations have been made, but probably as good a method as any is the result obtained by using the Trauzl lead block test. It is made by firing charges of different explosives in a standard-sized hole in a lead block, and measuring the increased volume. The relative power of an explosive obtained by comparing the increased volume of the hole in the lead block, with that produced by other explosives. The effect of the time in which the explosive develops its maximum pressure is also considered in connection with the power. The "rate of detonation" is measured by timing the passage of the detonating wave between two points of a cord or column of the explosive. The violence of the blow, called the "brisance," is particularly considered in connection with detonators.

Adaptability.

8–5. An explosive which catches fire easily and explodes when ignited is more dangerous for military uses than one which ignites with difficulty and burns quietly. A high explosive must also retain its stability under all conditions of storage, as it would be most difficult to determine the stability condition of separate large case or compressed charges. In particular the explosive must hold up against adverse hygroscopic conditions and remain effective though wet, as in a leaky mine case or torpedo war head. In addition, the facility with which a high explosive can be assembled into a charge is very important. One which can be melted at moderate temperatures and cast permits of loading into irregularly shaped volumes very easily. The explosives used must permit of easy handling without danger to personnel by accident or toxic effect.

Availability.

8–6. Many explosives, otherwise very suitable, are unsatisfactory due to the small yield, scarcity of raw materials, and difficulties in manufacture.

List of high explosives.

8–7. From a consideration of the above-mentioned factors, the following explosives substances have been or are standard for military use:

Guncotton.—Superseded by TNT.

Trinitrotoluol.—TNT.

Trinitroxylol.—TNX., sometimes used in mixture with TNT. A small quantity was manufactured during World War I; none is in service at the present time.

Trinitrophenol.—Picric acid used as a projectile filler, (not in United States Navy) and in boosters or relays for fuzes.

Ammonium picrate (*Explosive "D"*).—Used as projectile filler.

Trinitrocresol.—Similar to picric acid, used, when mixed with picric acid, in Austria in World War I.

Trinitro-aniline.—Not used on a large scale.

Trinitrophenylmethylnitramine or tetryl.—Used for booster charges and burster charges for certain minor caliber projectiles and relays; costly to manufacture.

Tetranitroaniline.—(TNA) Costly to manufacture; not entirely established; unstable with moisture.

Hexanitrodiphenylamine.—"Hexa," used by Germany and Italy mixed with TNT, poisonous.

Amatol.—TNT and ammonium nitrate.

Nitrostarch.—Trojan powder used in hand grenades.

Trinitrobenzene.—Costly and difficult to manufacture; low yields; very little manufactured.

RDX.—Also known as "cyclonite" and "Hexogen." Always used in mixtures with other materials due to its high sensitivity.

RDX—Composition A.—Mixture of approximately 90 percent RDX with 10 percent beeswax or other similar wax.

RDX—Composition B.—Mixture of approximately 60 percent RDX and 40 percent TNT plus a fraction of 1 percent of beeswax or other similar wax.

RDX—Composition C.—Plastic mixture of approximately 90 percent RDX and 10 percent of an emulsifying oil. Also known as "P. E."

Torpex.—Mixture of RDX, TNT, and aluminum powder plus a fraction of one percent of beeswax or other similar wax.

Barinol.—Mixture of TNT, barium nitrate and aluminum powder.

Miniol.—Mixture of TNT, ammonium nitrate and aluminum powder.

Guncotton.

8–8. The first modern high explosive to come into general use was guncotton. It is a cellulose nitrate of high nitration with about 13 percent nitrogen content. It was manufactured in a manner similar to that given for soluble nitrocellulose under the discussion of smokeless powder, except as to strength and mixture of acids and time for nitration. It is similar to ordinary cotton in appearance and, when pure, is white and has neither odor nor taste, and is free from either alkaline or acid reactions. After poaching, it is compressed into blocks containing about 25 percent moisture, and these are packed into war heads and mines. In England war heads were loaded by compressing the full charge into a former of the shape of the war head, and then loading in one operation. Due to its sensitivity when dry, its liability to deteriorate, and its low power as compared with other high explosives, it has been superseded for the most part by TNT. In the United States Navy it has been replaced by TNT and Torpex for war heads and mines.

Source of raw materials.

8–9. A glance at the list given above will show that most high explosives are derived from coal-tar products. When coal is subjected to destructive distillation, coke, gas, and coal tar are obtained. Coal tar is a heavy liquid of a complex mixture which, on further distillation, will yield the aromatic hydrocarbons (benzene, toluene, xylene, naphthalene, and anthracene) and the

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aromatic alcohols (phenol and cresol). Precise distillation of selected petroleums will also yield toluene, xylene, and benzene, although in small amounts. Benzene and toluene may be produced in large amounts by the catalytic cracking of petroleum. From these substances, or from other substances obtained from them, explosives may be made by nitration. Many of these substances are used in the dye industry, so that it is closely connected with the explosive industry.

Benzene.

8–10. Benzene, when nitrated once, becomes mononitrobenzene. This compound is used for perfumery and flavoring. When nitrated again it becomes dinitrobenzene, and explosive, very difficult to detonate, and used only when mixed with other explosives. When nitrated again trinitrobenzene is formed, but it is very difficult to manufacture and although it is an excellent explosive, being more powerful than TNT., it is little used.

Toluene and TNT.

8–11. Trinitrotoluol is formed by treating technically pure toluol with a mixture of nitric and sulphuric acid, forming mononitrotoluol; then treating this product with a similar mixed acid, forming dinitrotoluol, and finally by treating the dinitrotoluol with stronger mixed acid forming trinitrotoluol.

In the first step, spent acid from a previous mononitration is run into the kettle until it is about one-third full. The toluol charge is then fed into the nitrator and as soon as it is in the mixed nitrating acid is started. The flow of this acid is controlled with great care to avoid too high a temperature or firing of the charge, and to reduce the time of nitration and obtain the maximum yield. Excess temperature reduces the rate of nitration and the yield of mononitrotoluol.

As soon as all the nitrating acid has been run in the nitration is complete. Agitation is stopped to allow separation to take place. The acid separates to the bottom and the mono nitrated oil floats on top. The spent acid is then run off into a service tank. After all spent acid is drawn off the mono is removed to other nitrators located in separate buildings for the second nitration.

The first step in second nitration is to run in the nitrating acid. As soon as this is in, the mixed acid change is started. This operation is not so critical with respect to temperature as the first nitration because the reaction is not so violent and the presence of the large volume of acid tends to make for less temperature rise. The mixture is agitated constantly during this nitration. As soon as all the mono-nitro has been run in, the nitration is complete, and agitation is stopped. When the separation is complete, the spent acid is run off and is used in a mononitrating operation after being fortified. The dinitrotroloMuol is drawn off to a separate building for the third nitration.

The first step in the third nitration is dehydration, which consists of removing any water present by dissolving the dinitrotoluol in fuming sulfuric acid. The DNT is charged into the nitrator and this acid added. The removal of all moisture in this manner gives a higher yield with less nitric acid than a direct nitration. After the dehydration is complete, the mixed acid is started, the mixture is agitated, and the nitrator is heated with steam for about 2 hours. A test for completion of nitration is then made by determining the temperature at which a small sample of the nitrated oil will solidify. If the oil solidifies between 65° and 70° C., the nitration is complete. The product is allowed to separate and the spent acid is run off and is used in a dinitration after being fortified.

The crude molten TNT is purified by first washing twice with fresh, hot water; second with fresh cold water, which washes and solidifies the TNT; third, washing the TNT crystals with sellite solution (16 percent sodium sulfite); fourth, washing with fresh cold water. The first water washes remove free acids. The sellite solution has little effect on the desired symmetrical TNT; but reacts with the isomins to form sulfonates that are removed in a water solution. The elimination of these isomers reduces the amount of exudate which might form in storage.

It is often necessary to remove TNT from loaded ordnance items which have been in storage for considerable periods of time. The TNT is removed by melting from the container with steam. This material is then subjected to normal purification process, giving a product equivalent in all respects to newly manufactured TNT.

The TNT from the purification process is practically a pure product with a minimum melting point of 80.2° C. The process is repeated if samples show a lower melting point. This method of purification is used to replace the more expensive recrystallization in which solvents such as alcohol, carbon tetrachloride and acetone are used.

The crystalline TNT from the purification process is melted and air bubbled through it to remove all traces of moisture. The molten TNT is solidified either in "flake" or "granular" form.

The flake form is produced by running the molten TNT onto the surface of a cooled rotating drum from which a scraper removes it as flakes. The second form is produced in a granulator, a jacketed, agitated cooling kettle. The rate of cooling is controlled by the use of water and steam in the jacket. During solidification, agitation is continued, thus preventing the formation of large lumps of TNT.

The melting point of TNT is dependent on the impurities present in the form of dinitrotoluol, isomers of trinitrotoluol and nitrobodies of aromatic hydrocarbons or aromatic alcohols. The presence of the first is due to incomplete nitration in the third step; of the second, to side reactions which take place during nitration; of the third, to the use of toluol of only technical purety in the first nitration. These latter impurities could be avoided by the use of chemically pure toluol, but at a prohibitive cost.

8–12. TNT. is a white crystalline substance when pure, and varies in shade from a light yellow to a dirty brown when impurities are present. When pure it melts at about 80.5° C. Its purity is shown by its melting point. **TNT.**

Two grades, grade A and grade B have been used in the Navy. Grade A has had melting points above 79.5° C. The increase in purity and melting point of lots of recent manufacture is due to improvements in process. Old lots have melting points in the lower range. Latest lots have a melting point above 80.2° C., which is standard for all future lots of this grade. Grade B TNT having a minimum melting point of 75.5° C. is now used to a negligible extent by the Navy.

Properties of TNT.

8-13. TNT is neutral in reaction and, unlike picric acid, does not form sensitive compounds by combination with metals, even under unfavorable conditions of moisture and temperature. Grade B TNT, however, will evolve considerable gas after prolonged contact with aluminum. It has high chemical stability, even when subjected to temperatures as high as 150° F., for considerable periods of time. It can stand great variations in temperature without being affected. Although the specifications for TNT require rigid purification and elimination of all acids, its stability does not appear to be affected by traces of acids. Caustic alkalies, on the other hand, are known to increase its sensitivity and should be carefully avoided. It has been found that TNT darkens on exposure to light and the melting point is somewhat lowered.

Other properties of TNT.

8-14. TNT is relatively insensitive to shocks, friction, or pressure. When ignited, unconfined, it burns slowly with a dense black smoke and without explosion. It ignites at 300° C., and at 180° C. there is a slow evolution of gas. Experiments made at the Naval Proving Ground indicate that in case of a serious fire near or among TNT charges a violent explosion is probable. Incidents have been reported from abroad where TNT in storerooms has exploded during a fire; consequently this danger should always be kept in mind. TNT can be melted readily in kettles with steam or hot water jackets, or, due to its specific gravity, may be melted in a hot water bath where it drops to the bottom and may be drawn off in liquid form. In the melted form it has the appearance of melted maple sugar, solidifying like maple sugar when cooled. When melted it can be cast solid in any shape desired. This property makes it a very convenient substance for explosive charges in mines, torpedoes, bombs, and depth charges, and it is now in general use in most countries for this purpose. Grade B gives as powerful explosive effects as grade A and is considerably cheaper to make.

Explosive force.

8-15. The explosive force of cast TNT is about 10 percent greater than wet guncotton for equal weight and somewhat greater than this for equal volume, as its density is greater. The density of wet guncotton is about 1.3. The density of cast TNT runs from 1.50 to 1.61, and of loose crystalline TNT from 0.75 to 1 (hand-packed).

TNT boosters.

8-16. Cast charges of TNT are very difficult to detonate directly and a "booster" of granular crystalline TNT (grade A) is used to transmit the detonation of the fulminate detonator to the cast main charge. This is analogous to the use of boosters of dry guncotton to detonate main charges of wet gun-

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cotton. Unlike dry guncotton boosters, the crystalline TNT boosters may be stored aboard ship directly in the cast main charges.

Moisture in TNT.

8–17. Contrary to certain of the published literature on the subject, experiments conducted at the Naval Proving Ground and at the Naval Torpedo Station show conclusively that the presence of moisture adds greatly to the difficulty of detonating TNT and probably decreases its explosive force. Five percent moisture, or even less, will cause a "booster" charge of hand-packed crystallized TNT to fail altogether when using a service detonator, although dry guncotton will detonate successfully under these conditions. It is of the greatest importance that TNT boosters be kept dry in service.

Comparison with explosive "D."

8–18. Although extensively used as a projectile filler for field artillery ammunition and for 3-inch antiaircraft projectiles, and with black powder as a mixed filler in medium caliber common projectiles, TNT is inferior to explosive "D" for use in armor-piercing projectiles against thick plate, as it is more sensitive to shock and is, therefore, liable to premature explosion on impact, particularly with pressed charges.

Uses of TNT.

8–19. TNT is used in the United States Navy for the following purposes:

(*a*) Cast TNT for main charges of torpedo warheads, mines, depth charges, and bombs. Cast charges are ordinarily made of grade A TNT, although grade B may be used if grade A is not available. *Grade B TNT is used only for cast charges*, for which purpose it is entirely satisfactory as to stability, is equal to grade A in explosive force, is considerably cheaper, and is somewhat less sensitive. Its only disadvantage is that it gives off a dark brown liquid exudate and some gas under long storage. At present all TNT produced is grade A.

(*b*) Grade A loose, granulated, TNT for booster charges, in mines and depth charges.

(*c*) Grade A, granulated, loose or pressed into blocks, for demolition charges.

Grade A has been used in cast form as projectile filler for 3-inch antiaircraft projectiles and for flat-nose projectiles for antisubmarine work. The latter are now obsolescent. It has also been used, mixed with an equal weight of black shell powder, as a burster charge for projectiles of various calibers.

Care in storage and handling.

8–20. Like other explosives, TNT should not be subjected to high storage temperatures nor exposed to the direct rays of the sun. Particular attention must be paid to keeping TNT boosters dry.

(*a*) TNT should not be subjected to contamination of any kind, such as dirt, oil, acid, or alkali. It should be handled as little as possible.

(*b*) In case of a serious fire it should be remembered that charges of TNT are more inflammable than charges of wet guncotton. For this reason it is important that magazines containing TNT charges should be fully equipped with flooding and sprinkling systems.

(*c*) In torpedo war heads of old design, the booster is a charge of granulated TNT encased in a container of thin copper secured to the top of the

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exploder casing. The container has a recess in its under side for the detonator, so that when the detonator is raised to its "armed" position it is near the center of the booster charge and separated from the granulated TNT by the thin copper wall. TNT boosters have been replaced by tetryl boosters in the war heads of all torpedoes now in use. This replacement will probably be made in all older war heads before they are used.

Exudation.

8–21. A dark brown, oily liquid or exudate frequently separates out from TNT. The amount and rate of separation is dependent primarily upon the purity of the TNT and secondarily upon the temperature of storage. A grade B low melting point product will exude considerable liquid and some gas. This exudation is accelerated with an increase in temperature. Pure TNT will not exude any liquid. Exudate consists of the impurities which have not been extracted in the refining process. It is a mixture of isomers of TNT, nitro bodies of toluol of a lower nitration, and possible nitro bodies of other aromatic hydrocarbons and alcohols. It is inflammable, and has high sensitivity to percussion. Its presence does no harm to the stability, but somewhat reduces the explosive force of the main charge. No danger may be apprehended from the presence of this liquid on the outside of containers, providing instructions for its disposal are observed. Its presence may be considered a normal condition of cast grade B charges.

TNT exudate mixed with a combustible material, like wood chips, sawdust, or cotton waste will form a low explosive which is highly inflammable, ignites easily from a small flame and from it flame spreads rapidly over the whole surface. This material can be exploded in a manner similar to a low grade of dynamite, but the main danger is its fire hazard. Accumulation of exudate in such a form is considered a great risk, both explosive and fire, and should always be avoided by constant removal and disposal of the exudate. Constant inspection of all cast TNT charges should be made to see that this condition obtains. The exudate is soluble in carbontetrachloride, acetone, or alcohol. These solvents should be used to facilitate its removal and disposal. Under no circumstances should soap or other alkaline preparations be used to remove this exudate, as the addition of a small amount of hydroxide, caustic soda, or potash, will cause TNT to explode when heated to 160° F.

The gas which is liberated from cast TNT in which exudate is present is composed approximately of the following: CO_2, 9 percent; CO 3 percent; H_2 25 percent; CH_4 3 percent, and N_2 60 percent.

Trinitroxylene (TNX).

8–22. Trinitroxylene, or TNX, is made in a manner similar to TNT Due to difficulties in obtaining TNT during the World War I, this explosive was produced to supplement the available supply of TNT. The raw materials were available, and it fulfilled practically all requirements except that of ease in handling. Xylene is a higher boiling hydrocarbon than toluene and TNX has a higher melting point than TNT so that it cannot be cast directly in mine charges, but this high melting point also complicates manufacture. It has another drawback in that the yield is less than with TNT. The nitration is carried out in three stages, the first two in the same nitrator, and the third in a different one. The acids are handled as in the manufacture of TNT in three stages, i.e., the tri-spent acid is fortified and used as the bimixed, and this spent acid is again fortified and used as the monomixed acid. The monospent acids are denitrated and used in the acid plant.

8-23. The proper amount of acid is run in the nitrator, the xylene is added slowly, and the acid is drawn off to be used over again. The agitators in the nitrating kettles are started and the monomixed acids added slowly so that the temperature does not rise very materially. Cold water is run through a series of coils in the nitrator to keep the temperature down. After the agitator has continued for about an hour, the charge is allowed to settle, and in settling the acids and mononitroxylol separate. The acids, being the heavier, settle at the bottom of the nitrator where they are drawn off. This completes the first stage of the nitration operation. The bimixed acid is then added slowly, and the charge agitated and cooled with water. During the latter part of the reaction, if the charge cools too much, steam is passed through the water coils. Manufacture of TNX.

After the reaction is completed, the charge is again allowed to settle; the spent acids are drawn off as before, fortified, and then used over for the first stage nitration on a following round. The bioil as it is called (the dinitroxylol) is then forced by air to the scale tanks for the third stage nitration, being careful to keep it heated, as it becomes solid at room temperature. In the third stage, the bioil is added after the tri-mixed acids have been run into the nitrator; the agitation started, and the temperature is controlled by the cooling coils. The product now becomes a thick mush of TNX, mixed with acid, with an amount of DNX mixed with it. As the acids will not separate out, it is now necessary to pass the product through centrifugal wringers, and after that it is thoroughly washed, neutralized by the addition of bicarbonate of soda, dried in a hot-air continuous drier, and finally screened and packed for shipment. The TNX becomes solid in the third stage nitration and thereafter is in a granular form, sometimes quite lumpy.

8-24. TNX is a yellowish granular powder similar in appearance to T N T, but it has a melting point of about 165° C. It can be used as a mine, depth, or war head charge and is readily loaded when mixed in about a 50-50 proportion with molten TNT. None of this material is in service at present but circumstances may require its manufacture at some future date, so a small amount is now on hand at the ammunition depots. As with TNT, no special tests are required for TNX, as it is stable under all ordinary conditions of storage. Properties of TNX.

8-25. Trinitrophenol, or picric acid, a very powerful explosive, was adopted by several foreign countries as a projectile filler as early as 1886, under the name of "melinite." It was used in the cast form by the British as "lyddite." and by the Japanese as "shimose." It has appeared as a component in a number of Picric acid.

other explosives. It is a yellow crystalline substance, soluble in alcohol benzine, and only slightly soluble in water. It is used in the dye industry and in solution for treating burns. It has the property of reacting with metals, especially lead, to form sensitive and dangerous salts which must be avoided. With ammonia it forms a comparatively insensitive compound, ammonium picrate, which has been much used as a military explosive. Picric acid melts at 122° C. If stored properly it shows no tendency to decompose at moderate temperatures. It is more sensitive than TNT to shock and friction. Due to the fact that picric acid forms dangerous salts and that it will deflagrate on contact with heavy armor, its use as a high explosive in this country has been limited.

Manufacture of picric acid.

8–26. One method of manufacture of picric acid is from phenol or carbolic acid, which is melted in a sulfonator and sulfonated making phenolsulfonic acid. This material is then treated with nitric acid in a nitrator. The spent acid containing the picric acid in solution is cooled, thus precipitating crystals of picric acid which are removed, washed and dried. A second method of manufacture is to chlorinate benzol and nitrate this material. Either mononitro chlorbenzol or dinitrochlorbenzol may be produced. The nitrochlorbenzol is hydrolyzed to form nitro phenol. This material is then further nitrated to produce picric acid. This process requires the use of less nitric acid and benzene (a raw material for the production of phenol), than picric acid produced by the phenol method.

Ammonium picrate, Explosive "D."

8–27. Ammonium picrate, Explosive "D," has been adopted by the Navy as a filler for armor-piercing projectiles due to its insensitivity. It reacts much more slowly than picric acid in forming metallic salts—in fact in an almost negligible quantity when dry. When wet it reacts slowly to form metallic picrates. It is a crystalline powder, varying in color from orange to deep red, depending on the method of manufacture and the percent of excess ammonia present. It has high chemical stability. No acid products indicating decomposition are observed, even when subjected to temperatures as high as 150° F. for considerable periods of time. Ordinary variations in temperature have no effect on Explosive "D," but it should not be exposed to moisture as it will absorb up to 5 percent moisture, thereby losing power and sensitivity, as well as tending to form metallic salts. Explosive "D" is highly insensitive to shock, friction, and pressure. It cannot be melted like picric acid, but, when heated to 300° C., explodes. On account of its insensitivity, it is much better than picric acid or TNT for armor-piercing projectiles, as it will stand the shock of impact against any thickness of armor if properly loaded. The Trauzl test shows that cast TNT is more powerful than Explosive "D," as Explosive "D" is ordinarily used.

Characteristics of Explosive "D."

8–28. When Explosive "D" is ignited and not confined, it burns slowly, with dense black smoke, and without explosion. If confined and heated to the ignition temperature, it will explode. It requires a very strong detonation to explode it. On complete detonation it gives off a dense cloud of black smoke with a sooty deposit, due to the carbon freed in the reaction, and leaves a smell of ammonia in the vicinity. This is called a "high order detonation." When Explosive "D" deflagrates, and when the full explosive effect is not experienced, yellow smoke is observed and particles of unburned Explosive "D" remain. This is called a "low order detonation."

8–29. Ammonium picrate has been known for many years as an explosive. About 1870, propellent powders, consisting of a mixture of ammonium picrate and saltpeter, were introduced in France. These powders gave excellent results, being much more powerful than the black powder then in ordinary use, but they were later superseded by smokeless powder. Up to about 1907 a mixture of ammonium picrate and saltpeter was used in the British service as is the "exploder" for projectile burster charges of lyddite. Later, this mixture, which was known as "picric powder," was superseded by "tetryl." So far as known, the United States is the only country using straight ammonium picrate as the burster charge for high explosive projectiles at the present time. **Use of Explosive "D."**

8–30. Ammonium picrate is manufactured by saturating a hot water solution of picric acid with aqua ammonia or ammonia gas. The acid is neutralized, the end point being indicated by use of brom-thymol-blue paper as an indicator. When the acid has been neutralized, the solutions run to crystallizing tanks, where the ammonium picrate crystallizes out. Controlled cooling with a water jacket, and agitation with compressed air are employed to control crystal size, proper crystal size being of importance when loading the explosive into projectiles. The crystals are then removed, filtered, dried, and screened, and the explosive is ready for loading into projectiles. **Manufacture and use of Explosive "D."**

A second method of manufacture is by nitrating chlorbenzene and removing the chlorine radical with sodium hydroxide or soda. This product, ammonium picrate, may have a percentage of impurities such as dinitro-chlorbenzene present unless thoroughly purified. These impurities are highly toxic in small quantities. Proper precautions must be taken to avoid toxic effects when handling ammonium picrate which has been manufactured by this second method. Whenever Explosive "D" is being manufactured or handled the following precautions will be taken: Wearing dust masks, and clothing and gloves which are washed at frequent intervals; bathing of operatives immediately after working hours, and special medical examination to discover incipient toxemia.

Ammonium picrate removed from loaded items has too small a crystal size to be reused. It may be reclaimed for use by dissolving it in hot water, saturating with ammonia, and repeating the crystallizing operations used for newly manufactured ammonium picrate.

8–31. Like others, Explosive "D" should not be subjected to high temperatures nor exposed to the direct rays of the sun. It should be kept thoroughly dry and not subjected to contamination of any kind, such as dirt, oil, or acid, or such alkalis as lime, especially, and it should not be left in contact with unprotected metal surfaces, especially lead. Aboard ship, Explosive "D" is found **Care of Explosive "D"**

only in loaded projectiles and requires no special care, except to see that the projectile rooms are kept thoroughly dry and at moderate temperatures. In case of fire in the vicinity of projectiles, care should be taken to see that they do not become heated to a high temperature as the Explosive "D" might explode. In such cases, they should be kept cool by the use of the sprinkler system. No special tests or inspections of ammonium picrate are required afloat.

8-32. Trinitrophenylmethylnitramine, or tetryl, as it is usually called, is another aromatic nitrocompound which has come into use as a booster material. It is about 18 percent more powerful than TNT and more easily detonated. It is more sensitive to shock than TNT, but not sufficiently so to be dangerous. It is stable at all ordinary temperatures if manufactured properly. It melts at about 130° C., and explodes at 186° C. It is a very excellent explosive for booster charges, but it is expensive to manufacture, and is sometimes too sensitive for a projectile filler. Tetryl is made by the action of nitric and sulphuric acid on dimethylaniline. Aniline is heated with alcohol under pressure in autoclaves, in the presence of sulphuric acid, to form dimethylaniline. After nitration, the tetryl separates out as a crystalline powder and is then filtered, washed, and dried in trays in dry houses.

Torpedo war heads now use a booster charge of tetryl in a metal container which is inserted in a recess above the exploder casing at the time the exploder mechanism is installed in the war head. The booster has a recess in its lower end for the detonator, so that when the detonator is raised to its "armed" position it is near the center of the booster and separated from the tetryl by the thin metal of the container. Tetryl is used as the burster charge for certain small caliber, antiaircraft projectiles.

Care in handling.

8-33. The same precautions are followed in handling tetryl as in handling other high explosives. Special care is required in manufacture and loading, due to the dangers of tetryl poisoning.

TNA.

8-34. A similar explosive, derived from aniline, is tetranitroaniline. It is more powerful than tetryl and less sensitive to shock. It is rather poisonous and has a tendency to hydrolyze. It is expensive to manufacture and has not come into common use, but may be used in place of tetryl as a booster material. Its stability has not been wholly established.

Amatol.

8-35. The above-mentioned explosives are all aromatic nitrocompounds. During World War I, on account of the shortage of toluol, it became necessary to adopt a mixture for padding out the TNT, using inorganic compounds. Ammonium nitrate has been used for many years as an ingredient in mine explosives. Amatol is made by melting TNT and incorporating ammonium nitrate, making a 50-50 or an 80-20 mixture. This explosive may be encountered in certain projectiles or bombs obtained from the United States Army.

Nitrostarch.

8-36. Nitrostarch came into use during World War I for the same reason as amatol. It is never used alone but always mixed with some substance such as ammonium nitrate, or sodium nitrate, and diphenylamine. In its manufacture, starch is fed slowly into a mixture of nitric acid and sulphuric acid and agitated. The nitrostarch formed is separated from the spent acids, washed and centrifuged, and then dried. It is then mixed with ammonium nitrate and stabilizers, and packed in hand and rifle grenades and trench mortar projectiles. The amount of nitrostarch varies in different mixtures. When 40 percent is used, the mixture is called Trojan powder. Grenite contains about 95 percent nitrostarch and is used in grenades only. These powders are highly inflammable and more sensitive than TNT. Improvements in manufacture have increased the stability of these explosives, but they must be stowed in dry places at moderate temperatures. Nitrostarch explosives are hygroscopic. Due to poor stability of these explosives afloat, they have been withdrawn from service and no further procurement is contemplated.

8-37. Nitroglycerine has not been found suitable as a military high explosive, due to its great sensitivity. It is, however, one ingredient of double base powders. These powders are used by other nations as propellant gunpowders and by the United States Navy as rocket propellants. In addition it has been used to a great extent mixed with inert materials to form dynamite for commercial purposes. Nitroglycerine.

8-38. RDX, incorporated into explosive mixtures such as Composition "A," Composition "B," Composition "C," or Torpex, is a military explosive development which reached practical application during the Second World War. It is produced by the nitration of an organic material. Purification is accomplished by crystallization from various media, including acetone or glacial acetic acid. The crystals are then coated with beeswax or other similar waxes to reduce the sensitivity of the material. In this form RDX is insensitive enough to be handled readily. Further additions of less sensitive materials are necessary before it can be used as a military explosive. RDX.

8-39. Composition A may be used as a projectile filler. RDX Compositions A B, and C.

Composition B may also be used as a projectile filler. In addition, it is used to produce Torpex since it lends itself to cast loading technique better than other forms of RDX.

Composition C has advantages for use as a demolition explosive due to its plastic form.

8-40. In general, RDX explosive mixture loaded items can be treated in the same manner as TNT loaded containers. RDX mixtures in the bulk form must be handled with greater care due to the sensitivity of the RDX present. Stowage and Handling of RDX explosives.

8-41. Torpex, a much more sensitive but more powerful explosive than TNT, is used as the explosive charge for those types of weapons, wherein it is desired to have as great a radius of effect of the detonation as possible. Torpex.

8-42. The explosive properties of Torpex are much greater than that of TNT. On a weight basis, 100 pounds of Torpex will produce the same underwater damage as approximately 150 pounds of TNT. On a volume basis, 100 Properties of Torpex.

volumes of Torpex will produce the same underwater damage as 170 volumes of TNT.

The impact sensitivity of Torpex is much greater than that of TNT due to the RDX present. Thus the use of Torpex is usually limited to those weapons where exposure to bullets and projectile or bomb fragments is not likely.

Loading of Torpex.

8–43. The specific gravity of cast Torpex is 1.70 ± 0.05 compared to 1.52 for cast TNT.

Torpex is nonhygroscopic, noncorrosive, and surveillance tests prove it satisfactory.

The temperature stability is not appreciably different from that of TNT.

Torpex is cast loaded into containers in a similar manner to cast TNT loading.

Chapter IX. DETONATING SUBSTANCES

9–1. When black powder came into use as an explosive, it was ignited by the direct action of a flame. Later flint and steel were used. Because these methods were not safe and sure, improvements were sought. The discovery of mercury fulminate with its various characteristics made it a readily available material for use in a cap for the purpose of ignition. Mercury fulminate can be detonated by a blow and goes off with great heat and some flame. It is a powerful explosive and is used in very small quantities for the purpose of igniting black powder. If used alone, it explodes with great violence. To increase the heat and length of flame, the primer cap of the present time usually contains mercury fulminate, potassium chlorate, and antimony sulphide, and, in some instances, ground glass. It is fitted in a primer, and, when struck or heated, fires a small charge of fine black powder which ignites the smokeless powder charge. Primers are discussed in chapter 14. **General.**

9–2. In the discussion of smokeless powder, it was pointed out that the powder grains burn from the surface inward in parallel layers. To ignite a grain it is necessary to apply a flame for a long enough period to cause chemical transformation and oxidation on the surface, whereupon the grain begins to burn, the action continuing until the grain is consumed. The primer alone, which is adequate for black powder, will not ignite smokeless powder directly, for it does not give a sufficient volume of flame and heat. It is necessary to introduce another agent to prolong the primer flame until the smokeless powder starts to burn. Black powder is found to be most suitable for this purpose. It is introduced as a part of the primer in case ammunition or as the ignition charge in bag gun ammunition. Getting the proper effect from the ignition charge is very important, as variations will have an appreciable effect on muzzle velocities and pressures. From experimental work certain rules for assigning and distributing the weight of the ignition charge have been adopted, and these govern the present practice. **Ignition of smokeless powder.**

9–3. When black powder was in general use as a projectile filler, the fuzes operated on the same principle as the primers. A percussion cap, either directly or through the agency of a time train, fired a small priming charge of black powder which set off the burster charge. Such fuzes are called ignition fuzes, as they set off the burster charge by flame. With the introduction of high explosives, this method of causing a projectile to burst was found impracticable. Investigation showed that mercury fulminate would cause dry guncotton to explode. It was found that when dry guncotton exploded in proximity to wet guncotton it caused the latter to detonate. These discoveries made gun- **Projectile fillers.**

cotton a valuable high explosive for torpedo war heads and mines, but it was not suitable for use as the burster charge of projectiles. Since other nitrocompounds could be detonated by mercury fulminate and since some of them were suitable for use as explosive charges of projectiles, they were adopted for this purpose. However, ignition fuzes were not suitable for exploding high explosives. It became necessary to conduct a series of investigations of the phenomena connected with the detonating of high explosive compounds. The details of the fuzes used with high explosives are set forth in chapter 13.

Detonation.

9–4. To get the full explosive effect from a high explosive, it is necessary to have the substance change in a very short space of time into gaseous products. This almost instantaneous transformation is called a detonation. To obtain a detonation a very sudden and intense blow is necessary. Ignition of a part of the mass of a high explosive will not cause all high explosives to detonate. There is a class of these substances which, however, when ignited will burn for a very short space of time and then detonate. All high explosives will detonate from the shock of detonating substances placed close to them under proper conditions. Advantage is taken of these properties of high explosives in adapting them for military uses. The substances which will detonate by the application of ordinary means, such as heat, impact, or friction, and will impart a percussion blow of such character as to detonate these high explosives which cannot be detonated directly by the same ordinary means are called initiators or detonating substances. Among such are mercury fulminate, silver and lead azide, and nitrogen sulphide.

Theory of detonation

9–5. After the discovery of high explosives, it was realized that detonation was propagated as a wave, similar to a sound wave, and that the velocity of this wave could be measured. Investigation showed that smokeless powder burned, even under high pressures, at a velocity of less than a few meters per second; black powder at less than 300 meters per second; whereas high explosives detonated at velocities up to several thousand meters per second. A detonation is effected when the wave of detonation proceeds through the mass of unaltered explosive with a velocity of several thousand meters per second, changing the material as it proceeds into the transformed products of explosion. It was found that mercury fulminate, when heated to the ignition point, started to burn at a low velocity, and instantly increased to detonation at about 4,000 meters per second. This transition from burning to detonation is so rapid that it cannot be followed, but, if a sufficient quantity of fulminate is detonated in the presence of another high explosive, the latter will also detonate. The action of the second explosive in detonating is accounted for mainly by the pressure created by the initiator. It has been shown that very small quantities of mercury fulminate will cause certain high explosives to detonate readily; whereas other initiators require larger quantities to obtain the same results. One theory attributes the effect of the initiator to the development of an enormous instantaneous pressure, this pressure being caused by the kinetic energy of the molecules. In this the velocity of detonation, the volume of gas, and the heat of explosion affect the results. A second theory accounts for the action by the production of a very intense shock. Whatever the theory, "the explosion of a detonating substance gives rise to local action in the form of a violent blow or pressure due to the extremely rapid transformation of a solid of high density into a large volume of gas at a very high temperature, and that this property makes it so effective as an initiator of detonation in other explosives" (Colver, "High Explosives," footnote). The capacity to initiate detonation depends very little on the sensitivity either to heat or shock, but, for practical use, the detonating substances must be sensitive enough to start the action by simple means, such as firing locks and exploders.

Booster.

9–6. High explosives are sensitive to the action of a detonating substance to a greater or less degree. Picric acid, tetryl, and TNT, are more sensitive than ammonium picrate. Consequently, just as it is necessary to use black powder between a fulminate cap and a smokeless powder charge, so it is desirable, to obtain the best results, to use a secondary detonating substance between the initiator and the main charge of high explosive. With certain explosives, such as wet guncotton, cast TNT, and others when compressed to a high density, this secondary detonating substance is a necessity, as the initiator will regularly not explode the main charge directly. A detonator is a metal tube, usually copper, filled with a detonating substance, usually mercury fulminate or lead azide. An improvement has been made by reducing the amount of fulminate and replacing that removed with TNT, tetryl, TNA, or trinitrobenzene. With this latter change, the same detonating effect is obtained, but greater safety in handling results. The secondary, or intermediate detonating substance, is called the "booster." A compound is used which is too insensitive to be detonated directly but is sensitive enough to be detonated by the initiator and to pass along the effects to the main charge. Hence, we have boosters in torpedo war heads (formerly called torpedo warhead primers), mines, depth charges, bombs, and in detonator fuzes for projectiles. The relative weights of initiators and boosters are arranged to obtain the best detonation from the main charge.

Mercury fulminate.

9–7. Mercury fulminate was discovered in 1790, and was first used practically for the manufacture of percussion caps in 1815. The sensitivity is so great that accidents, especially in manufacture, are numerous, and frequent attempts have been made to find a suitable substitute. No substance, however, has replaced mercury fulminate to any extent except lead azide which has been adopted for the detonators in certain Navy fuzes, in all Army fuzes, and in commercial detonators.

Manufacture.

9–8. Mercury fulminate is made by adding a solution of mercury in nitric acid to ordinary 95 percent ethyl alcohol. Due to the dangers in manufacture, it is usually prepared on a small scale. A charge of pure mercury is dissolved in nitric acid. This acid solution is then poured into a container in which there is a charge of almost pure alcohol. A violent action results which, when completed, leaves the solid crystalline fulminate in the liquid. The charge is then screened and washed; all impurities removed, and the mercury fulminate drained and packed in bags in water. When required for use, the fulminate is dried.

Characteristics. **9–9.** When pure it is a fine, yellowish-white crystalline powder. The gray color of the commercial fulminate is due to small particles of unconverted mercury. When dry it is very sensitive and is readily detonated by percussion, friction, flame or spark, electric spark, or by contact with sulphuric or nitric acid. When moistened with from 5 to 30 percent of water, its sensitivity is much reduced, although the explosion of a quantity of dry fulminate in contact with wet fulminate will explode the latter even if completely immersed in water.

The sensitivity is increased with the size of the crystals and with heat, as it is more sensitive when hot than cold.

Storage. **9–10.** Mercury fulminate is unaffected by variations in ordinary storage temperatures but is affected by summer and tropical temperatures. Its ignition point is over 150° C. Its explosive qualities are adversely affected by moisture, however, and no effort should be spared to keep all fulminate detonators and ammunition containing fulminate caps dry. If unconfined, it burns fiercely, and when only slightly confined it detonates. When dry it reacts very slightly with metals, but, if any free mercury is present, it will form an amalgam with brass or copper, this action being increased with moisture.

Value as initiator. **9–11.** The explosive action is very sudden and violent, generating high pressures. It can not be compared with other high explosives by the usual tests, as its velocity of detonation is much less than that of other high explosives, and the total heat units per gram are less. Its property of igniting, then rapidly detonating, gives a powerful disrupting effect and makes it useful for initiating detonations; consequently, it is used only for this purpose, either alone or mixed with other substances.

Caps for small arms. **9–12.** Percussion caps for small arms and primers contain mercury fulminate. Potassium chlorate is added to increase the heat of explosion by its oxidizing action. Antimony sulphide is added to prolong the action of the cap as it produces a long flame. Powdered glass has been added to increase the sensitivity.

Azides. **9–13.** Certain substances are now used as substitutes for mercury fulminate. They are silver, lead, sodium, and other azides, of which lead azide or lead hydronitride is the most suitable. These substances are less sensitive, if the crystals are small and have more energy and are stable and durable. Lead azide also has the property of increased brisance with increased pressure. However, they are less brisant than fulminates, but this may be overcome by mixing azides and fulminates. Nitrogen sulphide and other similar substances are not stable enough and are too sensitive for use.

As noted in paragraph 9–7, lead azide has been adopted for the detonator of modern major caliber base detonating fuzes. In the Mark 19 fuze, its use was dictated by the failure of fuzes with fulminate detonators when tested against heavy plate. Under these conditions there resulted a high percentage of bursts on the face of the plate. Lead azide detonators, being less sensitive, have resulted in a practically perfect test performance in fuzes, Mark 19, against heavy plate. Since fuzes, Marks 19 and 20, are identical in their construction, the lead azide detonator was adopted for the Mark 20 fuze, after its suitability had been demonstrated in ballistic tests. The use of lead azide has been continued in later fuze design.

The Army's adoption of lead azide, in place of mercury fulminate, was based on its freedom from the aging effect, which tends to reduce the sensitivity of mercury fulminate after long periods in storage. These findings were to a certain extent confirmed by the Bureau's tests of ignition fuzes, Mark 10, and mods, from Naval Ammunition Depots, representing extremes of stowage conditions.

Chapter X. PROJECTILES

10–1. The word "projectile" is the standard nomenclature of the Bureau of Ordnance and the word "shell" is not standard, and should not appear in correspondence, specifications, or drawings. General.

10–2. The form adopted for the front end of a projectile is that known as the ogive, which is generated by the revolution of the arc of a circle around a chord, the chord being the axis of the projectile, the radius of the arc times the versed sine of the arc (from the point of tangency of the arc to the point of intersection of the arc to the axis of the projectile) being the semidiameter of the projectile, and the radius of the arc times the sine of the arc being the projected length of the ogive. The shape of the ogive is generally expressed by stating its radius in terms of calibers. Frequently the ogival shape is secured by the combination of several arcs of different radii. Form of forward end.

10–3. With proper rotation, it is desirable to keep the center of gravity of the projectile to the rear of, or in the immediate vicinity of, the center of form, particularly in long projectiles. As armor-piercing projectiles require a cap and a heavy nose for penetrative ability there will be a large proportion of metal forward of the cavity. As a relatively long ogive is conducive to long range, it has been advantageous to adopt light nosepieces or false ogivals which are termed "windshields."

10–4. Practically all United States naval projectiles have the corner of the base turned to a small radius, varying from 0.375 inch for large projectiles down to a mere touch of the file on the corner of the small ones. Form of after end.

10–5. For fixed ammunition another factor is added in connection with the form of the after end, for in such projectiles that portion must be kept cylindrical for a considerable length in order to provide a proper bearing for the cartridge case.

10–6. Between the ends, whatever their shape and length, is the cylindrical portion or body of the projectile. Near the after end of the cylindrical body is the rotating band or bands, and at the forward end of the cylindrical body is the bourrelet. Between these two parts the diameter of the body is slightly reduced, in order to provide a generous clearance from the bore of the gun. It is the support and bearing provided by the band and bourrelet which steady the projectile in its travel through the gun and it is quite evident, therefore, that there must be a reasonable distance between them, else too heavy a duty will be demanded of them in preventing wabbling. Form of body.

10–7. As a general rule projectiles are given, except on the bourrelet, only a rough machine finish; that is, one which, while smooth to the eye from a Exterior finish.

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distance of, say, 8 or 10 feet, shows on closer inspection the marks of the turning tools. It is a popular fallacy that a smooth finish is conducive to accuracy. A very complete experimental firing was carried out some years ago in which a series of 14-inch target and armor-piercing projectiles were fired at a standard elevation, velocity, and projectile weight, half of the projectiles being carefully ground and polished to a fine finish, while the other half were left the usual finish. The difference in finish appeared to have negligible effect on the dispersion; in fact, those projectiles with the rough or service finish gave a smaller dispersion than did those with the polish.

Weight.

10–8. Within reasonable limits projectiles can be given various weights for a given gun. The relation between weight of projectile and powder charge, muzzle velocity, and pressure is a part of interior ballistics. The normal weights of United States naval projectiles follow in general:

$$w=\frac{d^3}{2}$$

where

w = approximate weight of projectile in pounds.
d = caliber of gun in inches.

The weight of the projectile per square inch of bore is called the sectional density of the projectile and is represented by the following expression:

$$S.\ D.=\frac{W}{A},$$

where

S. D. = sectional density.

W = weight of projectile in pounds.
A = area of bore, including grooves, in square inches.

This figure has frequent application in gun and projectile design. The sectional density varies from 0.635 for a 1-pounder up to 13.4 for a 16-inch, averaging approximately 0.6 of the caliber.

The distribution of the weight in a projectile is a matter of considerable importance. As a general rule, the center of gravity should be in the longitudinal axis and close to or abaft the center of form. Slight variations in the location of the center of gravity, with respect to the center of form, have negligible effect on the dispersion.

The bourrelet.

10–9. The bourrelet is, as was stated previously, the forward bearing of the projectile. Its surface is generally ground to a fine finish in order to reduce friction and to minimize wear of the lands of the gun. This bearing surface is usually about one-sixth caliber in width; that is, longitudinally with the projectile. Some few small projectiles have no real bourrelet, the entire body of the projectile forward of the band replacing it. With the advent of longer projectiles it has become standard practice to provide in the rear of the band a rear bourrelet having the same diameter as the front bourrelet. The prjoectile is thus provided with better support in the gun and during the ejection from the muzzle.

10–10. The bore of a gun becomes "coppered" with a fine deposit of copper from the projectiles' rotating band after repeated firing. And frequently, also, the liner in a gun becomes slightly crumpled or ridged after repeated firing, particularly in wake of internal shoulders. A certain clearance must be provided between the bourrelet and the lands. The standard United States Navy practice is to make the bourrelet diameter 0.015 to 0.023 inch smaller than the bore of the gun. A minus manufacturing tolerance is added to this diameter of another 0.015 inch, so that the total clearance limits may vary from 0.015 to 0.030 inch. It is reasonable to assume that unnecessary clearance can have at least no beneficial action, and may have an injurious effect on the lands, due to the blows of possible wabbling. It is quite apparent, also, that the less the clearance the more accurate will be the initial direction of the trajectory.

The rotating band.

10–11. The rotating band has three primary functions—to seal the bore, to position and center the rear end of the projectile, and to rotate the projectile. Secondary functions are to hold the projectile in place during loading and elevating for firing. In addition to these functions the band has considerable effect on the range, dispersion, muzzle velocity, and life of the gun.

10–12. Rotating bands have been made of commercially pure copper for all minor and medium caliber projectiles, and of cupro-nickel alloy containing 2.5 percent nickel for major caliber projectiles, the nickel being added to secure greater strength. Some of the projectiles of later design have been banded with gilding metal consisting of 90 percent copper and 10 percent zinc. The addition of the zinc has been found in some cases to reduce the amount of coppering in the bore of the gun.

10–13. As a general rule rotating bands are about one-third caliber in width. In some instances, particularly abroad, the width of a band is kept to a maximum of about 1.5 to 2 inches, and where a greater strength is necessary two separate bands, separated by a short distance, are provided. Double bands have not been adopted by the Navy but are used by the Army on certain field artillery projectiles. Accordingly, they may be found in certain ammunition issued for landing force purposes.

10–14. The band is secured in a score cut in the projectile body, there being a dovetail on each edge to assist in overcoming centrifugal force, and with either waved ridges, longitudinal nicks, or knurling in the bottom of the score to insure against slipping during acceleration. The rough band has a slightly less internal diameter than the rear end of the projectile and is heated to expand to a diameter that will permit the band to be slipped over the rear of the projectile and pressed into place.

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10–15. The forward edge of the band is slightly conical and enters a correspondingly coned seat at the origin of rifling. The central portion of the band is cylindrical and of a slightly greater diameter than the diameter of the bore, plus depth of rifling. An expression often used to obtain the diameter of the cylinder is "$0 = C + 2p + .02$ inches," where C is the caliber of the gun and p the depth of the grooves. It will be observed that a raised lip is on the rear part of practically all bands used in powder bag guns. This lip serves the purpose of insuring a good gas check and, at the same time, because of its considerably greater diameter, preventing overramming in a worn or eroded gun.

10–16. In order to insure a tight joint, the diameter of the cylindrical portion of the band is generally a few thousandths of an inch greater than the diameter of the bore across grooves. Any excess metal in the band will be pressed or wiped back toward the base of the projectile, this being more pronounced in wake of the bands. Should this excess metal be of sufficient quantity it will form a scalloped skirt or fringe extending abaft the band score. Now at the instant that this skirt clears the muzzle there will be a rush of gas past it, which, aided possibly by centrifugal force, may turn this skirt out radially at a considerable angle. A pronounced fringe can have a material effect on range and dispersion, the effect being greatest on minor and medium caliber projectiles. All separate loading projectiles are now made with nonfringing bands in which the lip is at a considerable distance forward of the rear edge of the band and is undercut to allow space for the displaced metal without the formation of a fringe. Bands for projectiles to be assembled in fixed ammunition are lipless.

Underwater attack.

10–17. The successful design must not only provide sufficient metal in the band to secure the desired performance but must also insure against fringing. Grooves or "cannelures" are placed in the cylindrical portion of large bands, for the purpose of allowing space for excess copper, additional space is provided by undercutting the lip as discussed in the preceding paragraph.

10–18. When an ogival-headed projectile, traveling in air, strikes water, it deviates from its trajectory in a violent and uncertain manner. At small angles of fall it tips up, runs parallel with the surface for a short distance, and then, if it still has sufficient velocity, emerges and again takes to the air. This is called a ricochet.

At large angles of fall it is liable to deviate in any irregular direction, the general tendency being to turn downward toward the vertical and to lose velocity rapidly.

10–19. During World War I the demand for projectiles intended particularly for antisubmarine work led to the development of flat-nose projectiles in which there is no ogival form for the bourrelet. These projectiles were adopted with the expectation that they would maintain their trajectory with reasonable accuracy after entering the water. Flat-nose projectiles proved to be of comparatively limited use and they have been dropped from the standard allowances. The greatly reduced range and erratic behavior resulting from the flat-nosed form renders them of doubtful utility for this purpose.

Classification.

10–20.—United States Navy projectiles are divided into 15 classes as follows:

1. *Armor-Piercing* (*AP*).—These projectiles are primarily for use against class A armor but are also effective against class B.

2. *Special Common* (*Sp. Com.*).—These projectiles are for use against class B armor. They contain slightly less explosive than common and more than AP.

3. *Common* (*Com.*).—These projectiles are for use against class B armor but less effective in penetration than Sp. C. or AP.

4. *High capacity* (*HC*).—These are thin-walled projectiles similar to AA and carry about the same percentage of high explosives. They are assembled with no delay base fuzes, tracers, dummy nose plug, and auxiliary detonating fuzes. The dummy nose plug may be removed and a point detonating fuze or a time fuze substituted. These projectiles are for shore bombardment, antiaircraft or for use as common projs.
positions. They carry base detonating fuzes.

5. *Field* (*Fld.*).—These projectiles are for field use. They carry nose detonating fuzes.

6. *Antiaircraft* (*AA*).—These projectiles are for use against aircraft.

7. *Antiaircraft Common* (*AA-C.*).—These projectiles are similar in construction to A. A. except that the base is threaded for a base detonating fuze, thus making the projectile suitable for use against surface targets as well as aircraft targets.

8. *Illuminating* (*SS*).—These projectiles are for use in illuminating enemy ships or target by means of an illuminating element.

9. *Tracer* (*Tr.*).—These are special projectiles designed solely to leave visible trace in the daytime and do not have bursting charges. They are a separate class from other projectiles, and when required may be filled with tracer material. These are obsolescent.

10. *Smoke* (*Sm.*).—This is a special projectile containing a smoke producing element designed solely to make a smoke screen. These projectiles are still in the experimental stage and are intended only for landing exercises for use by landing forces.

11. *Shrapnel* (*Shrap.*).—A modern shrapnel is a projectile containing shrapnel balls which are expelled from the shrapnel case by means of a small charge of explosive, the case remaining intact.

12. *Flat Nose* (*FN*).—Flat-nose projectiles are for use against submarines and are designed to prevent ricocheting on water impact. These projectiles are obsolescent.

13. *Line Carrying* (*LC*).—This is a special projectile designed to carry a line for use in rescue work.

14. *Target* (*T. or Tar.*).—This is a special projectile designed for target practice, ranging, and proving ground work.

15. *Proof Shot* (*PS*).—This is a special projectile designed not to ricochet on water impact and is for use in proving-ground work. It is not contemplated that more of these projectiles will be procured when the present stocks are exhausted.

10-21. Open-hearth steels—acid, basic, and electric, are used for armor-piercing projectiles, but the melting is given far greater care than is received by the average commercial steel. The ingots are cast nose down in iron molds in order to chill them rapidly to prevent piping and injurious segregation.

10-22. There are two general systems of forging. In one the ingot is cast of greater diameter than the finished projectile, and is forged down, being lengthened in the process, under a press or hammer, and in this process the cavity is bored out. In the other process the ingot is of smaller diameter than the finished projectile, is upset in a die under a press to the proper diameter, and its base is then pierced by a punch to form the cavity, the rear walls of the body being somewhat extruded. In the first process mentioned the grain or fiber of the steel is longitudinal whereas in the other process it is transverse.

10-23. The rough forgings are then annealed, after which they are rough machined nearly to size. The next step is a series of heatings and quenchings in oil and hot water for the purpose of refining and fibering the grain structure. After this treatment the forging is turned to exterior and interior dimensions, allowance being made for the fitting of base plug and finishing of band score and bourrelet.

10-24. The next step is the hardening, which is accomplished by a graduated heating beginning with the point followed by a complete quench in agitated cold water. This puts the entire projectile in an exceedingly hard condition. The heating for this treatment is generally accomplished in a bath of molten lead, such procedure being conducive to accurate control of both temperature and position of application of heat. After this the base of the projectile is heated to a lower temperature than was used for quenching and upon withdrawal from the bath or furnace is suspended nose down and immersed up to the bourrelet in agitated cold water. This procedure draws or tempers the rear portion while preserving the hardness in the head. The result is an exceedingly hard head to the rear of which the hardness gradually decreases with increase in toughness. The hard head is to effect the smashing of the plate's face while the tough rear is to support the head and stand the breaking strain of angle impact.

10-25. Finally, the projectile is sand blasted, the band score is finished and the band pressed into place, the cap and windshield are put on, the bourrelet is ground, the band is turned to size, and the base plug fitted.

10–26. The cap follows, in general, the same methods of manufacture and treatment as are applied to the projectile, although, of course, no special ingot is made for it. After forging it is annealed and rough turned, is then fibered, then finish machined, except threading for the windshield, then decrementally hardened and finally finish turned and threaded and installed. Caps are made, in general, of the same kind of steel as are the projectile bodies.

10–27. Caps are secured to the projectile by peening the skirt of the cap into nothces cut in the ogive of the projectile and by soldering the cap to the head of the projectile body with a special low melting point solder. Such a solder is required to prevent the heat necessary for soldering from drawing the temper of the ogive.

10–28. Caps should be held securely in place, and it is quite probable that their efficiency on oblique impact is materially affected by the security of the bond.

10–29. It occasionally happens that caps become loosened by rough handling. Such projectiles should be returned to an ammunition depot for recapping.

10–30. The windshield is made of either forged mild steel, steel stamping, or aluminum, and has no special strength other than that necessary to prevent destruction during handling and setback on firing. Windshields are generally screwed on the cap, and frequently the thread is cut on a tapered surface. After screwing home they are "set" by a center punch at the joint. They sometimes become loose in handling and in that event they should be tightened and reset.

10–31. Base plugs are good quality forged, manufactured from nickel-steel.

10–32. The steel for armor-piercing projectiles is the finest quality, nickel-chrome steel. Due to the comparatively small mass and more convenient size the carbon can be carried much higher than is possible in armor manufacture. For instance, we find the carbon content as high as 0.75 percent. Similarly the chromium can be carried a little higher and we find the chromium content as high as 2.60 percent. The nickel runs about the same as for armor.

10–33. Various theories have been advanced as to the reason for the increase in penetration secured by the application of the cap. The simplest, and perhaps the most reasonable, is that the cap acts to break down the initial strength of the plate, allowing the nose to reach an already strained surface and then provides powerful circumferential support to the point and nose as they begin to penetrate the hard face, maintaining the support until they are well into the plate. **The action of the cap.**

10–34. The shape of the ogive of the projectile itself has considerable effect on the efficiency of the projectile. The curvature of the ogive was increased to about 2.5 calibers because of the desire to reduce air resistance, and this curvature was retained under the cap after its adoption. Shorter curvature is desirable, however, to secure a shorter projectile, and the modern tendency is to fix the ogive radius between 1.5 and 2 calibers. **Form of internal ogive.**

Common and class B projectiles.

10–35. The development of common, AA, AA-common, and field projectiles followed logical channels being based on the attack on unarmored vessels, the upper works of armored vessels, aircraft, earthworks, and fortifications.

10–36. As a general rule the design of and selection of materials for these projectiles is predicated on the physical properties required for the purpose intended. Steel used for the special common and common are similar to steel used for AP projectiles.

10–37. Methods of fabrication differ with the caliber and type. In large calibers each projectile is usually made from a separate ingot, while in medium calibers large ingots are "cogged down" in a rolling mill to billets of round, square, or polygonal section and then cut or broken to proper length. The ends of these blanks are usually inspected to eliminate those which contain piping or injurious segregation.

10–38. Considering major and medium caliber projectiles, and the ingots or billets made for them, as mentioned above, fabrication continues, in general, as follows:

10–39. The projectile blank is heated, placed in a die approximating the exterior contour, nose down, but of excess diameter, and then pressed under the plunger of a hydraulic press, thus forming the ogive. A piercing die or plunger of slightly less diameter than the cavity is then forced into it, which forms the cavity. These two steps can be done with one heating.

10–40. In some projectiles this is the only forging required, but generally the extrusion performed by the piercing die is insufficient to make the cavity long enough. In this case, which is quite general, the forging or blank is reheated and placed in a draw bench, the nose being placed in a die containing a circular hole slightly larger than the finished diameter, and it is then forced through this drawing die by a hydraulically operated plunger which is inserted in the already partially formed cavity. This drawing process forces the sides back over the plunger, thus extending the blank to the required length. In some cases more than one draw is required, and this is generally performed in one heat by forcing the forging through several rings or dies in succession in the same draw bench. The method just described applies, of course, to open-base projectiles. Where the base is to be solid and the nose is to be open the same general process is followed, except that the projectile is worked from the base instead of from the nose.

10–41. The blank is then generally annealed, or normalized, and if high physical properties are required, it may be heat-treated to secure them. It is then passed to the machine shop for finishing.

10–42. The finishing consists in turning and boring to the correct dimensions and tolerances, banding, fitting the plug, painting the interior of the cavity, and inspecting and stamping for shipment. As a general rule all surfaces are finish-machined except as noted below. Many efforts have been made to omit the machining of the cavity, but the forge finish is not satisfactory because the forging temperature is so high that a rough and scaly surface results.

10–43. Some projectiles are fitted with heavy nose or base plugs, others have smaller adapters to carry the fuze, and others may be designed to receive the fuze itself. In most of these classes the cavity is always of larger diameter than is the hole for these fittings. This condition is met in two ways.

10–44. Where the hole is large and the amount of metal to be removed from the rough forged cavity is small, or where the projectile is completely heat-treated, the interior is finished in a boring machine or lathe, using a tool on the end of a bar which is inserted in the hole. This bar is swung on a pivot in order that the tool can be made to follow the desired contour of the interior.

10–45. Where the cavity is large and entails the removal of considerable metal, or where the forward or after fuze plug hole is so small as to render machining impracticable, an entirely different process called nosing in, or basing in, as the case requires, is employed. Here the inner portion of the cavity is machined to size while the outer portion of the cavity is machined to a cylindrical or nearly cylindrical size, any shoulders or seats being also partially machined. The exterior surface of the projectile, in the wake of that portion of the cavity which is to be closed in, is then turned to the reverse curvature of the cavity, or, in other words, the approximate contours of the cavity and outside are exchanged and reversed. That part of the projectile which is to be closed in is then carefully heated in a nonoxidizing flame, and is then either forced, under hydraulic pressure, into a die, which is cut to the proper exterior shape or is pressed into shape under radial pressure. As was stated above, this process can be applied to either the ogive or the base.

10–46. This operation can be so satisfactorily performed that no machine work is necessary on the closed in portion except the fitting of screw threads and gastight seats.

10–47. It is generally customary to select tensile test specimens from heats or lots after all forging or heating is completed, in order to insure that uniform and satisfactory results are being secured.

10–48. The processes referred to above apply to practically all kinds of projectiles, except armor-piercing and minor caliber projectiles.

10–49. Minor caliber projectiles are generally machined from round rolled bars, the forging to shape with final finishing being more expensive than complete machining.

10–50. Base plugs, fuze hole plugs, adapters, and the miscellaneous interior parts of shrapnel, illuminating projectiles, gas and smoke projectiles, etc., are manufactured by the various drop forging, drawing, and machining processes covered in text-books on mechanical processes.

Special projectiles; shrapnel.

10–51. Shrapnel is a type of projectile designed for use against aircraft and personnel and its only naval use is, therefore, in connection with landing parties, bombardment of fortifications, and attack of aircraft. It is interesting to know that the name is derived from the man who invented it in Europe in 1784.

10–52. The most common form of shrapnel consists of a case in the rear of which is a black powder bursting charge, connected to a nose fuze by a central explosion tube around which is packed a large number of lead (88 percent) antimony (12 percent) balls held securely in place by a matrix of hot poured rosin. When the fuze acts the balls are expelled forward by the bursting charge and scattered in a cone-shaped cloud. Shrapnel are, however, frequently given other features. For instance, a high explosive may replace the rosin to increase the violence of the burst and the area or damage; or there may be a heavy head with a high explosive burster and suitable fuze in order to follow the cloud of balls with a secondary explosion, and finally the balls may be replaced by small hollow open-ended cylinders in which phosphorus or other incendiary compound is packed, the object of this design being to add to the local explosion and distribution of missles the probability of creating a conflagration. This design is particularly valuable against aircraft of all descriptions, especially those which employ hydrogen.

Illuminating projectiles.

10–53. The illuminating projectile has a case, similar to a shrapnel case, with a very small expelling charge in the front and just abaft the fuze and an interior assembly of a star or candle with a parachute, and a very lightly held base plug. The explosion of the expelling charge forces out the base and the interior assembly. It is quite desirable to expel the assembly with considerable velocity (at least 300 to 400 foot-seconds relative to the case) in order that it will have as small a velocity, in space, as possible. It would be preferable to have the assembly expelled at the same velocity as the case, but at present this is not possible. The star or candle is a steel container in which is packed, under heavy pressure, an illuminating compound in which magnesium is an important constituent. The explosion of the expelling charge ignites the star or candle. The closed end of the star container is attached to the strand wires of the parachute. The parachute is carefully folded and, with its strand wires, is rolled so that upon expulsion it opens, thereby suspending the candle or star. Because of the high velocity at which the projectile is traveling when ejection takes place, it is necessary to slow down the star-parachute assembly before the parachute comes into full action. This is done by a retarding device which consists of a center wire, one end of which is secured to the center of the parachute and the other to the star. This device holds the center of the parachute nearer the star than when in full release and causes the parachute to spill air thereby preventing a too heavy initial strain on the parachute. After the star has burned for a few seconds the end of the center wire is released from its point of attachment to the star. This permits the parachute to open fully and give its greatest support to the star. (See par. 1–31.)

Smoke and gas projectiles.

10–54. Smoke and gas projectiles, when specially designed for the purpose, are quite similar to any projectile of large capacity so far as the projectile itself is concerned; the difference lying in the kind of fuze, contents, and method of loading.

Target projectiles.

10–55. Economy requires that target projectiles be made of the least expensive materials. They are, therefore, made of cast iron or semisteel. A good grade of metal and efficient methods of casting are necessary, however, to insure that the setback and centrifugal force do not cause fracture, either in the gun or in initial flight. They are so designed that they are similar to their prototypes in exterior shape, weight, and balance. No economy can be effected in the rotating band, as it must function in the normal way.

Proof shot.

10–56. Proof shot, sometimes called "slugs," are solid cast iron shot with a square forward end. From the forward edge of the rotating band to the rear, they are identical in shape with the standard projectile of their caliber, but their only other similarity is their weight and bourrelet diameter. As a result of this design their behavior in the gun or their interior ballistic performance is similar to, while their flight is much shorter than, that of the standard projectile. They are used for proving ground work. Their use in spotting practices has been discontinued.

Line-carrying projectiles.

10–57. Line-carrying projectiles are simply loose fitting slugs which carry a rod extending to the muzzle with an eye in the end, to which is attached a light cord. The projectile turns around immediately after firing, and is held to its trajectory by the strain of the trailing cord. The cord is coiled down on deck and, after the projectile has passed over the target, a heavier line is bent to it and with succeeding heavier lines, a hawser can finally be run. A range of about 350 yards can be secured in a 3-pounder saluting gun.

10–58. High capacity projectiles are forged from medium alloy steel which is heat treated. They are forged by piercing from the nose end as contrasted to AP's being forged from the base end. These projectiles may also be used against aircraft by screwing a time fuze in the nose or against surface craft or shore targets with a steel nose plug or time fuze. All are assembled with auxiliary detonating fuzes, no delay base detonating fuzes, and tracers.

10–59. The A. S. projector charge used with MK 20 projector is made up of the following components: body, tail (also called motor unit), rocket propellant assemblage, contact fuze and fuze adapter, and high explosive filler. It is intended for forward throwing from small boats against submarines, the absence of recoil because of rocket propulsion making possible the use of this type ammunition on these relatively small craft. The body (containing about 30 pounds of high explosive), the fuze, and the tail are stowed ashore and also shipped, unassembled. The body and tail are mated by means of a threaded coupling when stowed aboard ships; the fuzes, however, remain in separate stowage aboard ship until the ammunition is placed in the ready service box. Care should be taken to insure that the tail has screwed home completely into the body and is wrench-tight prior to firing of the charge. Designations and markings of this ammunition are given in Bureau of Ordnance Confidential Circular Letter A4–43 dated January 17, 1943. Ordnance Pamphlet No. 1002

(Confidential) gives a description of the A. S. projector Mark 20 and ammunition.

10–60. The A. S. projector charge used with the MK10 projector is made up of the following components: body, tail, contact fuze and fuze adapter, two piece cartridge case (with primer and propellant powder), and high explosive filler. The projector throws a circular pattern of charges, each weighing approximately 65 pounds and containing about 30 pounds of high explosive, a mean distance of 200 yards. The charge is fired from a solid spigot over which the tail tube of the charge containing the cartridge and powder in the end of the tail joined to the body, has been placed. The spigot rests against the lower half of the divided cartridge case which contains the electric primer. The body and tail containing the loaded cartridge are mated together by means of a threaded coupling and are stowed and shipped assembled. The fuze, however, is not placed in the body until the round is placed in ready service stowage and separate fuze stowage is to be provided aboard ship. Care should be taken to insure that the tail has screwed home completely into the body and that it is wrench tight prior to firing of the charge. Designations and markings of this ammunition are given in Bureau of Ordnance Confidential Circular Letter A4–43 dated January 17, 1943. Ordnance Pamphlet No. 1001 (Confidential) gives a description of the A. S. projector Mark 10 and ammunition.

Identification of projectiles.

10–61. When a requisition drawing is prepared for a new type of projectile a mark number is assigned to the design. If individual manufacturers use drawings differing in no essential point from the requisition drawing, the projectiles delivered are designated by the same mark number with an individual modification number for each manufacturer. If, however, the individual manufacturer's designs differ markedly in internal arrangement from the requisition drawing, mark numbers are assigned to each such manufacturer's design.

10–62. For the purpose of ballistic tests and acceptance, the projectiles on a contract are divided into lots, the number in a lot depending on the caliber of the projectile. The caliber, type, the mark and modification, the lot number, and the year of the specifications under which manufactured are stamped on each projectile. These are the normal marks on a projectile and are the only ones by which a projectile can be identified definitely.

10–63. In certain instances improvements in design have been applied to projectiles already in service by the modification of rotating bands, windshields, etc., and such modifications have in general been indicated by the addition of letters after the modification number.

Chapter XI. CARTRIDGE CASES AND CASE AMMUNITION

11–1. In the design and preparation of ammunition for service use, consideration must be given to the ease, facility, and rapidity of loading, the safety of the personnel, and the cost of manufacture and preparation. When the whole charge, including the projectile and primer, can be loaded in one operation, greater rapidity of fire is possible than when loading the projectile and powder separately. When the powder is protected, as in a cartridge case, the danger from flare-backs is greatly reduced. However, as the cartridge case contains the powder charge and primer, additional care must be exercised in handling, for if a sharp edge strike the primer it will explode, and thus ignite the charge.

11–2. The ammunition for the smaller guns is made up with the powder and primer put up in brass or steel cartridge cases, which are hollow cylinders with flat heads, shaped to fit the chamber, some being bottle necked. For ease in loading, the limit for fixed ammunition is placed at the 5''/25-caliber gun. Above this it is necessary to load the powder and projectiles separately. Be- Cartridge cases.

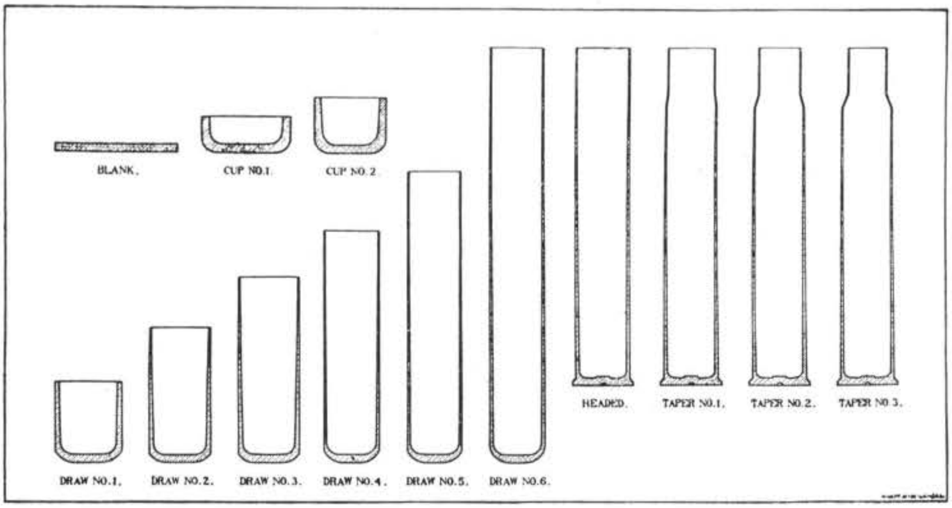

FIGURE 24.—Operations for making 4-inch, 50 caliber cartridge cases.

sides affording a convenient method of loading the cartridge case performs the very important function of preventing the escape of gases through the breech. The cartridge case has a fairly snug fit in the chamber and, on expansion, due to firing, makes a gas seal. Some military forces, notably the German Navy, utilize this method of gas checking in practically all guns, but in our naval service, due to difficulties in handling large cases, especially in disposing of the empties, another system is used. The cartridge case in the larger caliber guns is eliminated and the powder is put up in silk bags. The gas checking is obtained by the mushroom and pads on the breech plug, and the primer is fired by a lock attached to the breech plug. Were cartridge cases used in all sizes of guns, with very large charges it would be necessary to put part of the charge in a case and part in silk bags or thin brass cylinders, as was done in the German Navy, but this complicates the loading. With case guns, gas ejector systems are not necessary except in enclosed mounts. In such mounts gas ejector systems are essential to prevent the accumulation of gas within the mount while with bag guns, gas ejector systems are required to accelerate the clearing of the bore.

Manufacture of cases.

11–3. Brass cartridge cases are manufactured by drawing out blanks of special cartridge case metal. The general features of the manufacture of the different sizes are the same. The metal is cast in slabs of a composition approximately 70 percent copper and 30 percent zinc. It is scraped, annealed, and rolled out to the proper thickness and disks are stamped out to form the blanks, the disks being made of a sufficient diameter to allow for drawing the material out into the finished case. The first operation (fig. 24) is performed in a press with a suitable punch and die to form the cup. Successive drawing operations are then carried on and the cup gradually assumes the general form of a cartridge case. The number of drawing operations depends on the size of the case being made. After each draw, as a general rule, the strains in the metal are relieved by annealing. When the blank has been drawn out to the proper length, the open end is trimmed off and the head is then formed by the action of suitable punch and die in a press. To give the bottle-neck effect, two or three operations are required, depending on caliber of case. The case is then finish machined, the primer hole drilled and tapped, if for a screw primer, and finally the case is carefully gaged. All parts of case are given 100 percent inspection for defects in material and for compliance with dimensions. Steel cartridge cases are similarly formed but with considerable difference in the heat treatment applied.

Care of cartridge cases.

11–4. Cartridge cases may be reloaded and consequently must be given considerable care to the end that when returned to an ammunition depot they may be prepared for reissue. They must be kept free from salt and moisture at all times whether empty or loaded. When empty they should be stowed on end or in the tanks and boxes in which they were received rather than being laid on their sides or stacked horizontally without tanks. Cases must not be washed by ships force after firing but must be cleared of possible inflammable gases by standing on their bases in the open air for a period of ten minutes before being stowed below. They must be dry when replaced in cartridge tanks.

11-5. The marks, modifications, and drawing numbers of cartridge cases manufactured at any time, as well as those currently standard for the service calibers are indicated in the pertinent section of O. D. 515.

Test cases.

11-6. To permit the testing of firing circuits both local and director, vessels mounting 4″/50, 5″/25, 5″/38 and 6″/47-caliber case guns are provided with short cartridge cases called test cases. The diameters of test cases are the same as the corresponding diameters of regular cases for the same guns, but the primer seat is made to take a lock combination primer Mark 15, Mod. 1 instead of a case combination primer Mark 13. An extract or groove is provided so that fired primers may be removed readily without necessarily removing the case from the chamber.

Care in handling fixed ammunition.

11-7. In loading fixed ammunition, particular care must be taken that the point of the projectile or fuze held by one loader may not actually strike the primer in the base of a cartridge in the hands of another loader.

Care should be taken that projectiles are not loosened in the mouth of the cartridge case since a loose projectile may result in a jammed round during a load.

Plate 14 shows the assembly of 20-mm. ammunition.

Plate 15 shows the assembly of 40-mm. ammunition.

Plate 16 shows the assembly of 1.1-inch ammunition. Figures 1 and 2 indicate service assembly and figure 3, the assembly with the projectile blind loaded and plugged.

Case ammunition types.

Plate 17 shows the assembly of 1-pounder ammunition. Figure 1 is the assembly with service projectile with a base fuze; and figure 2 shows the target projectile.

Plate 18 indicates the assembly of 3-pounder ammunition. Figure 1 shows the service cartridge; figure 2 shows the target projectile.

Plate 19 shows the assembly of 6-pounder service ammunition. Target practice cartridges are assembled in the same manner with target projectiles substituted for common projectiles.

Plate 20 shows the assembly of 3″/23-caliber AA ammunition with types of projectiles used.

Plate 21 shows the assembly of 3″/50-caliber ammunition, with the several types of service and target projectiles.

Plate 22 shows the assembly of 4″/50-caliber ammunition, with the several types of projectiles used.

Plate 23 shows the assembly of 5″/25-caliber ammunition with AA common projectile loaded and fuzed, and blind loaded and plugged, and illuminating projectiles.

Plate 24 shows 5″/38-caliber ammunition.

Plate 25 shows 6″/47 caliber ammunition.

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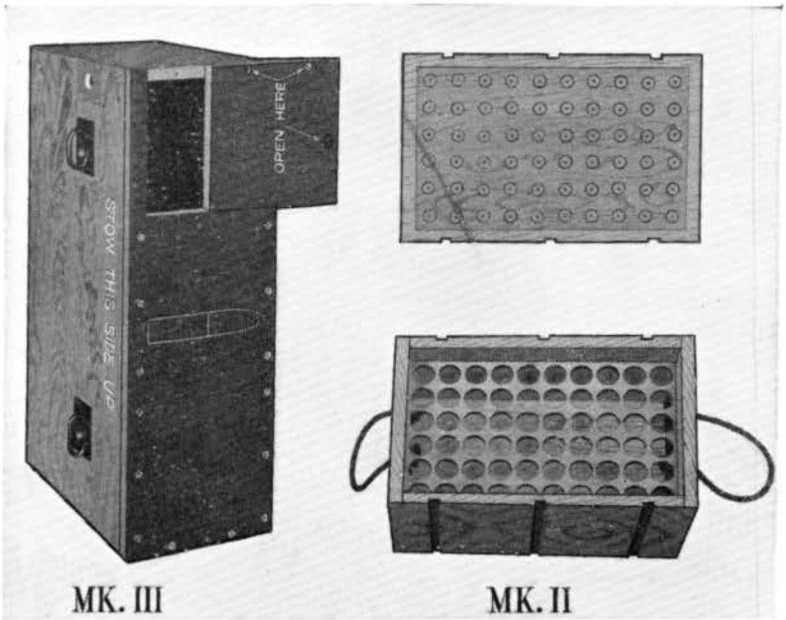

FIGURE 25.—1-pounder ammunition boxes, Marks 2 and 3.

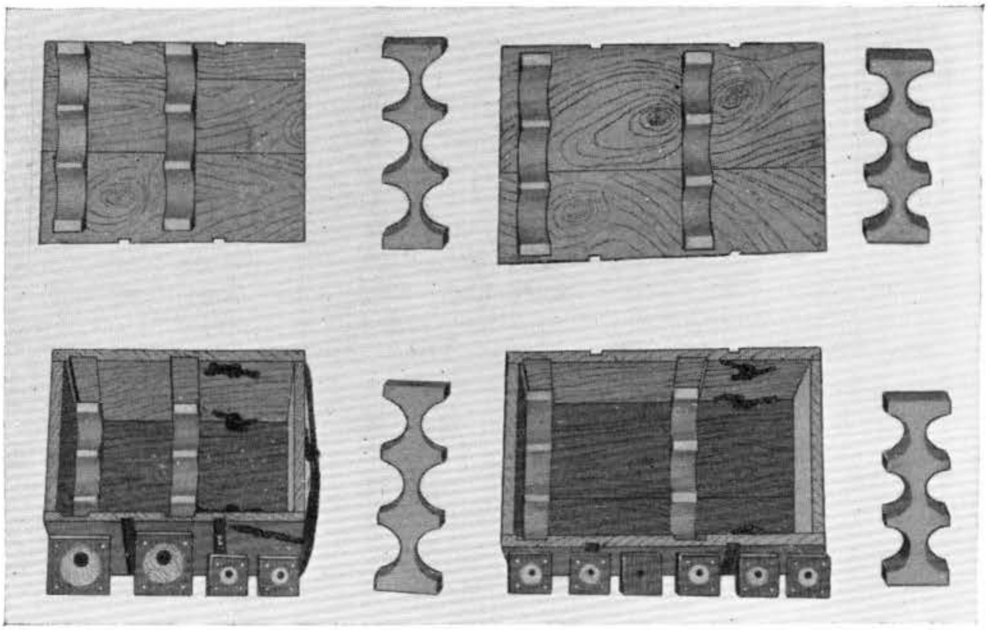

FIGURE 26.—3″/23 ammunition boxes, Mark 4 and 4 Mod. 1.

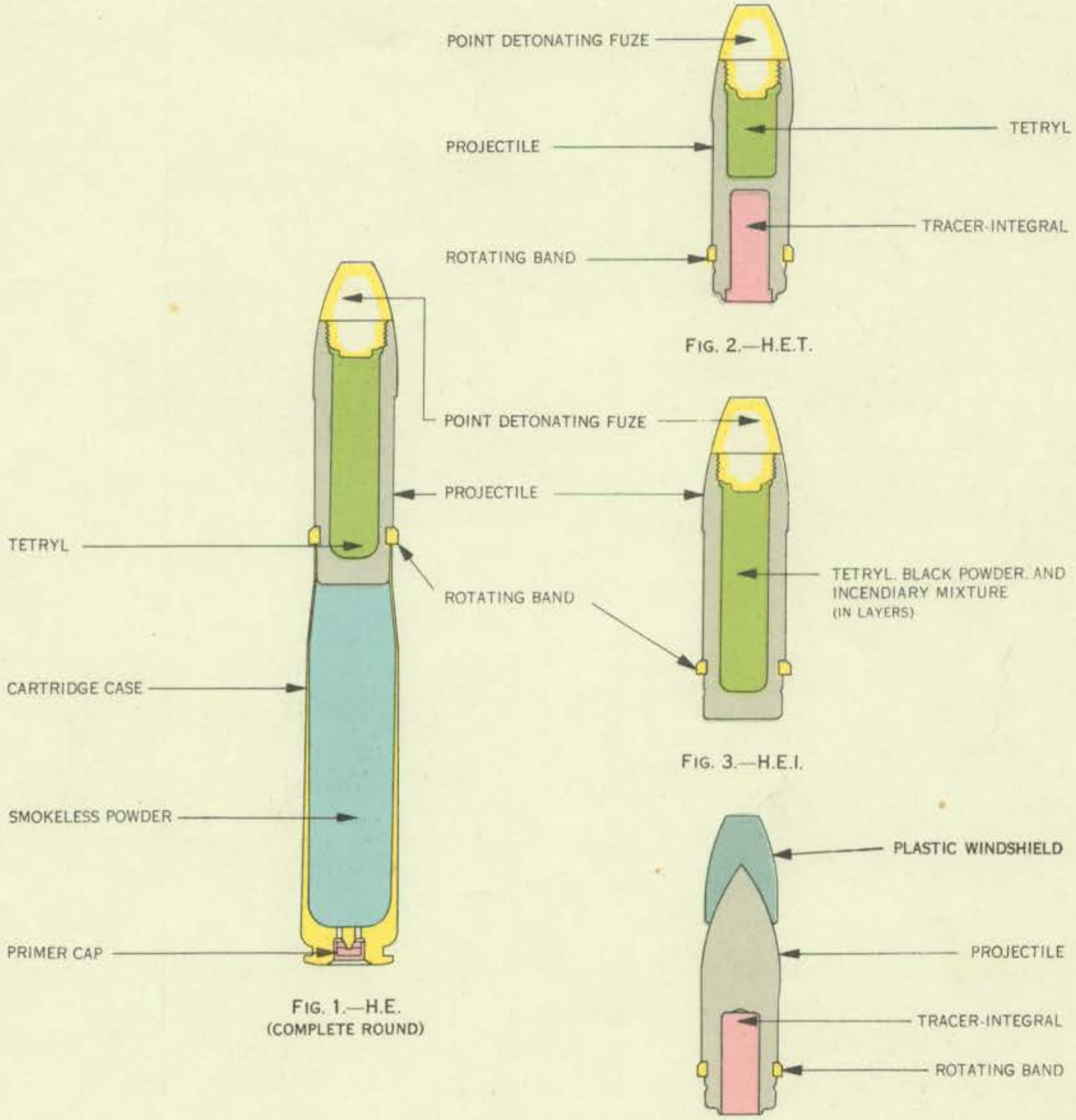

FIG. 1.—H.E. (COMPLETE ROUND)

FIG. 2.—H.E.T.

FIG. 3.—H.E.I.

FIG. 4.—ARMOR PIERCING

20 MM. AMMUNITION

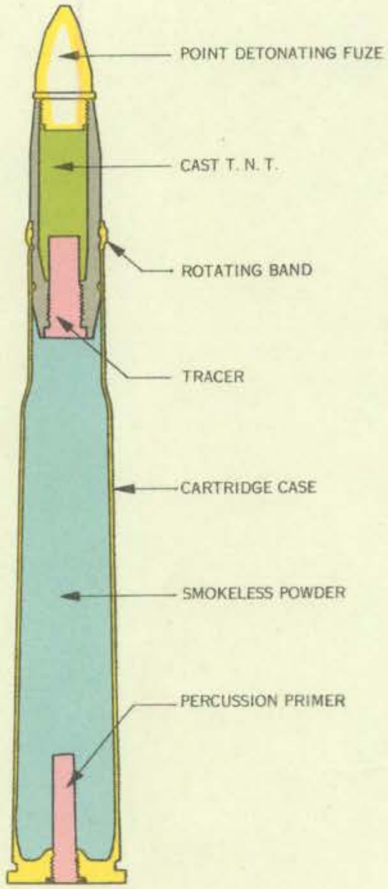

FIG. 1.—ANTIAIRCRAFT
(COMPLETE ROUND)

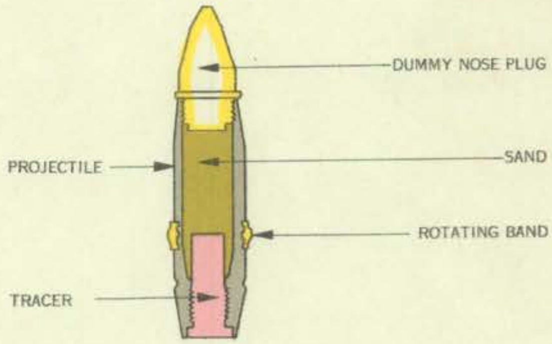

FIG. 2.—TARGET

40 MM. AMMUNITION

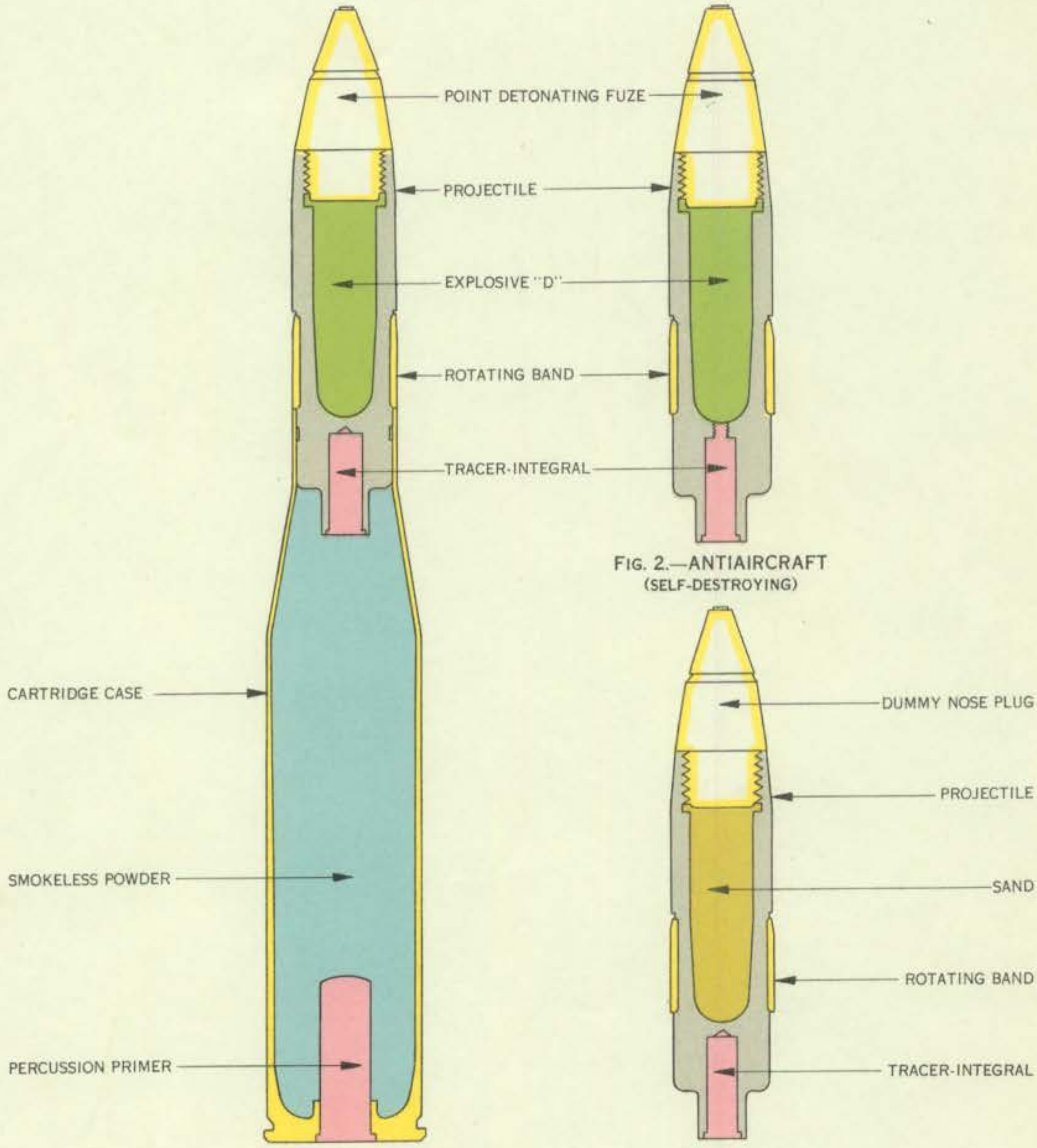

FIG. 1.—ANTIAIRCRAFT (COMPLETE ROUND)

FIG. 2.—ANTIAIRCRAFT (SELF-DESTROYING)

FIG. 3.—TARGET

1.10 INCH AMMUNITION

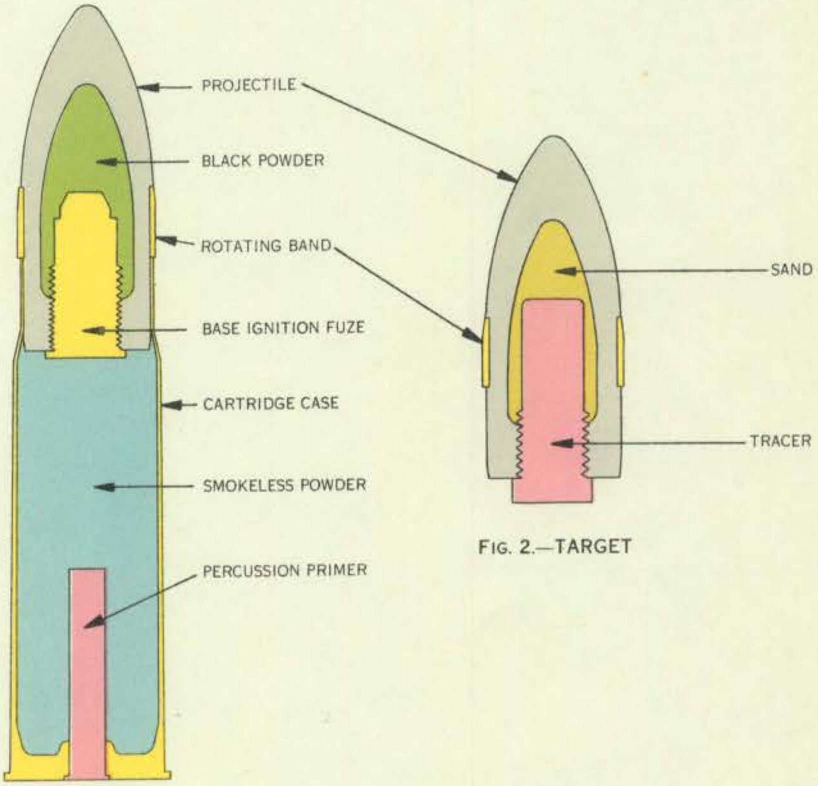

FIG. 1—COMMON
(COMPLETE ROUND)

FIG. 2.—TARGET

1 PDR. AMMUNITION

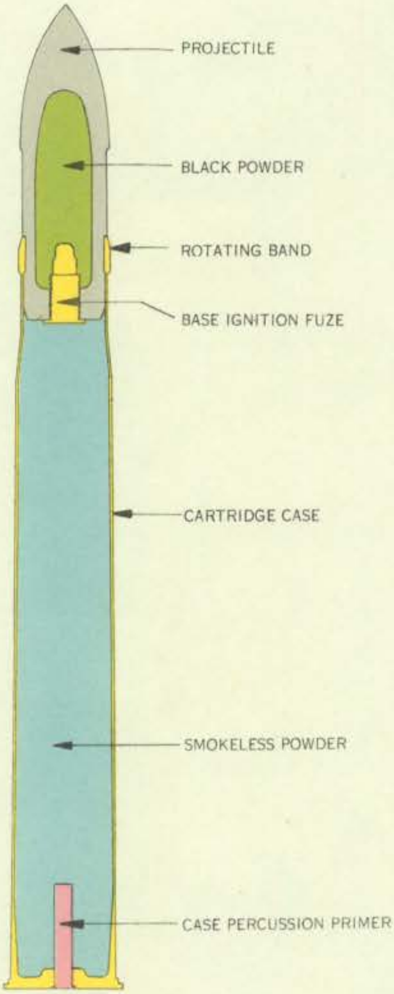

FIG. 1—COMMON
(COMPLETE ROUND)

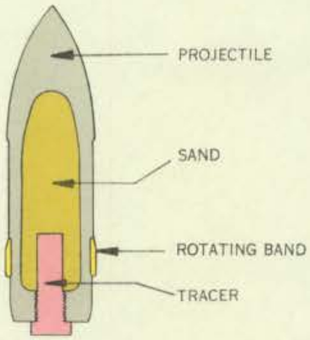

FIG. 2.—TARGET

3 PDR. AMMUNITION

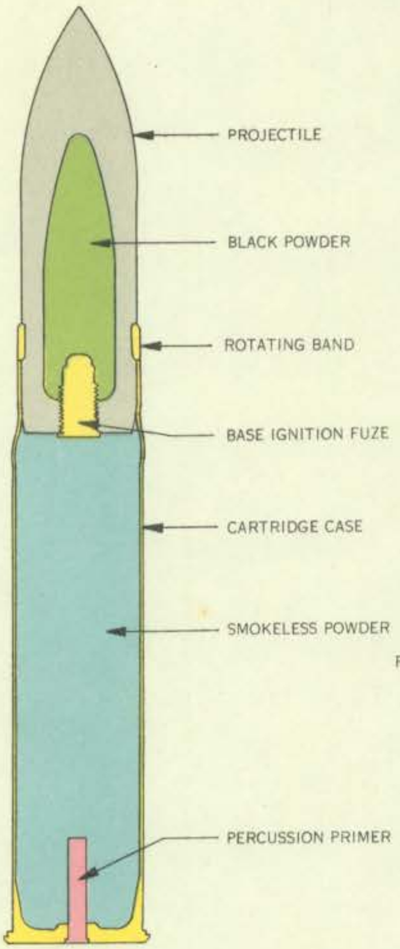

FIG. 1—COMMON
(COMPLETE ROUND)

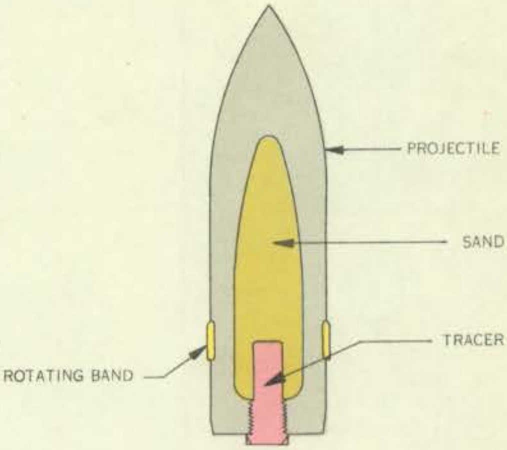

FIG. 2.—TARGET

6 PDR. AMMUNITION

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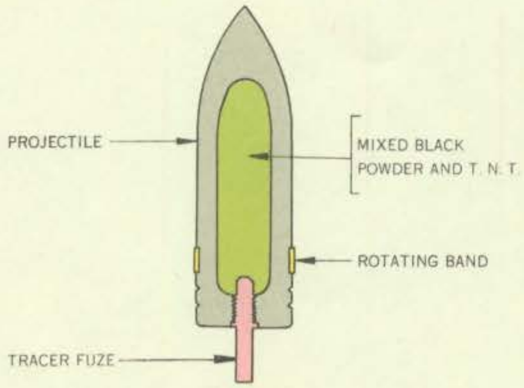

FIG. 2.—COMMON

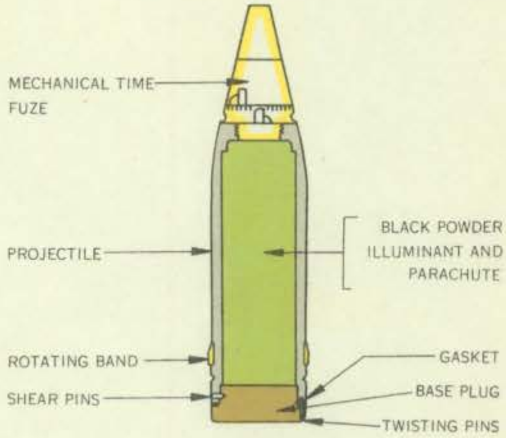

FIG. 3.—ILLUMINATING

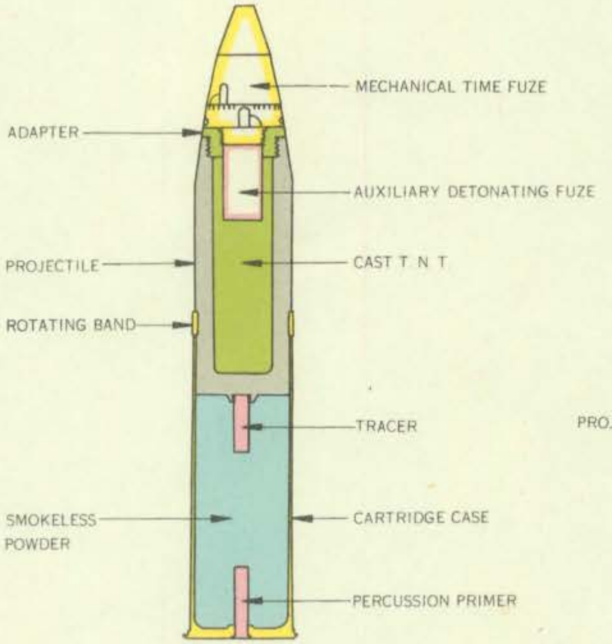

FIG. 1.—ANTIAIRCRAFT
(COMPLETE ROUND)

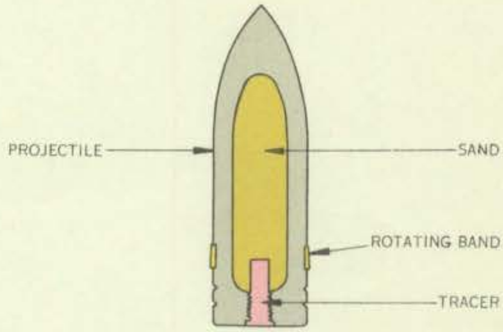

FIG. 4.—TARGET

3-INCH (23 CAL.) AMMUNITION

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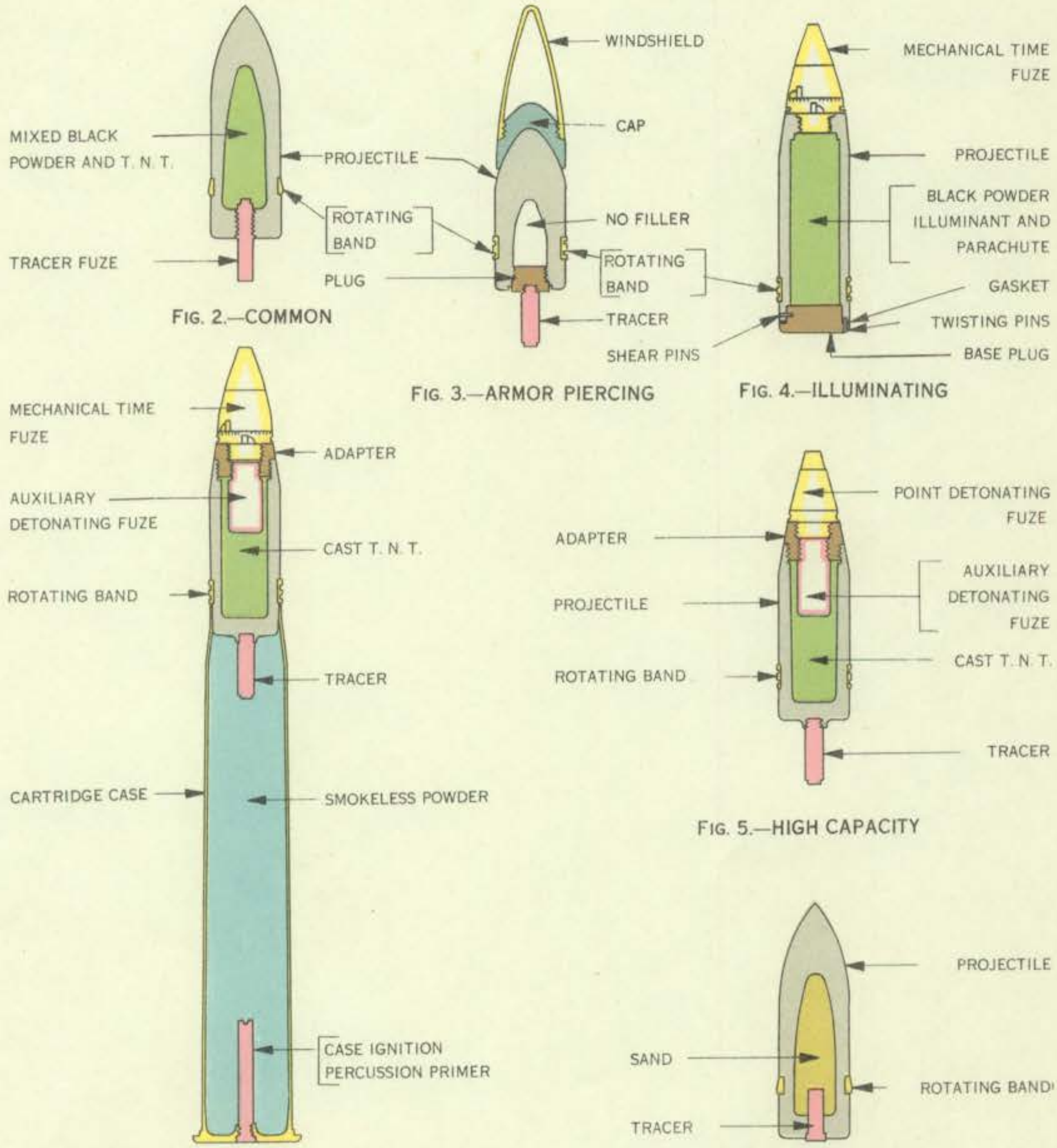

FIG. 2.—COMMON

FIG. 3.—ARMOR PIERCING

FIG. 4.—ILLUMINATING

FIG. 5.—HIGH CAPACITY

FIG. 1.—ANTIAIRCRAFT (COMPLETE ROUND)

FIG. 6.—TARGET

3-INCH (50 CAL.) AMMUNITION

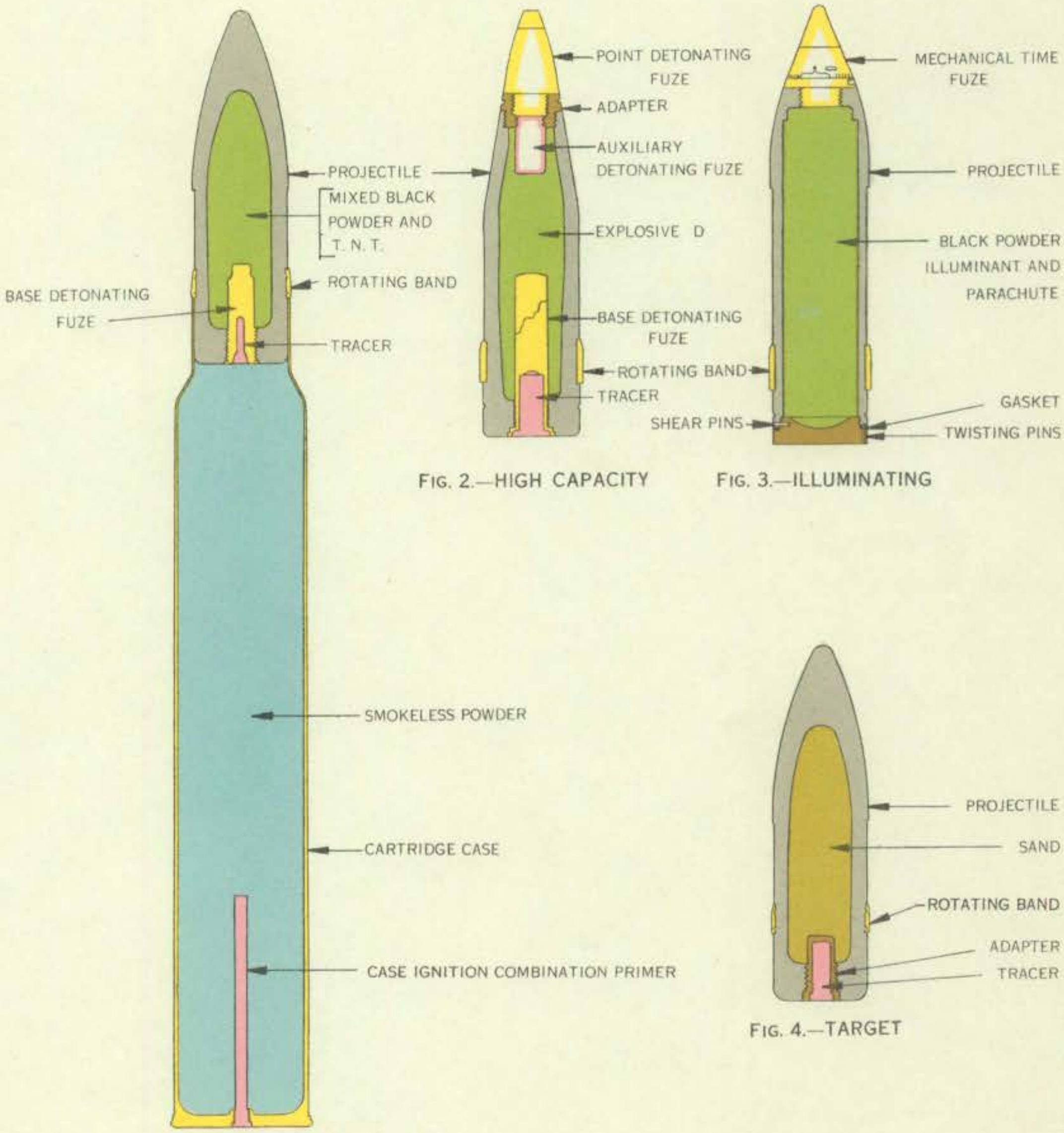

FIG. 1—COMMON (COMPLETE ROUND)

FIG. 2.—HIGH CAPACITY

FIG. 3.—ILLUMINATING

FIG. 4.—TARGET

4-INCH (50 CAL.) AMMUNITION

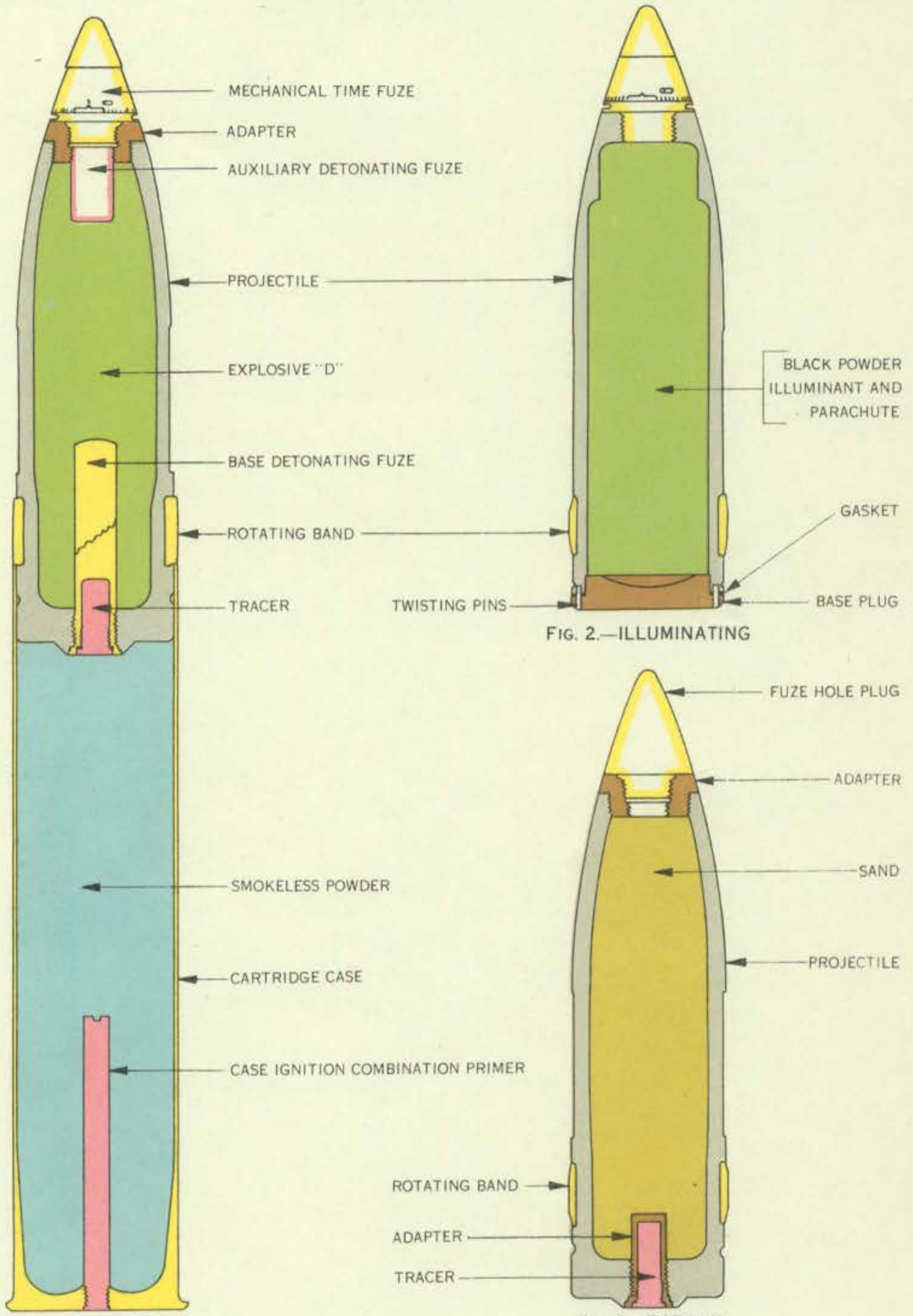

FIG. 1.—ANTIAIRCRAFT (COMPLETE ROUND)

FIG. 2.—ILLUMINATING

FIG. 3.—TARGET

5-INCH (25 CAL.) AMMUNITION

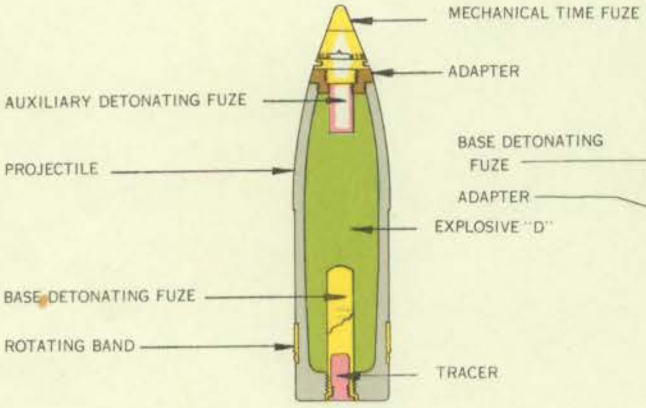

FIG. 2.—ANTIAIRCRAFT COMMON

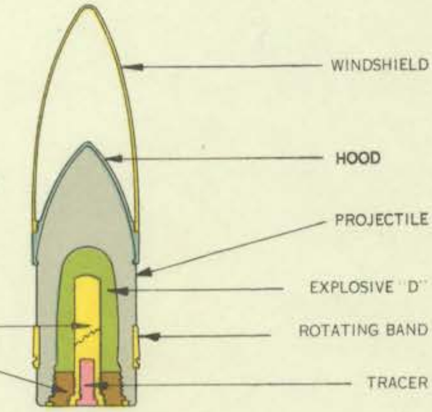

FIG. 3.—COMMON

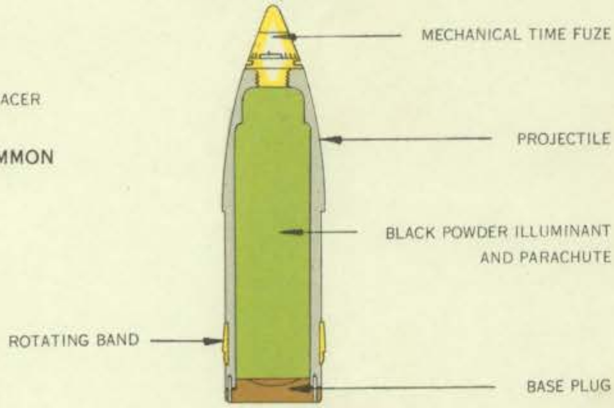

FIG. 4.—ILLUMINATING

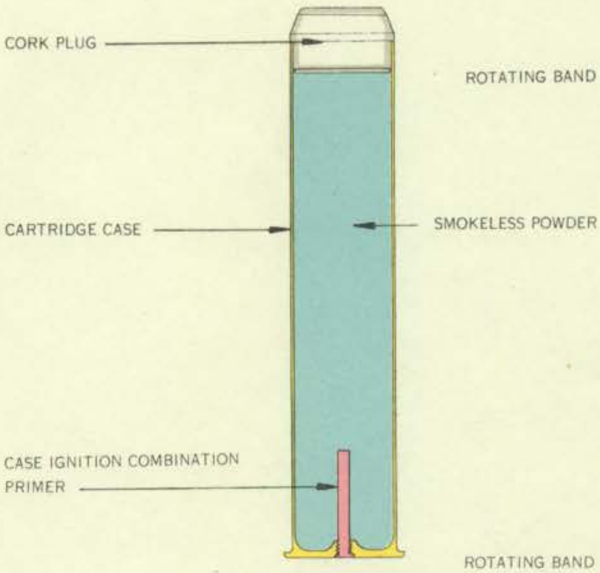

FIG. 1.—CARTRIDGE

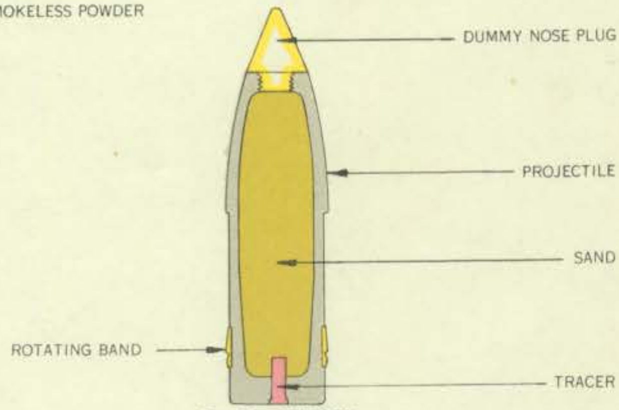

FIG. 5.—TARGET

5-INCH (38 CAL.) AMMUNITION
(SEMI-FIXED)

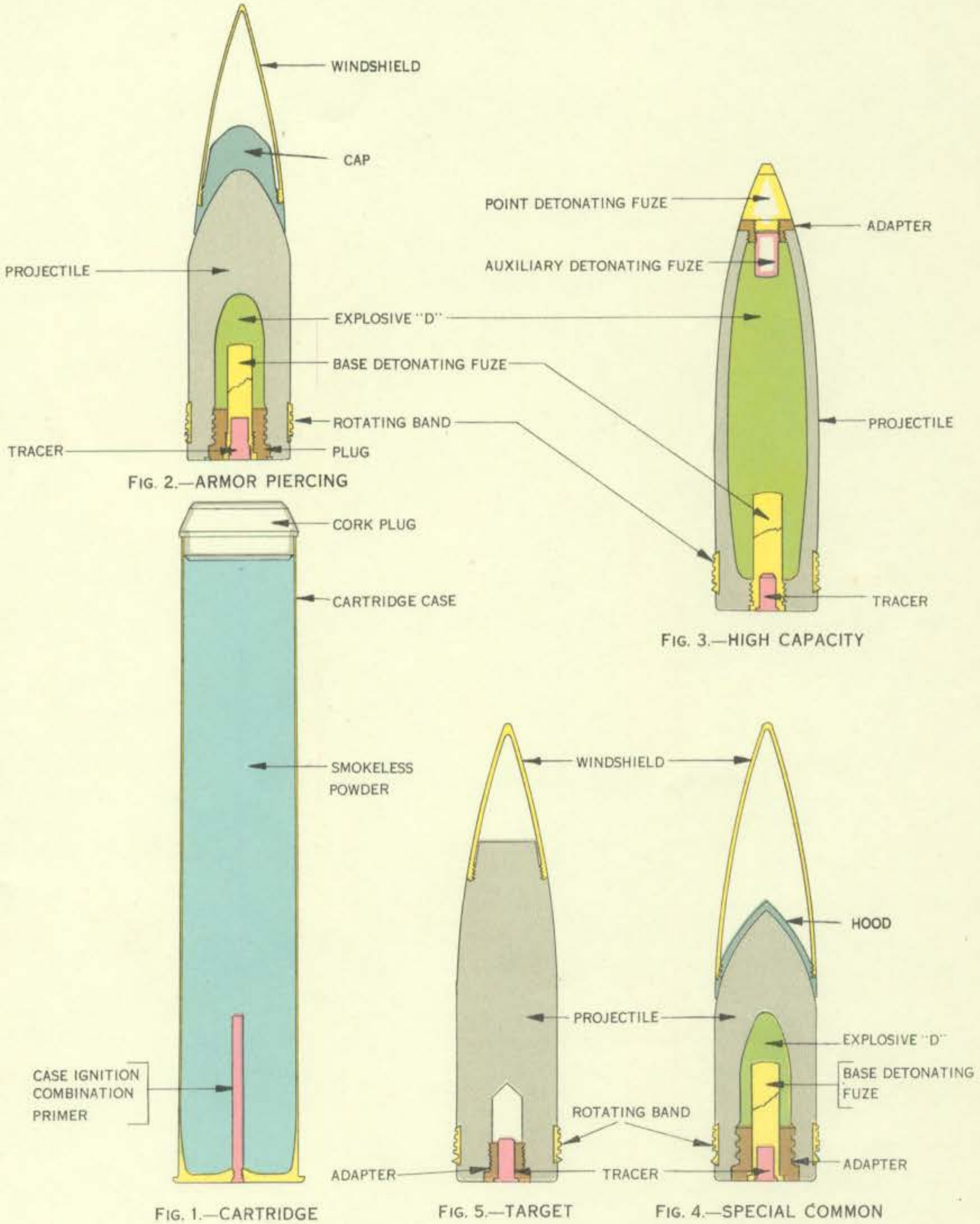

FIG. 2.—ARMOR PIERCING

FIG. 3.—HIGH CAPACITY

FIG. 1.—CARTRIDGE

FIG. 5.—TARGET

FIG. 4.—SPECIAL COMMON

6-INCH (47 CAL.) AMMUNITION
(SEMI-FIXED)

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Chapter XII. AMMUNITION CONTAINERS

12–1. Fixed ammunition and semifixed cartridges are issued in special tanks or boxes for safe transportation and stowage. Each type of ammunition for each caliber has its assigned tank or box. Stowages in magazines are arranged for the type of ammunition container standard at the time the ship is built. Since the nose contours of various projectiles in any one caliber vary, it is necessary to have nose supporting blocks suitable for each type. Care must be taken in replacing ammunition in containers that the proper nose supporting block for the ammunition in hand is used. **Cartridge tanks.**

12–2. The number of cartridges packed in a container is determined by the over-all size and weight with a view to facility in handling and to keeping the size of the hoist openings through decks at a minimum. The following are standard:

4-inch, 5-inch, and 6-inch cartridges (fixed and semifixed)	1 per tank.
4-inch cartridges	1 per box.
3″/50-caliber	1 per tank or 4 per box.
3″/23-caliber	6 per box.
3″/23-caliber for submarines	7 per tank.
6-pounder	7 or 11 per box.
3-pounder	16 per box.
1-pounder	60 per box.
1″.1/75-caliber	36 per box.
40-mm. caliber	16 per box.
20-mm	180 per box.

12–3. The current standard cartridge containers are aluminum or steel cartridge tanks designed to interlock with one another in stowage either ashore or aboard ship. The tanks are required to be airtight and before assembly at an ammunition depot, each tank is tested to determine that it meets this requirement. It is important that daily inspections of magazines include a check of the covers of cartridge tanks to insure that they are tight, particularly if there be any noticeable odor of ether in the magazines. Due to critical shortage of aluminum, all tanks are now fabricated from steel.

12–4. For 1″.1/75-caliber ammunition, galvanized steel boxes are issued with aluminum tube nests providing complete support and protection for each cartridge. The extra protection thus afforded is essential in order that cartridges may not be deformed in stowage since a deformed cartridge will result in a jammed gun. 40-mm. cartridges are stowed in galvanized tanks in clips ready for use, four clips of four cartridges each.

12–5. In tightening or removing the covers of cartridge tanks only the wrenches furnished for the particular tank concerned should be used. Smaller

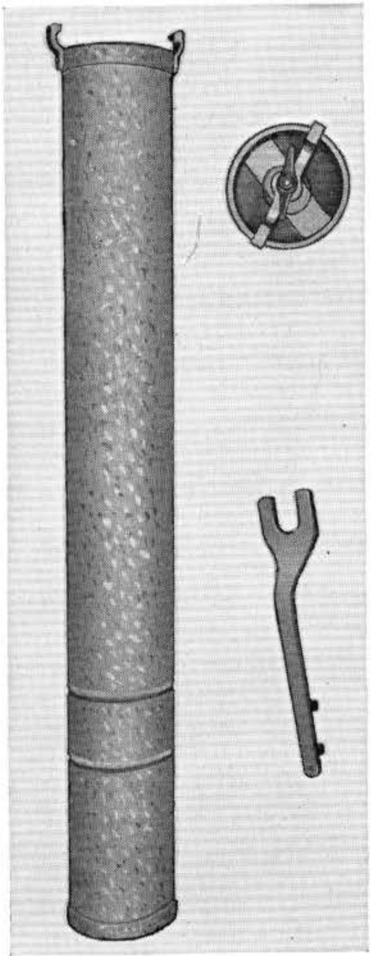

FIGURE 27.—4″/50 cartridge tank, Mark 2.

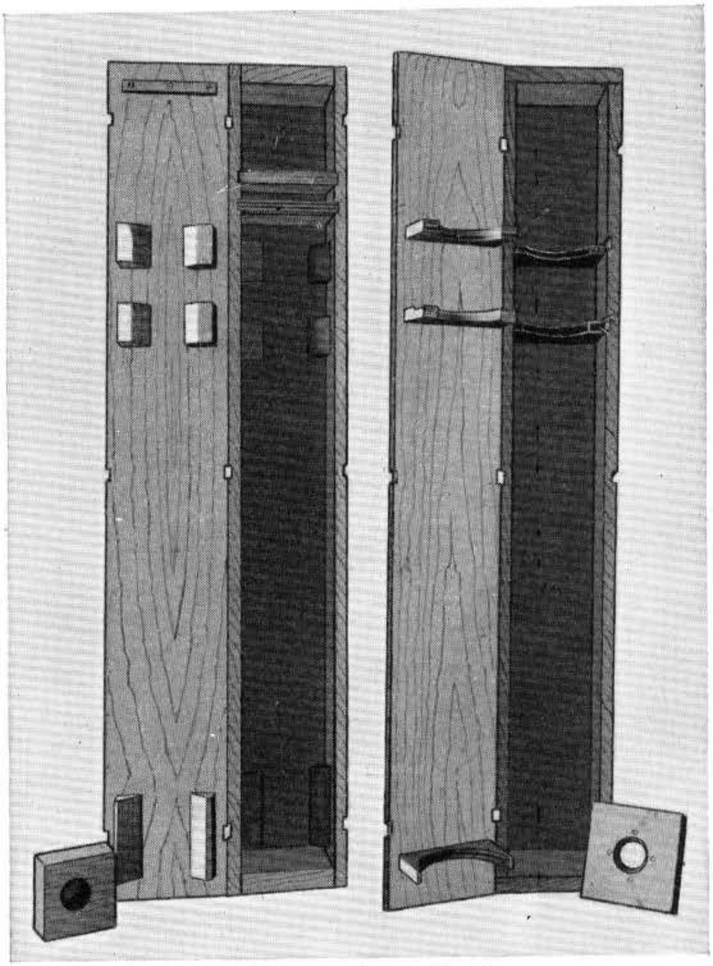

FIGURE 28.—4″/50 cartridge boxes, Mark 3 and 3, Mod. I.

wrenches may result in failure to tighten the cover properly while a larger wrench may carry away part of the tank or cover.

12–6. The guns assigned to auxiliaries and other vessels for installation on mobilization being usually of relatively old designs, their ammunition is issued in the cartridge tanks or boxes originally provided.

12–7. As with cartridge tanks, the standard powder tanks are made of aluminum in order to reduce stowage weight and to facilitate handling. Aluminum powder tanks are provided for 6″/47-caliber bag guns, 8″/55-caliber guns on heavy cruisers, and 16-inch guns on battleship beginning with BB–55. All other powder charges are issued in galvanized steel tanks or, in the case of certain obsolescent guns, in copper tanks protected by longitudinal wooden reinforcing strips. Currently due to critical shortage of aluminum, powder tanks are fabricated from steel, with various methods of spark proofing. **Powder tanks.**

The requirements of air tightness and the methods of insuring that they are met, discussed under cartridge tanks, apply with equal force to powder tanks. The precautions relative to the use of proper wrenches are likewise applicable to powder tanks as well as to cartridge tanks.

12–8(a). Since aluminum ammunition containers are particularly susceptible to denting and since, their lightness when empty is conducive to rapid handling, it is essential that all personnel concerned with the handling of ammunition exercise particular care that neither the containers themselves nor their contents be damaged in the handling processes. **Care in handling ammunition containers.**

12–8(b). All cartridge and powder tanks, and particularly aluminum tanks (or 1″/1 tank tubes), must be kept dry to prevent corrosion. Any wetting of tanks, due to accidental sprinkling or flooding of magazines, or other causes, will result in corroded tanks, particularly adjacent to top or bottom rings. When transporting tanks in boats, they should be effectively covered to prevent wetting due to spray. Immediate action to dry tanks is necessary. No wet or damp cases, cork spacers, extractors, projectile grommets, etc. are to be stowed in cartridge or powder tanks. Catapult corks and spacers are to be returned in separate stowage and must not be placed in fired cases.

12–8(c). Cargo nets alone shall not be used for transferring empty or filled tanks or other ammunition containers. If nets are used a rigid wooden platform or base shall be fitted in the net upon which the containers can be stood, stacked or piled upon thin stowage rings in such a manner as to prevent shifting and bumping or exerting pressure upon their thin sides. It is preferable to handle all tanks in a cargo box or skip rather than in a cargo net equipped as specified above.

12–9. Primers and detonators are issued to vessels in airtight containers designed particularly for the mark and modification of the ammunition detail contained. It is important that these containers be not unnecessarily opened since it is not feasible for forces afloat to reseal containers except by the use of electric friction tape which is suitable only for limited periods of stowage. **Miscellaneous ammunition containers.**

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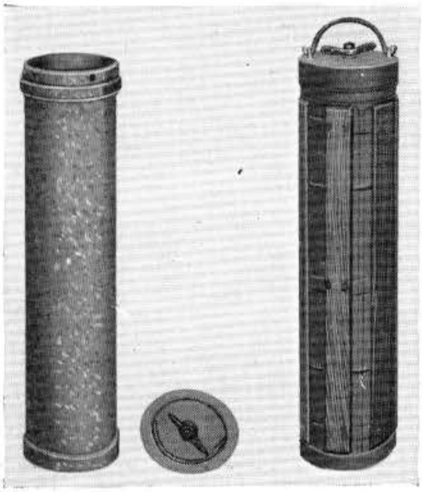

FIGURE 29.—5-inch powder tanks.

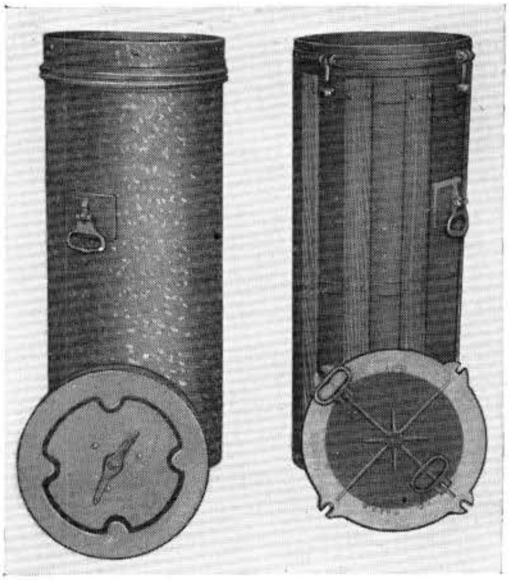

FIGURE 30.—12-inch powder tanks.

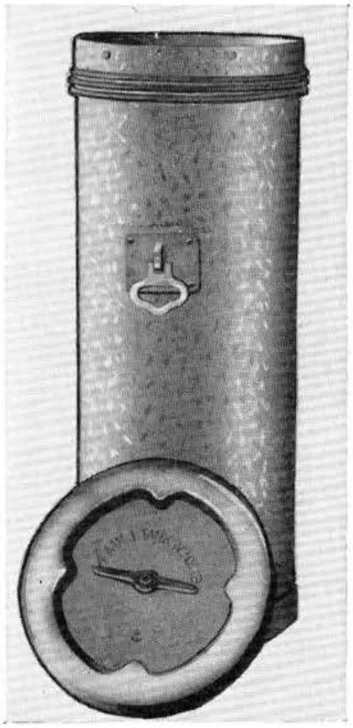

FIGURE 31.—14-inch powder tank.

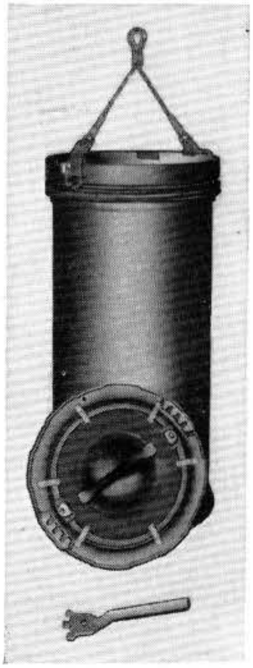

FIGURE 32.—16-inch powder tank.

Chapter XIII. FUZES AND TRACERS

13–1. A fuze for use in a projectile is a device for causing explosion of the bursting charge when certain conditions have been fulfilled. Definition.

13–2. By act of Congress, the following definitions have been established:

Fuzes.—Devices used in igniting the bursting charges of projectiles.

Fuses.—Slow burning fuses used commercially and intended to convey fire to an explosive or combustible mass slowly or without danger to the person lighting.

Detonating fuzes.—Fuzes used in naval and military service to detonate the high explosive bursting charges of projectiles, mines, bombs, or torpedoes.

Fuzees.—Fuzees ordinarily used on steamboats and railroads as night signals.

Primers.—Devices used in igniting the propelling powder charges of ammunition.

13–3. Fuzes are divided into classes according to—

(*a*) Their location in the projectile:

- (1) Nose.
- (2) Base.

(*b*) The action contemplated, whether—

- (1) Ignition.
- (2) Detonating.
- (3) Auxiliary detonating.
- (4) Time:
  - (i) Mechanical.
  - (ii) Powder Train.
- (5) Combination including both time and percussion features.

13–4. In the design of fuzes, the following forces or elements may be used to achieve the desired results:

(*a*) *Set back.*—The inertia forces tending to move all parts of the fuse to the rear as the projectile starts its forward motion.

(*b*) *Spin.*—The centrifugal force resulting from the projectile's rotation.

(*c*) *Creep.*—The forward movement of parts within a projectile not decelerated by air resistance.

(*d*) *Impact*.—The inertia tending to continue all parts of a fuse in motion in the line of flight when the projectile is retarded by hitting any object.

(*e*) *Friction*.

(*f*) *Springs*.

(*g*) *Clock mechanisms:*

(1) Operated by springs.

(2) Operated by centrifugal force.

(*h*) Burning compressed of powder trains or pellets.

13–5. The essential requirements for a fuze are:

(a) Safety in handling.

(*b*) Safety within the bore of the gun and for a sufficient distance outside the muzzle to insure safety of personnel in the vicinity.

(*c*) Initiation of projectile bursting action at the impact or at the expiration of the time desired.

13–6. The fuze designer must select the combination of the elements indicated in paragraph 4 which will best meet the particular combination of requirements from paragraph 5 presented by the immediate problem.

Uses of types.

13–7. For projectiles having bursting charges of black powder or mixed filler, an ignition fuze is sufficient. For projectiles having bursting charges of high explosive, a detonating fuze must be used either by itself or as an auxiliary detonator whose action is initiated by a time fuze. Fuzes for use in projectiles having a marked degree of plate penetration capability require some form of delayed action in order to permit the projectile to pass through the plate before explosion of the burster is initiated. A failure of the delay action defeats the projectile and renders useless its penetration qualities.

For 5-inch double purpose guns simplification of the ammunition supply dictated the adoption of the AA common porjectile when it was found that the forged brass body of the combination fuze in the nose did not stand up under impact on even light plate sufficiently long for the percussion action to take effect. The AA common projectile thus has in the nose a time fuze and an auxiliary detonating fuze and, in the base, a medium caliber base detonating fuze.

13–8. In fuze design up to and including World War, it was generally considered that one safety feature could be relied on to meet the safety requirements of the fuze. Serious casualties resulting from the failures of a single safety feature have indicated the necessity for at least two safety features which are accordingly incorporated independently of each other in all modern fuze designs. While it is possible that one of the safety features might fail due to defective material or assembly in spite of the precautions taken during manufacture and inspection to guard against such defects, the likelihood of both safety features failing at the same time is exceedingly remote.

13–9. It is generally impracticable to initiate explosive action of a projectile filler solely by use of a detonator in a detonating fuze. It is customary therefore to include in the fuze a booster of tetryl whose explosive action can be initiated by the detonator and which can in turn set off the projectile filler. In the design of fuzes, it is important that lead-ins and lead-outs with minimum air gaps provide for carrying the explosive train from the detonator to the booster.

13–10. The design of current standard fuzes for the naval service is maintained in a confidential status, and, in general, no descriptive data are furnished to the service. It is sufficient to state that for projectiles which cannot be expected to penetrate more than destroyer plating, instantaneous fuzes are used, while for projectiles which may penetrate an inch and a half or more of class B or class A plate, appropriate delay action is included in the fuze design. For AA projectiles in the 1.1-inch caliber, supersensitive nose fuzes are provided to insure bursting action immediately in the rear of very light plate or fabric, while, for common and high capacity projectiles of 3-inch and up, time fuzes are furnished to burst the projectile at the point desired in the air.

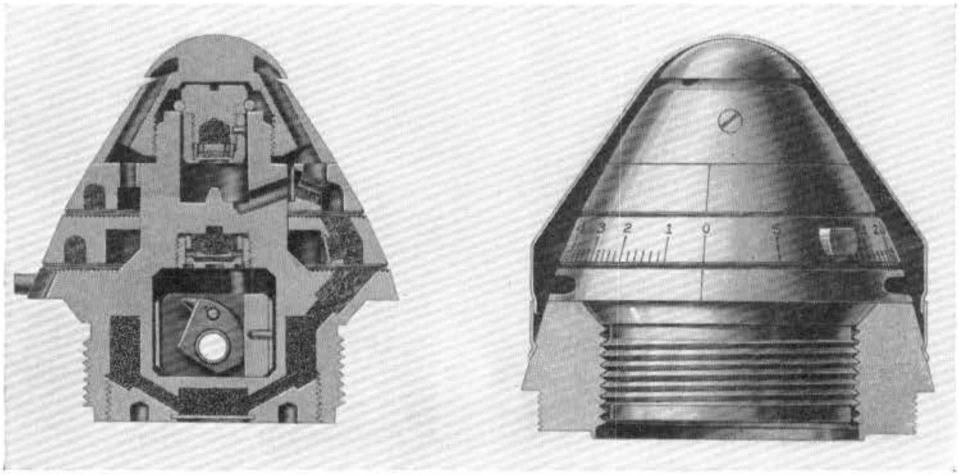

FIGURE 33.—Frankford Arsenal 21-second combination fuse.

13–11. For many years the 21-second time fuzes used in 3-inch field, shrapnel, AA and illuminating projectiles and the 45-second time fuzes used in all other illuminating projectiles and in 5-inch AA common projectiles were of the powder train type. In these the setback causes a small plunger carrying a cap to impinge on a fixed firing pin, the flame from the cap igniting one end of a double train of compressed black powder. The total length of the two trains to be burned is determined by the setting of the fuze which rotates the ring containing the upper train in relation to the end point of the lower train. When Time fuzes.

the designed length of train has burned through, the flame flashes through to the black powder magazine in the base of the fuze from which the flame is communicated to the projectile charge or the pressure acts on the auxiliary detonating fuze. Since the rate of burning of a powder train time fuze is affected by the change in atmospheric pressure in the projectile's flight along its trajectory, efforts have been made for a long time to provide a workable mechanical time fuze. Obviously those mechanical fuzes which rely solely on the centrifugal forces resulting from the projectile's spin are less affected by long periods of stowage than are those which include a spring mechanism. After extensive experiments with medium caliber projectiles, the Army and Navy have standardized on mechanical time fuzes based on the Junghans principle. However the spin rate of major caliber projectiles is so slow that spring-driven mechanical time fuzes are necessary. The fuzes used by the two services differ only in detail and in external contours, the differences being the result of the varying needs of the using services.

Tracers.

13–12. To assist in the control of fire, tracers are provided by which the flight of AA projectiles may be followed by day and the flight of other projectiles by night. Essentially a tracer is a column of pyrotechnic mixture designed to burn with a definite color during enough of the projectile's time of flight to provide for proper control. On the outer end of the pyrotechnic column, there is pressed a small quantity of starter mixture which is a mixture of pyrotechnic materials capable of easy ignition. The tracer and starter mixtures are pressed into the steel tracer bodies by hydraulic presses under very high unit pressures. Tracers are sealed to exclude moisture by closing disks of celluloid or metal, the former being necessary when tracers are used in target practice where reduced velocities are used.

13–13. In some of the older types of ignition fuzes and in certain old type detonating fuzes, tracers are provided directly in the fuze stock. For modern fuzes, tracers are loaded in tracer bodies. The bodies may screw into the cavity or a recess in the fuze stocks and may be internal or external with respect to the projectile. For 1″.1 and 20-mm. projectiles, the tracer mixture is loaded directly into the tracer extension of the projectile proper.

Colors.

13–14. The tracer colors now standard in the naval service are red and white for AA projectiles and orange for night tracers in AP and common projectiles.

Chapter XIV. PRIMERS

14–1. A primer is a device for initiating the burning of the propelling charge in the chamber of the gun by means of a flame. In case guns the primer contains a sufficient charge of black power to ignite the smokeless powder which surrounds the tube of the primer. In bag guns the primer is fired in a firing lock. The resulting flame, passing through the vent in the mushroom stem, impinges on the black powder ignition charge quilted in the rear end of the powder bag.

14–2. It is necessary that the flame for ignition of the smokeless powder charge endure over a sufficient time to raise the temperature of the surface of the grain to the ignition point.

14–3. Primers are divided into three classes, depending on the method of firing them: (*a*) percussion, (*b*) electric, and (*c*) combination, and into two types, depending on the manner in which they are used in the gun: (*a*) case, (*b*) lock. **Types of primers.**

14–4. For case guns from 1-pounder and 1".1-inch to 3"/23-caliber, with exception of Mark 21 primer for 20-mm. ammunition, inclusive, primers are used which are so dimensioned as to be a force fit in the primer seat in the base of the case. For 3"/50-caliber cartridges Mark 14 primers are used. These are percussion primers, having a short magazine extension containing the black powder ignition charge. For all other case ammunition, except catapult cartridges, case combination Mark 13 primers are used. They have the percussion feature of the Mark 14 primer and an electric feature as well. The ignition tube and primer stock extension is longer in view of the greater length of the cartridge case and of its contained charge. For all bag guns lock combination Mark 15–1 primers are used. These primers are also used in test cases for testing firing circuits in case guns and in torpedo impulse charges where the primer seats in a special primer holder. For use with catapault charges, a Mark 14–1 primer was manufactured. This is identical with the Mark 14 primer except that the metal closing plug was replaced by a celluloid disk.

14–5. In a percussion primer the essentials are: (*a*) a cap containing a "primer mixture" which usually consists of fulminate of mercury with potassium chlorate and antimony sulphide added to prolong and increase the intensity of the flame; (*b*) a black powder charge in the forward part of the stock sufficient to produce a flame adequate to ignite either the smokeless powder charge directly or the black powder ignition charge after passing

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through the primer vent; (*c*) a plunger to be driven in to fire the cap; (*d*) a stock which will hold the above parts, exclude moisture, and fit tightly in the primer seat in the base of the case.

14–6. In an electric primer it is necessary that there be: (*a*) a bridge wire of high resistance which will heat to incandescence very quickly with the passage of a very small current; (*b*) a wisp of gun cotton in such close proximity to the bridge wire that it will ignite and start the next step in the primer train when the current is applied; (*c*) means for insulating the primer plunger from the primer stock so that current from the firing pin can reach the ground only by passing through the bridge wire; (*d*) a mixture capable of ignition by flame from the wisp of gun cotton; (*e*) a black powder charge and a stock as described for percussion primers.

14–7. For combination primers the requisites for electric and percussion primers are combined.

14–8. Electric primers as such are no longer manufactured. All primers containing means for electric ignition also have percussion features.

14–9. The following table shows the primers in use in service:

Type	Mark	Use
Case percussion	Mark 10–9	1-pounder, 3-pounder, 6-pounder, 3″/23 service.
Do	Mark 10–8	Saluting.
Case percussion, ignition	Mark 13	4″/50 to 6″/47 caliber, inclusive.
Do	Mark 14	3″/50 caliber.
Do	Mark 14–1	Catapult.
Lock combination	Mark 15–1	All bag guns, torpedo impulse charges, and test cases.
Case percussion	Mark 19–3	1″.1/75 caliber.
Electric screw	Mark 18–1	Practice mines.
Case percussion electric	Mark 20	Depth charges.
Case percussion (screw)	Mark 21–1	40-mm.
Case percussion (push fit)	Mark 22	Do.
Electric screw	Mark 25	A. S. P. 10 projector ammunition.

Drill primers.

14–10. For use in training primer men and in testing firing circuits there are supplied to ships drill primers which are lock combination primers of the oldest lots on hand in the depots. The allowance of drill primers is established on an annual basis and is adequate for all necessary training provided that reasonable care in expenditure be used.

Testing primers.

14–11. In order that forces afloat may be assured of the quality of the lock combination primers issued for service and target use, capital ships, heavy cruisers, and tenders are furnished with Mark 1 primer testing sets, which are essentially Wheatstone bridges so constructed as to indicate directly whether

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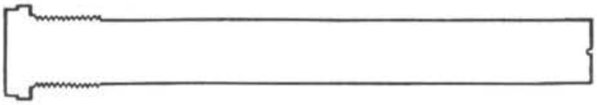
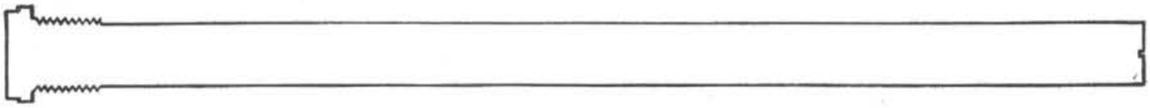
the resistance of the primer bridge and the other parts of the primer forming the electric circuit are within the specified limit of 0.55 to 0.70 ohms or are outside those limits. Primers found outside the established limits should be used for drill purposes or turned in to an ammunition depot. If any considerable percentage of the primers tested falls outside the established limits the tests should be reported to the Bureau and the advice of the nearest ammunition depot should be sought.

14–12. While the current involved in the use of the primer testing set is exceedingly small it is not safe to use such sets on assembled ammunition. Accordingly, there is no means available to the forces afloat for the testing of primers in case ammunition, either fixed or semifixed. The ammunition depots, however, use Mark 1 primer test sets to test each primer assembled in case ammunition and no primers falling outside the established limits are used. Further, a percentage of each lot of primers selected for assembly is tested by percussion and no lot showing an inacceptably high percentage of percussion failure is used for either target practice or service assembly. Plate 27 shows the construction of primers Mark 10–9, Mark 13, Mark 14, and Mark 15–1.

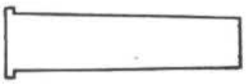
CASE PERCUSSION PRIMER, MARK 10 MOD. 9.



CASE PERCUSSION IGNITION PRIMER, MARK 14.



CASE COMBINATION IGNITION PRIMER, MARK 13.



LOCK COMBINATION PRIMER MARK 15, MOD. 1

FIGURE 26.—Primers.

Chapter XV. ASSEMBLED CHARGES

15–1. Ammunition, as issued to ships, is prepared in all respects for use and does not require any work to be performed on it aboard ship, except for setting of time fuzes and assembling of saluting cartridges and torpedo impulse and single depth charge projector charges. The Bureau of Ordnance obtains all the component parts from Government plants or from private manufacturers, except wads, distance pieces, tags, paints, luting, and similar materials, which are obtained by ammunition depots on requisition and prepared for use. Ammunition details, powder, projectiles, fuzes, tracers, explosives, cartridge cases, tanks, and boxes, are distributed by the Bureau of Ordnance among the ammunition depots in accordance with plans for the ultimate distribution of assembled charges to ships. Orders for the assembly and issue of ammunition originate in the Bureau of Ordnance, based on the requirements for service and target practice uses. A careful check on each ship's ammunition is made from the various reports received in accordance with Navy Regulations, and from a consideration of her allowance list and target practice requirements, as set forth in the Orders for Gunnery Exercises. Ships desiring additional ammunition or desiring to turn in ammunition, except for temporary storage, shall refer the matter to the Bureau of Ordnance. Vessels or stations desiring ammunition shall submit letter request to the Bureau. The issue of certain materials for target practice and training to fill allowance is covered by article 2B30 in the Bureau of Ordnance Manual. Issues to vessels.

15–2. Ammunition depots report the amounts of all details on hand to the Bureau yearly, and thereafter whenever a change occurs, so that when it becomes necessary to provide a ship with ammunition, exact specifications of the order may be supplied the depot from the latest information on hand. In preparing an order in the Bureau, the powder index is selected, the projectile, fuze, primer, and projectile filler are specified, having due consideration for the armament of the ship and the use to be made of the ammunition. In order to prevent errors a very careful check is made of all details of the order by several officers and clerks. This system requires a centralized organization, due to the fact that the latest information regarding batteries, requirements, proposed changes, contemplated movements of ships and materials available at the various depots is better known in the Bureau than elsewhere. Ammunition orders.

15–3. When an ammunition order is received at a depot it is checked by the inspector, the ammunition officer, and the ammunition clerk with the records at the depot to insure that the weight of charge agrees with that previ- Handling orders.

ously assigned and that the ammunition is suitable for the gun for which it is ordered. To allow for this check, the ammunition depots are informed of all changes in assignments of powders by means of an Ordnance circular letter termed a powder bulletin. Powder bulletins are not distributed to forces afloat.

The ammunition order is then made out as a job order at the depot, specifying in detail the work to be performed. The details, which are stowed in separate magazines and storehouses, are then provided and arranged in the filling house to be used. All preliminary work which can possibly be done on details, such as printing of tags, stencilling of boxes or tanks, inspection of cases and containers, testing of primers, cleaning and gaging of projectiles, etc., is performed before the actual assembly has commenced.

Loading projectiles.

15–4. In preparing projectiles for loading, they are cleaned, inspected, gaged, and the cavity painted with an antiacid paint. The fuzes, at the same time, are inspected, gaged and, if necessary, painted. Two general types of projectile loading are used, being classed as loose fillers and compact fillers. In the former the density of the bursting charge is that of the loose granular explosive, while in the latter a greater density is due to a compression or casting of the explosive.

Mixed filler.

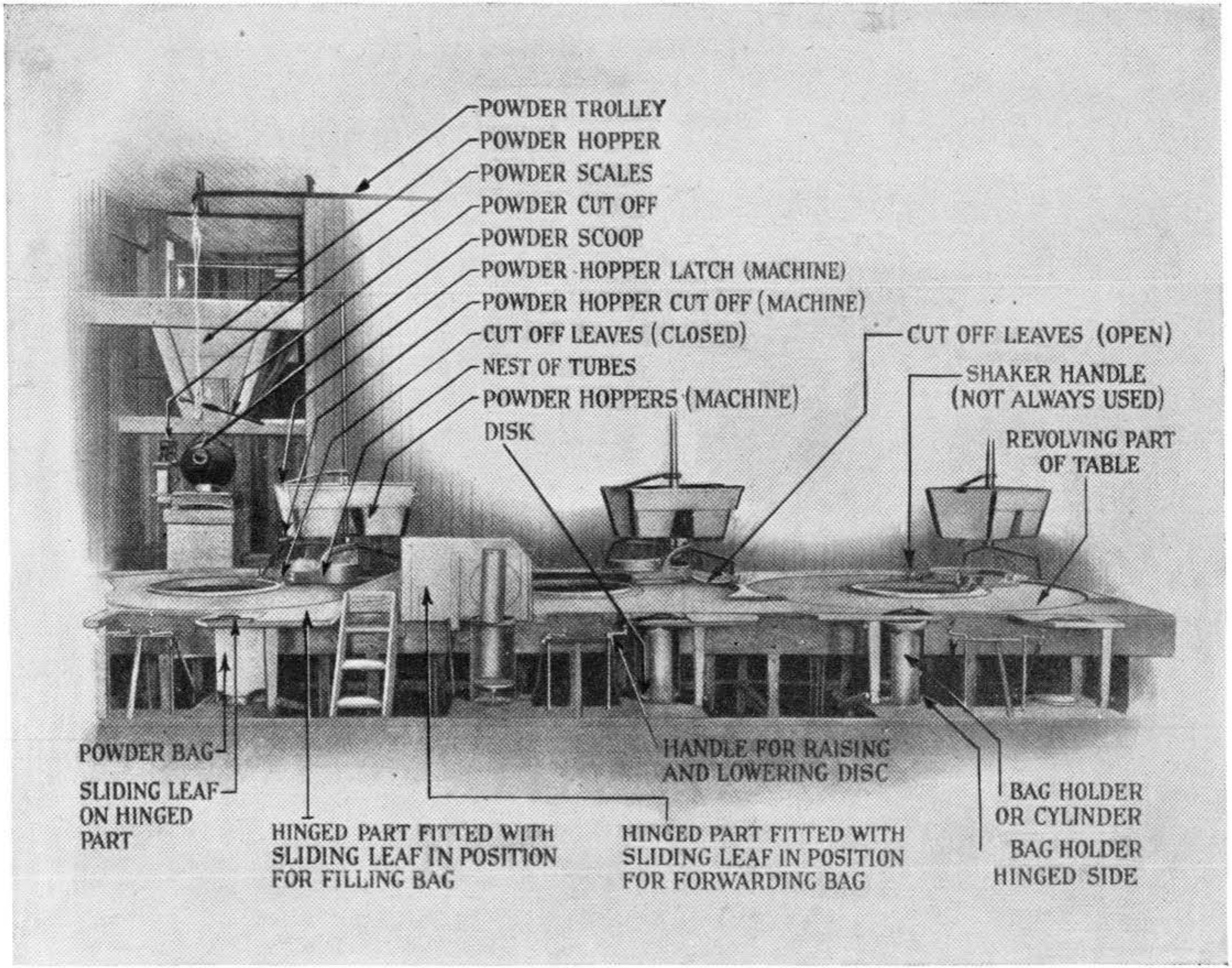
15–5. Loose fillers are loaded in minor and medium caliber projectiles, usually those not having a base plug. Minor caliber projectiles are loaded with black powder and the larger projectiles are loaded with a mixed filler composed of equal parts by weight of black powder and granular TNT. The addition of the high explosive to the black powder makes a suitable charge since either alone produces fragments too large and the other too small. The loading methods for black powder and mixed filler are the same. In mixed filler, the TNT is placed in the cavity first, the projectile is bumped or agitated, and then the black powder is added. To load with black powder, the projectile is placed nose down in a holder; a copper funnel is inserted in the base, and the required amount of black powder is poured in. The powder is settled by tapping with a rawhide mallet or by a special settling table which gives a bumping motion to the projectile carrier. A wooden former, in the shape of the fuze, is then forced gently down, making a cavity the exact size of the fuze, the funnel having been removed. The fuze threads are then cleaned with a small brush dipped in alcohol, and the fuze, on the threads of which a luting has been applied, is then entered and screwed home. The final setting home of the fuze is done in a room barricaded from the other operations by a concrete wall. A special fuze wrench, or fuzing machine, is used for this purpose.

Compressed and cast charges.

15–6. Loading with compact fillers is done by compressing the charge or casting the charge. Certain projectiles are loaded with cast TNT charges; the TNT is melted and poured into the cavity and, when cool, the fuze cavity is drilled out. Other types are loaded with Explosive "D" under high pressure, in special power presses. The fuze cavity is drilled out after pressing with base plug in place. Projectiles fitted with base plugs and base fuzes have these gas checked to prevent entry of burning powder gases into the cavity when the projectile is fired.

15–7. In assembling case ammunition, cases are inspected and gauged and if satisfactory they are primed. For ammunition from 1-pounder to 3″/23 caliber the case percussion primer is used. This is of the so-called drive type and is assembled in a press which forces the primer into the orifice in the cartridge case head. This operation is very simply performed by a small press. 3″/50-caliber cartridge cases take the case percussion ignition primer and those above 3″/50-caliber take the case combination ignition primer. These are screw primers, screwed into place by a machine, power or hand operated. Before assembling primers, a number from a lot to be used are tested in a primer drop testing machine, to make certain that they will function when struck a blow of predetermined force. In this way doubtful lots, or any found to have deteriorated in storage, are eliminated. This method does not, however, test each individual primer for the percussion test, as such a procedure is not practicable. Consequently an occasional primer may be encountered which fails later but, considering the number used yearly, the percentage of failures is negligible. In addition to the percussion test each case combination ignition primer, after assembly in the case, is tested electrically for open circuit and resistance. The powder charge is weighed in carefully adjusted scales, which are checked hourly with check weights frequently tested by the Bureau of Standards, dumped into individual cases, and settled and gently tamped down. A wad is then inserted in the mouth of the case and this is followed by a distance piece. The distance pieces are specially cut for each weight of charge, so that the entire space in the case will be taken up and the powder will not get away from the primer. The cases are then removed to the projectile-loading machine, where a cork plug or projectile, after it has been loaded and painted, is placed in the mouth of the case and then forced into place by a press. The cartridges are then gaged, inspected, greased and tanked or boxed. They are then ready for shipment. The powder index number is stenciled on the cartridge cases and a tag is put in with the charge giving the necessary information regarding the assembly. Case ammunition.

15–8. In preparing bags for charges, the following materials are used: Silk, powder-bag cloth, silk lacing, silk thread, and black powder. The powder-bag cloth is pure silk without the admixture of any other material whatever, except the sizing for the yarn. Only such sizing as is absolutely necessary is used. It is sodium or aluminum silicate or sulphate. The cloth is plain single or double basket weave and must pass certain required trade tests and annual physical tests for strength. Two grades are used: the heavy for the body of the bags and the light for the ignition ends. The silk lacing is made of pure spun silk, woven, and must not fray or ravel. Standard silk thread is used in stitching the bags together. Bag charges.



Stacking machine, Naval Ammunition Depot, St. Juliens Creek, Va.

Ignition ends.

15–9. The ignition ends are made first, and sewed to the bags afterwards. In preparing ignition ends, circular pieces are cut from the light-weight silk, some plain color and some dyed red. A plain color and a red color are then taken and stitched together around the periphery, except for a small opening for filling. The remaining operations are done in a special so-called quilting house, as there is some risk attendant on the operation. The bag formed by the ignition end is filled with the proper amount of black powder and the opening stitched together. The pad is then placed under a special sewing machine and the charge smoothed out and evenly disposed before the quilting operation is started. By using a bronze needle this operation is made safer. The quilting holds the powder in place uniformly distributed. The ignition ends are then sewed into the bags, which have been cut and sewed, and the whole bag is stowed in airtight containers for transportation and storage.

Assembly of bags.

15–10. Bag charges are either stacked or loose. It will be noted that the sizes of charges are fixed as to length. It is important, for the purpose of obtaining uniform velocities, that the charge should always be disposed in the chamber the same way. The general rule is that the total length of the sections, placed end to end, will be within 2 inches of the length of the powder chamber, subject to the limitations of the powder tanks in length. In assembling unstacked charges, the powder, after being weighed and checked, is dumped into its bag; the bag is then rolled and laced tightly in order to make a compact package. A tag is placed under the lacing of the bag giving the details of the loading. The sections, after gauging for size, are then put in tanks in which a clean piece of wrapping paper has first been placed.

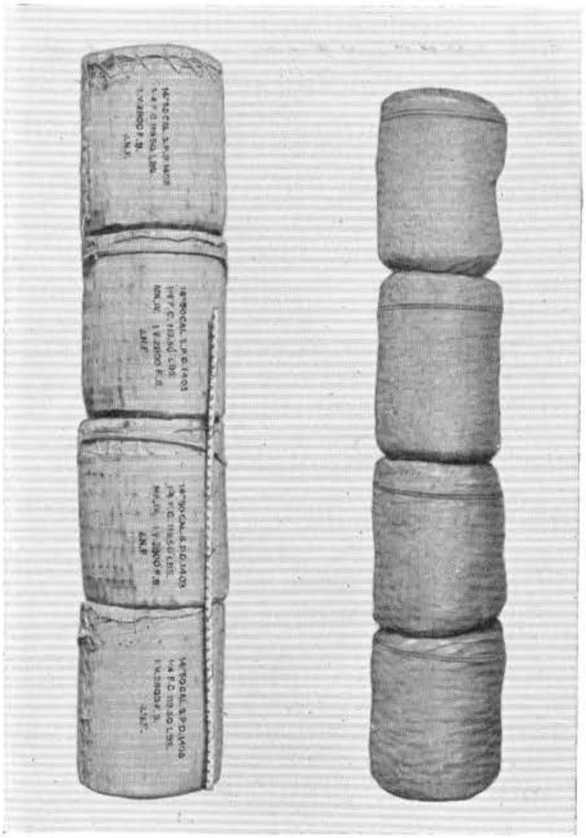


FIGURE 34.—Stacked (left) and unstacked powder charges.

Stacked charges.

15–11. For all 14- and 16-inch charges, unstacked charges have been replaced by stacked charges. Stacking places the powder grains on end in layers in such a way that a tight, compact charge is obtained. The results of stacking are: greater ease for the loading crews, a smaller charge for handling, and a longer life to the bag, as there is less chance for the sharp edges of the grains to cut the cloth, as the charges chafe in the tanks, due to the motion of the ship. Stacking is done in special machines, of which there are several types, differing at each depot in details of construction. The essential feature is the device for arranging the grains in layers and transferring the layers to the stacking cylinder from which they are placed in the bag. Figure 34 shows an unstacked and a stacked section of a 14-inch charge. For unstacked charges a small opening is left in the side of the bag, this opening being stitched up after filling. With stacked charges the end is left off, as the bag must be pulled over a brass cylinder which holds the powder grains. The end is laced on by hand. Stacked charges are also laced up to make them more compact. The arrangement of rows and number of grains in a row is so fixed that the finished section will have the length fixed by the Bureau's tables. This arrangement differs with each index and is found by actually loading a test charge.

15–12. All operations requiring the exposure of powder to the atmosphere are carried out only when standard hygrometric conditions obtain. To insure this, psychrometer readings are taken frequently and work is discontinued when conditions are unsatisfactory, unless dehumidifying systems are installed in filling houses. By taking such precautions the ballistic regularity of the powder is not affected. Powder is always screened and sorted when weighed before loading in order that powder dust, chips, broken grains and foreign particles will not be included in the charge.

Chapter XVI. MISCELLANEOUS AMMUNITION

16–1. The Bureau of Ordnance Manual in chapter 13, section D, gives complete information as to the types of small-arms ammunition issued to the Naval service together with a brief description of each and a statement as to the uses for which assigned. Small-arms ammunition.

16–2. The Bureau of Ordnance Manual also gives complete instructions as to issues of small-arms ammunition. Particular attention is invited to the requirement that small-arms service ammunition is to be kept for use in the same manner as the service ammunition for larger caliber guns.

16–3. Attention is likewise invited to the necessity for maintaining intact the original, sealed containers for small-arms ammunition until such time as the ammunition is actually required for use in order to prevent undue deterioration. When, for any reason, ammunition containers are opened and the ammunition is not used immediately thereafter, every possible care should be taken to prevent losses due to deterioration. If the ammunition is loaded in belts or in magazines for automatic weapons the belts or magazines should have attached identification tags showing the caliber, type, model, manufacturer, and ammunition lot number of the ammunition.

16–4. The methods of grading ammunition and the allowable uses of the different grades of ammunition are given in the Bureau of Ordnance Manual. The grades of the different lots of ammunition, and current modifications, and/or special precautions in the use and care of ammunition will be given in Bureau of Ordnance circular letters. The grade is published (or corrected) annually or oftener if necessary. Before firing any lot of graded ammunition the grade should be verified from the latest Bureau of Ordnance grading order.

16–5. Small-arms ammunition is obtained from the Army and a description of the method of packing and the markings on the outside of the boxes is contained in Army Technical Regulations. These regulations also contain complete descriptions of the majority of the types supplied, and valuable data on the common defects found. Copies of these regulations will be supplied upon request to the Bureau.

16–6. Instructions relative to the salvage of components are contained in chapter I and also in chapter XIII of the Bureau of Ordnance Manual.

16–7. Shotgun ammunition of commercial manufacture is supplied to certain special units (see Bureau of Ordnance Manual); it is not, however, supplied for general issue. Under no circumstances should it be attempted to fire a Very signal cartridge in a shotgun (or vice versa).

Torpedo-impulse charges.

16–8. Torpedo-impulse charges are made up aboard ship by using sphero-hexagonal black powder or sodium nitrate black powder (issued to ships in bulk) in the impulse cases provided.

16–9. Sphero-hexagonal powder is used for all torpedo-impulse charges on 1,200-ton destroyers and on all destroyers subsequent to the 1,200-ton class which mount wing tubes only. Destroyers subsequent to the 1,200-ton class mounting any tubes on the center line use sodium-nitrate black powder for all torpedo-impulse charges. The sodium-nitrate black powder furnishes the pressure and velocity requisite for insuring proper torpedo ejection from center-line tubes but the excess heat resulting from this powder renders it undesirable where its use can be avoided.

16–10. The weights of either type of powder required for each mark and modification of torpedo are determined experimentally and are published to the service in an O. D. The detailed instructions contained in this O. D. shall be complied with in preparing torpedo impulse charges. Torpedo impulse cases shall be cleaned thoroughly after firing since the black powder residue will cause corrosion if allowed to remain.
The weight of powder and yards range is stenciled on side and head of case.

Charges for Y-gun and single depth charge projectors.

16–11. Charges for Y-guns and single depth charge projectors are made up as follows:

Y-gun charges

Charge designation	Weight charge [1]	Portion of allowance	Range
No. 1	17½ ounces	⅓	50 yards.
No. 2	24 ounces	⅓	72 yards.
No. 3	29¾ ounces	⅓	93 yards.

[1] Weights of charge listed are for the new manufacture sphero-hexagonal black powder.

Cartridge Case: 3-inch case, Mark 2, Modified, Bu. Ord. sketch 87195.
Primer: Mark 10, mod. 9.
Pyralin wad: Sketch No. 97107.
Powder: Sphero-hexagonal black powder.
Boxes: Standard ammunition boxes or special Y-gun ammunition boxes.

Impulse charges for single depth charge projector, Mark 6

Charge designation	Weight charge [1]	Portion of allowance	Range
No. 1	12½ ounces	⅓	50 yards.
No. 2	17 ounces	⅓	75 yards.
No. 3	25 ounces	⅓	120 yards.

[1] Weights of charge listed are for the new manufacture sphero-hexagonal black powder.

The impulse charges for the Mark 6 Single Depth Charge Projector are assembled in accordance with Bureau of Ordnance Drawing 300248, Latest Revision, with components as follows:

Cartridge Case: 3-inch case Mark 5, Bu. Ord. Drawing 300249.
Primer: Mark 20.
Pyralin wad: Bu. Ord. sketch 97107.
Powder: Sphero-hexagonal black powder.
Boxes: Same as for Y-gun charges.

It should be noted that in, the event sphero-hexagonal black powder is not available, sodium nitrate black powder can be substituted with weight of charge as follows:

Y-gun charges			Single depth charge projector (Mark 6) impulse charges	
Range	Weight charge	Charge designation	Weight charge	Range
50 yards	20 ounces	1	13¼ ounces	50 yards.
75 yards	28¾ ounces	2	19 ounces	75 yards.
90 yards	34 ounces	3	29½ ounces	120 yards.

16–12. Saluting ships are issued an allowance of saluting cartridges (usually 3-pounder or 6-pounder) and also a supply of powder, primers, felt wads, and cork plugs for the preparation of additional charges on board ship as may be required.

Instructions for the preparation of saluting and black ammunition.

16–13. The following instructions regarding the preparation for saluting charges are issued for the guidance of ships and ammunition depots and shall be strictly complied with. The ammunition details required for the preparation of these charges are issued to ships from the depots, and none but the authorized details may be used. The use of nonstandard primers, paper wadding, homemade plugs, etc., is forbidden. The safety precautions contained in Bureau of Ordnance Manual, article 13(L)3 shall be observed strictly in the preparation of saluting cartridges or other blank ammunition afloat.

Cartridge cases.

(*a*) Saluting cases are similar to service cases except that they are shorter, having the bottleneck cut off. They are ordinarily manufactured at the depots from service cases which have splits in the neck or other slight defects which render them unsuitable for service use. Before assembling, the cases should be carefully inspected to see that they are in sound condition and thoroughly clean and dry. They should also be tested by trying them in the gun to determine that they have not become deformed. Any cases which are damaged or which do not fit in the gun should be laid aside for return to a depot at first opportunity.

(*b*) Saluting cartridges for 1-, 3-, and 6-pounder guns and for 3-inch field and landing guns are primed with standard minor caliber cannon primers. After inspection and before loading the charge, the cases are primed. It is preferable not to prime cases until just before they are to be loaded. Primers should not be hammered in place, but should be pressed in, using the "repriming tool" shown on Ordnance drawing 41272. At least one of these tools is allowed each saluting ship. Care should be exercised that the primer is flush with the face of the cartridge case; if it is sunken in a misfire is likely, while if it protrudes a premature explosion may result. Cases shall not be primed in the same room with black saluting powder or assembled charges.

(*c*) Standard black cannon powder is issued to ships in bulk in drums or tanks for use in the preparation of saluting charges. After priming, the cartridge case is filled with black saluting powder to within about 1¾ inches from the top. Immediately before the powder is loaded the case should be inspected and thoroughly wiped out and freed from moisture. The powder is loaded directly into the case with the funnels provided, and special care should be taken not to spill any of the powder about, as this may become a source of serious danger. The normal weight of charge for the 3-pounder and 6-pounder saluting cartridges is about 1 pound, but it is preferable to fill the saluting cases furnished up to within 1¾ inches of the top, as specified above, rather than to attempt to load in a specific weight of charge. Due to the large stock on hand, black shell powder may be issued to ships for saluting purposes only. The method of preparation of charges with black shell powder is the same as for black cannon powder, the only difference being that the smaller granulation black shell powder is a little quicker and consequently gives a slightly higher pressure when fired. The following weights of black shell powder should not be exceeded in preparing saluting or blank charges:

Gun	Maximum weight of charge of black shell powder	Remarks
1 pounder	100 grams	Shortened case filled.
3 pounder	1.0 pound	Do.
6 pounder	0. 9 pound	Do.
3"/23 caliber	1. 5 pounds	
3"/50 caliber	2. 5 pounds	

(*d*) After loading the charge, as directed above, a hair felt wad about 1 inch in thickness and ⅛ inch larger in diameter than the mouth of the case is placed directly on top of the powder. These wads are specially manufactured and issued for use in the preparation of saluting cartridges, and are for the purpose of preventing fine grains of black powder from passing the wad. No substitute is authorized. Care must be taken that no grains of powder are left above the hair felt wad. On top of the hair felt wad is placed a cork plug specially furnished for the purpose. The cork plug should seat firmly on the hair felt wad, should be a tight fit in the mouth of the cartridge case, and, when seated in place, its top should be slightly below the upper edge of the cartridge case. Finally, the exposed surface of the cork plug and the inner edge of the cartridge case should be covered with a thick coating of shellac.

NOTE.—No great force should be used in pushing the cork plug into place, as pressure may force the primer out; if the cork plug will not enter readily, the felt wad should be taken out and some of the powder removed.

(*e*) Saluting and blank ammunition including unpriming of cartridge cases shall be prepared under the direct supervision of the gunner or other responsible officer and, before use, should be critically inspected to determine that the primers and plugs are properly seated, that the mouth of the case is properly shellacked, and especially that no grains of powder are adhering to the cartridges. When saluting ammunition is prepared on board ship, new tags will be placed on the ammunition boxes, giving the initials of the officer who supervised the work.

(*f*) As soon after firing as practicable, the fired primers shall be removed from the cartridge cases by backing out from the mouth with the decapping tool shown on Ordnance drawing 17410. Primers must never be removed from cases except by the use of this decapping tool. The cases should then be thoroughly washed in a strong solution of lye or soft soap to remove all powder residue, and, after washing, thoroughly rinsed and then dried.

(*g*) An efficient solution for washing saluting cartridge cases and blank cartridge cases may be prepared by using ingredients in the following proportions: One gallon of water, 2½ ounces of soft soap, and 5½ ounces soda. The mixture should be boiled and stirred until the ingredients are entirely dissolved. This solution should be used hot and in sufficient quantity to completely immerse the cases.

16–14. "Signal-gun charges" are occasionally issued for 3″/50-caliber and 4″/50-caliber guns for special purposes. These charges are put up in shortened service cartridge cases, and in general their method of assembly is similar to that described for saluting charges. These and other special blank charges will be issued to ships by ammunition depots as required and will not be prepared on board ship.

16–15. When empty, black-powder tanks and drums should be returned to a depot at the first opportunity. Particular care must be taken that such empty drums have no black powder left in them.

16–16. Case charges assembled with mouth plugs and using black powder shall have the plug firmly fixed in place. In case of continued use, as in firing a salute, if the mouth plug drops out, there is danger of igniting a part of the charge from the hot chamber and causing a premature explosion.

16–17. The Bureau of Ordnance Manual gives a list of the different types of mortar ammunition supplied the Navy. These types are of standard Army manufacture except that some 3-inch trench mortar high-explosive projectiles have been reloaded with TNT or Explosive "D" at naval ammunition depots. Some of these reloaded projectiles are marked in accordance with paragraph 20–25. Complete descriptions of the different types are contained in Army Technical Regulations and Training Regulations and these regulations will be supplied on request.

16–18. The mortar is normally fired at elevations in excess of 45 degrees and the range is decreased by elevating the mortar. The propelling charges for the 81-mm. and 3-inch trench mortar ammunition are made up of a charge contained in a blank shotgun cartridge and increment charges which are attached to the projectile. The ranges are varied by increasing or decreasing the number of increment charges. Care should be taken that the authorized number of increment charges is not exceeded. Range tables contain statements as to the authorized number of increment charges.

16–19. Before firing 3-inch and 81-mm. mortars consult War Department Technical and Training Regulations for the particular weapon in use. Lacking this information the following precautions are to be observed in firing the 3-inch and 81-mm. mortars:

(1) See that external surfaces, particularly bourrelet(s), are clean.

(2) See that the propelling charges and increment charges are firmly fixed to projectile.

(3) The bore of the mortar must be free of excess oil.

(4) Do not use more than the authorized number of increment charges.

(5) Remove cotter pin with ring attached (safety ring) from fuze just before firing, but *not* until just before firing. Save the pin until the projectile has been fired and, in case the projectile is not fired immediately, replace the pin.

(6) Misfires may occur from one of the following causes:

(*a*) Defective cartridges.

(*b*) Loose or defective firing pin.

(*c*) Dirt or grit on projectiles or in bore, or excessive grease or oil on projectile or in bore, causing projectile to slide slowly down the bore and strike the firing pin with insufficient force to function the primer in the cartridge.

(*d*) Defective or bent cartridge container preventing firing pin from striking primer of cartridge.

(7) Check laying of mortar after each shot.

Rifle grenades.

16–20. All rifle grenades supplied to the Navy are of Army design and manufacture. The present types have been discontinued in manufacture; however, due to the supply on hand, they will continue in service for a number of years. Two general types have been manufactured: the VB type requiring a special discharger and the rod type, having a rod which is placed in the bore of the rifle, and which requires a special blank cartridge for a propelling charge (see par. 16–27 (b) for a description of the rod type). The VB rifle grenade fits in a special discharger attached to the muzzle of the rifle. When a regular service cartridge is fired, the projectile hits the striker, which fires the primer and ignites the fuze. The grenade is ejected by the powder gases with a velocity sufficient to carry it 300 yards.

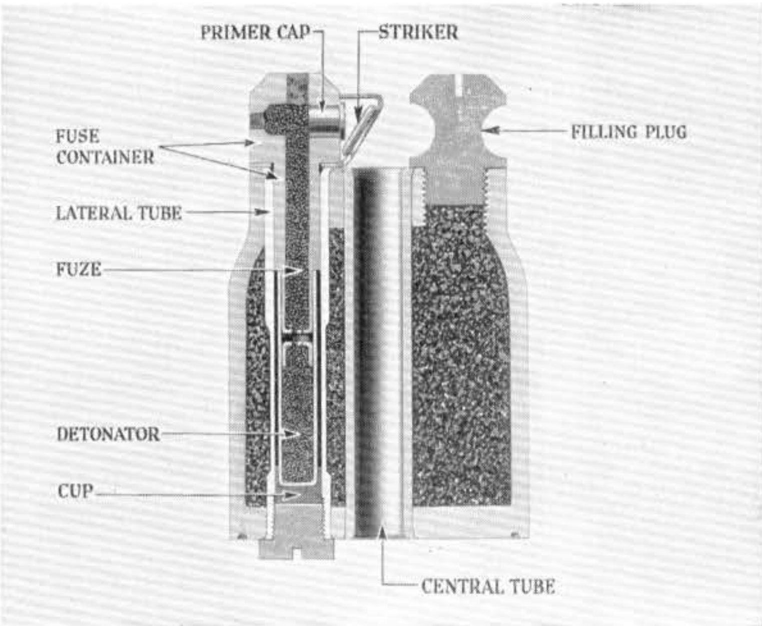


FIGURE 35.—Cross section of a V. B. rifle grenade.

16–21. The VB rifle grenade, figure 35, is approximately 2½ inches in length by 2 inches in diameter and weighs, when loaded ready to fire, 17¼ ounces. The body is divided on the inside surface into 40 parts by deep grooves in order to insure proper fragmentation. The grooves are usually on the outside of grenades, but on account of the discharger used in firing the VB grenade an inside division by grooves is necessary, so that a close fit may be secured between the outside of the grenade and the discharger, thus allowing the gases from the cartridge to exert a maximum pressure on the base of the grenade in propelling it. If the grenade were grooved externally, the gasses would escape through the grooves and most of the pressure would be lost.

16–22. The central tube and the lateral tube are expanded into the machined holes of the body, the central tube having its ends beveled on the inside to permit the free passage of the bullet. The walls of the lateral tube are made thin at the point which surrounds the detonator to insure its bursting when the detonator explodes. This tube is carefully reamed at the upper end to a size that will insure a tight fit with the fuze container and its lower end is tapped to receive the screw plug which holds the detonator in position by means of the intervening soft rubber cup.

16–23. The fuze container is provided with a hole for the primer, a loading hole in the top through which the meal and loose powder are inserted, and a vent opposite the primer. After loading the fuze the loading hole and vent are plugged with wax plugs to protect the powder train. These plugs are blown out by the explosion of the primer, thus affording an ample vent for the gases from the fuze and preventing a premature bursting of the grenade, which would be caused by the gases reaching the detonator. The fuze container, which is machined on the lower end to a size which will allow the upper end of the detonator to fit over it, is forced into the lateral tube through the hole in the end of the striker, and thus holds the latter in position. The striker is punched from sheet steel.

16–24. One end of the detonator is left open This end is inserted in the lower end of the lateral tube and overlaps the lower end of the fuze container. The rubber cup is then placed over the lower end of the detonator and both parts are held in position by the screw plug washer under the plug. This arrangement of the detonator at the top and the rubber cup at the bottom prevents the detonator from receiving any shock from the plug end or from being in too close contact with the walls of the lateral tube. It is entirely a safety device

16–25. The grenade is loaded with the main charge, granulated TNT, through the loading hole and is protected by the filling plug.

16–26. The discharger, rifle Mark 4, is the only discharger issued to the service. It is for use on the Springfield 1903 rifle and is to be used for both the rifle lights and the VB rifle grenades. It consists of a hollow stem, arranged to fit snugly over the muzzle of the rifle, surmounted by an enlarged hollow cylinder into which the grenade or rifle light is placed. The Ordnance Department of the Army has several types of dischargers, but none other than that described herein should be used on the 1903 Springfield rifle. The discharger is fitted on the muzzle of the rifle, a grenade is put in the discharger, and the rifle loaded with an ordinary 30-caliber ball cartridge. The rifle butt is placed on the ground or deck and pointed in the direction in which it is desired to fire. The grenade is now ready for firing. On firing the cartridge the bullet passes through the barrel of the rifle and through the central tube, forcing the striker against the primer. At the same time the gases from the chamber collect in the chamber of the discharger under the grenade and eject the latter from the discharger. The explosion of the primer ignites the fuze, which is timed to burn 8 seconds, when it explodes the detonator and this detonates the main charge.

16–27. (*a*) A dummy grenade is supplied for elementary training in firing VB rifle grenades. The grenade, as issued, is merely a cast iron spool of the same weight as the VB fragmentation grenade. The flanges (bourrelet) and central hole, through which the bullet passes, are concentric. A special caliber .30 cartridge with a wooden bullet is supplied for use in firing both the dummy and fragmentation VB grenades for training purposes in areas where the falling bullet may be dangerous.

(*b*) The rod type grenades have been supplied in chemical types only, and at present the only type known to be on hand is the CN type. Any phosphorous loaded rod type rifle grenade found on hand should be destroyed. These grenades consist of the following main parts: (1) Grenade body, (2) fuze, and (3) rod. The first grenades supplied were furnished with the fuze mechanism separate but the later types have the fuze assembled in the grenade body. The fuze is a "time" type, ignition of the powder train being initiated by set-back. It burns for approximately 6 seconds when, for the CN type, ignition of the charge takes place, and for the white phosphorous detonation of the bursting charge, a No. 8 commercial primer, takes place. The grenade is prepared for firing by (1) assembling the fuze if not already assembled, and (2) assembly of the rod by screwing it on to the base of the grenade. To fire the grenade, proceed as follows: (1) Insert rod to full length in bore of rifle with bolt open; (*a*) remove safety pin from fuze making sure fuze cover is thrown clear of the fuze; (3) place butt of rifle on ground, preferably moderately firm ground; (4) insert special blank cartridge in chamber of rifle and close bolt; (5) check direction and elevation of rifle; (6) fire rifle by pulling trigger.

(*c*) Precautions for firing all types of rifle grenades:

(1) *For VB. type grenade:*

Do not assemble detonator in grenade until just before firing.

A resilient rubber cup *must* be used, otherwise shock of firing may cause instantaneous detonation of main charge.

In loading grenade, be sure the filling plug and primer cap is up.

Load grenade only when bolt of rifle is open.

Use special precautions in handling detonator to prevent shock or overheating.

Do not handle duds. Destroy in place if practicable.

(2) *For rod type grenades:*

Use only special caliber .30 cartridge, blank, M1, marked "CRG" on head for propelling charge.

Do not remove safety pin from fuze until ready to fire.

Make sure fuze cover is off fuze before firing.

To prevent damage to rifles, do not fire grenades with butt of rifle on unyielding material, use Springfield Army Rifle (SA) of serial numbers greater than 800,000 only.

Do not handle duds for at least 10 minutes.

(3) *For all types of grenades:*

Fire live grenades from cover only. Have minumum number of persons present. All persons in the immediate vicinity of the firing to wear steel helmets and, when the grenades are fired, to keep heads below the muzzle of the rifle.

16–28. Two general types of hand grenades are now in service: (1) Fragmentation grenades and (2) chemical grenades. The different types on hand are all of Army manufacture and are completely described in Army Technical regulations.

Hand grenades.

16–29. The fuze assemblies of hand grenades are commonly referred to as "Bouchons." These operate by a striker actuated by a coil spring striking a small primer which ignites a powder tracer in the fuze. This striker is held in a "cocked" position by a lever which is held in place by a cotter pin with a ring attached. When this cotter pin is removed the lever is thrown clear of the

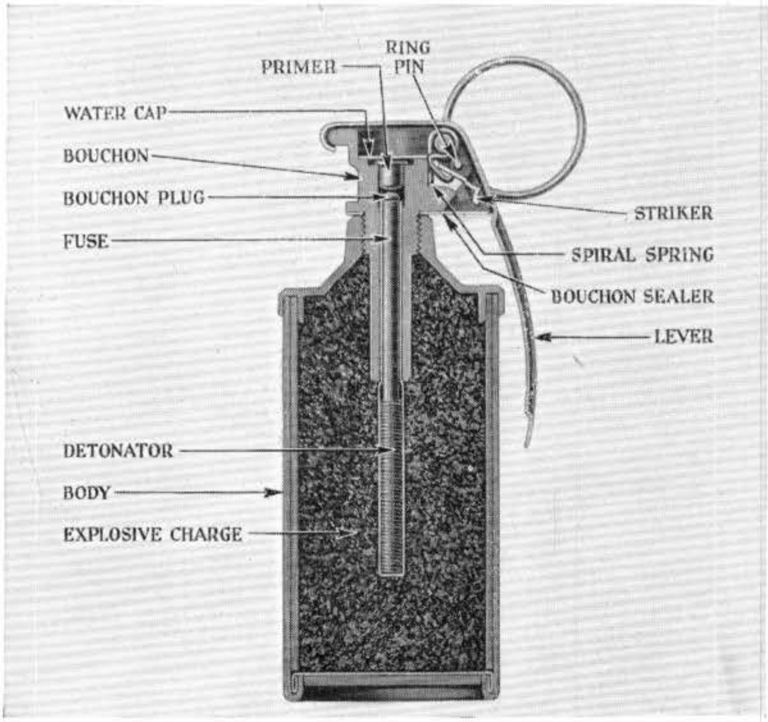


FIGURE 36.—Cross section of a hand grenade.

fuze and the striker is free to rotate and strike the primer. In throwing the grenade, it is grasped in the hand so that the lever is held against the grenade by the palm of the hand; the pin is withdrawn and when the grenade is thrown from the hand, the lever is thrown clear and the striker operates. EVERY PRECAUTION MUST BE TAKEN TO PREVENT THE PIN'S BEING REMOVED FROM THE GRENADE UNTIL IT IS PROPERLY GRASPED, READY TO THROW. Accidents have occurred due to the cotter pin being accidentally withdrawn by being caught in clothing or other objects. The fuze is a time type set for about 5 seconds. If the fuze is functioned accidentally, the grenade can be thrown farther than a person can run in this delay time.

16–30. The present standard fragmentation grenade is the Mark 2 and it is loaded with a commercial powder known as "EC blank fire powder." It is shipped and stored loaded and fuzed. There are still on hand a number of cast TNT loaded Mark 2 fragmentation hand grenades. These grenades require a fuze assembly fitted with a detonator and are stored and shipped unfuzed. All chemical hand grenades are shipped and stored fuzed. Practice and dummy grenades for training are supplied. The dummy grenade is of cast iron similar in shape and weight to the body of a Mark 2 grenade but has no moving parts. The present standard practice grenade has the same body as the Mark 2 fragmentation grenade but contains no powder charge. The fuze mechanism is the same as that used in the "EC" powder loaded Mark 2 grenade except that it has a small amount of black powder added to the bottom of the fuze. It is fired in the same manner as the fragmentation grenade but the fuze has only sufficient charge to blow out the cork plug in the bottom of the grenade. The bodies should be salvaged for use with spare fuze assemblies. Two types of spare fuze assemblies are now supplied: one without a detonator, the fuze merely giving off a small puff of smoke, and the other with a detonator. The detonators have sufficient power to cause severe injuries and they should be handled as provided for other detonators.

16–31. The grenades are marked in accordance with Army instructions. Briefly, this system is as follows:

For all fragmentation grenades, the body is painted yellow.
For all practice grenades, the body is painted blue.
For all chemical grenades, the body is painted gray with the type of filler stenciled in either green or yellow.

Precautions.

16–32. Remember that a grenade is always loaded and cocked. If the striker should accidentally function in a fragmentation grenade, throw the grenade as far as possible, for you throw it farther than you can run. Then throw yourselves on the ground.

16–33. If the striker accidentally functions on the fast burning chemical grenade, run up-wind. The chemical grenade has a delay of only about 2 seconds, and it has a very limited radius of action up-wind.

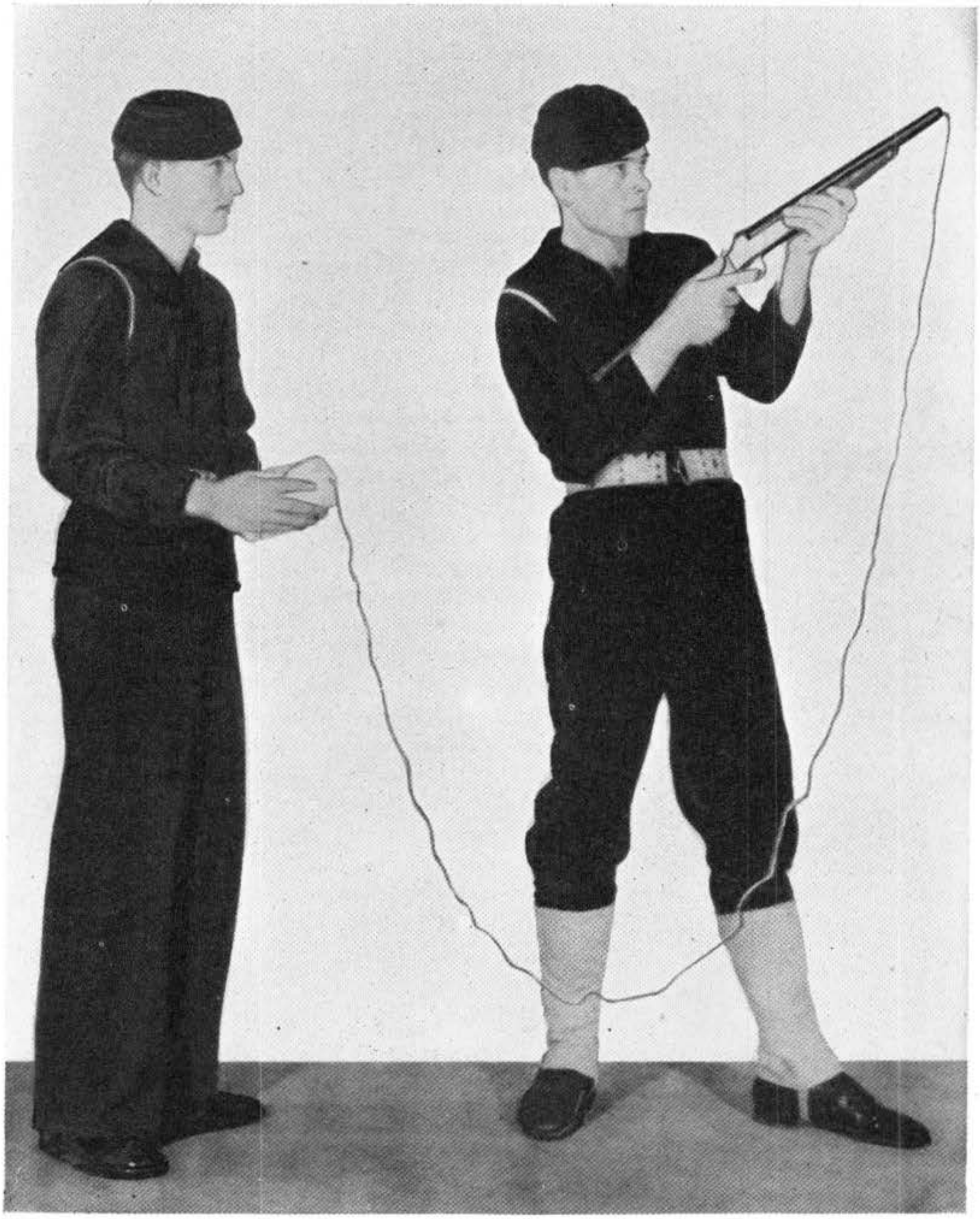


PLATE 28.—Method of use of 45-caliber line-throwing apparatus.

16–34. Before handling grenades, familiarize yourself with their construction and method of operation.

16–35. Know what type you are using.

16–36. Do not pull safety pin until grenade is firmly in the hand and until you are ready to throw it.

16–37. Throw fragmentation grenades from cover only and when wearing a steel helmet. Fragments may be thrown to a distance of 200 yards.

16–38. Do not hold grenade after striker is released (see 32 above).

16–39. Handle fragmentation grenades with care. Through careless handling, a safety pin may be pulled.

16–40. Detonators used for TNT-loaded grenades and with some practice fuze assemblies, are sufficiently powerful to blow the fingers off a hand.

16–41. The detonator contains a small charge of fulminate of mercury. This explosive is very sensitive, and the slightest jar or a sudden change in temperature may be sufficient to cause explosion. Consequently the only safe thing to do is to treat all detonators with proper respect.

16–42. Army Technical Regulations give the methods of packing and marking grenades. Read these before handling grenades.

16–43. HC smoke grenades are subject to spontaneous combustion when subjected to just the right amount of moisture. Keep them in dry storage and away from other types of explosives.

16–44. Some of the first types of fragmentation hand grenades were loaded with Trojan (Nitro-starch) powder. Any of these found on hand should be destroyed immediately.

Line-throwing ammunition.

16–45. Line-carrying equipment for the use of vessels is provided as follows:

(*a*) For vessels carrying saluting guns, 3-pounder and 6-pounder line-carrying projectiles and charges.

(*b*) For all vessels, 45-caliber line-carrying guns and ammunition.

(*c*) For Coast Guard vessels mounting 3-pounder and 6-pounder guns, corresponding line-carrying projectiles and charges.

Figure 37 shows the 3-pounder and 6-pounder line-carrying projectile and the proper method of attaching the shot line. The shot lines and faking boxes are under the cognizance of and supplied by the Bureau of Ships. Plate 28 shows the 45-caliber line-carrying equipment and the method of its use.

Preparation of charges.

16–46. In using the line-carrying 3-pounder and 6-pounder projectiles, the line is prepared, faked down near the muzzle of the gun, and the end is attached to the thimble in the end of the spindle. About 2 fathoms of the line from the end is wet down. The projectile is loaded in the muzzle and the case is then loaded. The line should then be cleared for running out. It is preferable to use the lines provided, but if these should not be available, a soft, pliable line of the required size will be satisfactory. The same precautions should be taken with the cartridge as for other types. The charges are prepared as for saluting charges, using shortened cartridge cases. The following weights of charge of black cannon powder are assigned (weight and expected yards range is stenciled on case head and body):

3-pounder:	6-pounder:
250 yards, 8 ounces.	300 yards, 6 ounces.
300 yards, 10 ounces.	350 yards, 12 ounces.

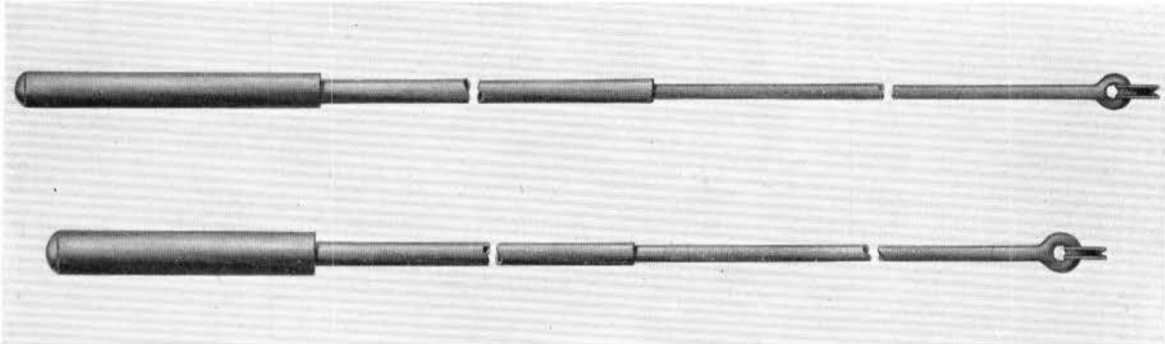


FIGURE 37.—3- and 6-pounder line-throwing projectiles.

16–47. It is difficult to control the range by varying the weight of charge. Not less than 6 ounces nor more than 12 ounces shall be used for the 3-pounder and not less than 6 ounces nor more than 13 ounces for the 6-pounder projectile. The experience of the United States Coast Guard indicates that entirely satisfactory results are obtained with 6-pounder line-carrying projectiles using a 6-ounce charge. The projectile should be loaded from the muzzle, care being taken that the eye in the rod is sufficiently clear of the muzzle to insure against parting the line. The line should be passed through the eye and held in place by three loose half hitches. Do not secure the line tightly to the eye.

16–48. The 45-caliber line-throwing gun is shipped in boxes together with 50 cartridges, 10 projectiles, 4 lines, spindles, cleaning gear, and book of instructions.

16–49. A 30-caliber line-throwing equipment is now standard in the Coast Guard.

16–50. For detailed description on the use of line-throwing equipment, see O. P. 546.

Chapter XVII. AIRCRAFT AMMUNITION

17–1. Aircraft bombs are classified as follows: Aero bombs.

(*a*) Demolition bombs.
(*b*) Fragmentation bombs.
(*c*) Armor-piercing bombs.
(*d*) Smoke bombs.
(*e*) Incendiary bombs.
(*f*) Gas bombs.
(*g*) Dummy bombs.
(*h*) Practice bombs.
 (1) Miniature.
 (2) Water-fillable.

17–2. Detailed descriptions of the above bombs together with their dimensional characteristics and notes as to limitations on their use are contained in Ordnance Pamphlet 736. Accordingly, the data contained in that pamphlet are not repeated herein.

17–3. Aircraft bomb fuzes in general are armed by the action of the air during flight on an impeller or vaned wheel. The steps in arming may be accomplished either directly by the action of the impeller and the screws or gearing driven by it or there may be a combination of such action and spring action. In general, once a bomb fuze has been armed, it cannot be unarmed without disassembly of the fuze. Accordingly, any fuzed bomb found with the fuze apparently armed should be treated as dangerous.

17–4. Detailed descriptions of aircraft bomb fuzes are contained in confidential ordnance pamphlets. By reason of their confidential nature, it is not desirable to repeat such descriptions in this pamphlet. The pertinent confidential pamphlets should be studied carefully by all personnel concerned with fuzing aircraft bombs and with the use of fuzed bombs.

17–5. In general, aircraft bombs which are loaded with cast TNT are issued to ships and stations with the cast charges and the booster or boosters in place, the whole being contained in a metal crate. Tail fin assemblies are crated and stowed separately and the operation of preparing a bomb for service use includes uncrating, fuzing, and assembling the tail.

17–6. The water-fillable practice bomb, which is a sheet-metal bomb of the least expensive construction practicable, is designed to furnish a bomb approximating in external dimensions and weight the service bomb which it represents, but which at the same time can be procured in sufficient quantities to Water-fillable practice bombs.

afford ample training. By reason of its light construction, a water-fillable practice bomb is highly susceptible to damage in handling and particular care must therefore be exercised in the stowage and handling of this bomb to prevent impairment of its flight characteristics.

17–7. In order further to extend its individual training in bombing, miniature practice bombs have been developed. These are small die cast bombs weighing approximately 2.7 pounds with an axial hole in which may be placed a miniature practice bomb signal which will be fired by the firing mechanism on impact with either ground or water.

17–8. In assembling miniature practice bomb signals in the miniature practice bombs, the procedure and precautions set forth in paragraph 10, chapter 7, Ordnance Pamphlet 562, must be followed strictly.

Chapter XVIII. STOWAGE OF AMMUNITION

18–1. In the design of ships, arrangements are made so far as practicable to provide stowages for the several types and calibers of ammunition which will be supplied as service allowance and for target and training purposes in accordance with the provisions of chapter 14, section C of the Bureau of Ordnance Manual. Those restrictions are in themselves based on the safety precautions contained in Navy Regulations, Article 972.

18–2. The provisions of chapter 14, section C, of the Bureau of Ordnance Manual must be observed strictly aboard ship. Where it is found that stowage conditions not contemplated by that section exist on board ship and that these conditions are not specifically covered by the ship's plans, the question should be presented to the Bureau of Ordnance for decision. It is particularly important that mixed stowages of various types of ammunition be not allowed since the hazards involved with certain types are considerably greater than with other types and the over-all danger to the ship or the likelihood of loss of essential ammunition may be unduly increased. In this connection, attention is invited to the discussion of safety requirements and hazards incident to the stowage of explosives contained in chapter 14, section D of the Bureau of Ordnance Manual, which covers the storage of ammunition and explosives ashore. While the quantities and distances involved are, of course, not applicable to shipboard stowages, the general principles involved are the same.

18–3. The provisions of the Bureau of Ordnance Manual relative to the handling of ammunition and explosives and to the care, cleaning, ventilation, and cooling of magazines, as set forth in chapter 14, sections A and B, must be complied with strictly.

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Chapter XIX. PYROTECHNIC MATERIALS

19–1. Pyrotechny, or the art of fire, is usually considered as the art of producing pleasing scenic effects by means of fire. The effects utilized for display purposes lend themselves readily to many uses in the art of war, and consequently recent developments in this direction have been very rapid. Fire was originally used considerably in various forms of worship. **Pyrotechny.**

19–2. The effects desired in scenic displays tended toward a variety of colors, as well as the display of fire in various forms and patterns. The materials used were saltpeter, sulphur, charcoal, iron, and salamoniac. With this small variety beautiful effects were obtained, but modern chemistry has added many other materials to the list of available substances, such as phosphorus, arsenic, mercury, barium nitrate, magnesium salts, lime salts, potassium nitrate, potassium chlorate, aluminum, resin, strontium, carbonate and oxalate, potassium permanganate, sodium oxalate, and other metallic salts, so that a great variety of lighting, smoke, and other effects may be obtained. The modern improvements consist in the star arrangement and in the substitution of various colored smokes for the fire. **Material used.**

19–3. Pyrotechnics supplied by the Bureau of Ordnance are classed as ship pyrotechnics or aircraft pyrotechnics, although some items are common to both classes. **Kinds of pyrotechnics.**

19–4. Ship pyrotechnics include:

(*a*) Ships emergency identification signals.
(*b*) Submarine emergency identification signals.
(*c*) Submarine float signals.
(*d*) Rockets.
(*e*) Grenades; hand, smoke, and gas irritant.
(*f*) Very's signaling equipment consisting of pistol and star cartridges.
(*g*) Hand signal flares.
(*h*) Smoke mixture.

Detailed descriptions of each of the above types are in O. P. 725, which should be understood thoroughly by all personnel concerned with the use of these pyrotechnics.

19–5. Aircraft pyrotechnics include the following:

(*a*) Aircraft parachute flares.
(*b*) Bombardment flares.
(*c*) Float lights.
(*d*) Aircraft day distress signals.
(*e*) Very's signaling apparatus.
(*f*) Aircraft emergency identification signals.
(*g*) Miniature practice bomb signals.

Detailed descriptions of each of the above pyrotechnics, with instructions and safety precautions for their use, are contained in O. P. 562, which must be studied and understood thoroughly by all personnel concerned with the use of these pyrotechnics.

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NAVY DEPARTMENT
BUREAU OF ORDNANCE
WASHINGTON 25, D. C.

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OP 4 CHANGE 1
1 June 1945

1 Page —— Page 1

ORDNANCE PAMPHLET 4 is changed as follows:

AMMUNITION—INSTRUCTIONS FOR THE NAVAL SERVICE

Insert the attached page (page 142a and 142b) immediately preceding page 143. 490

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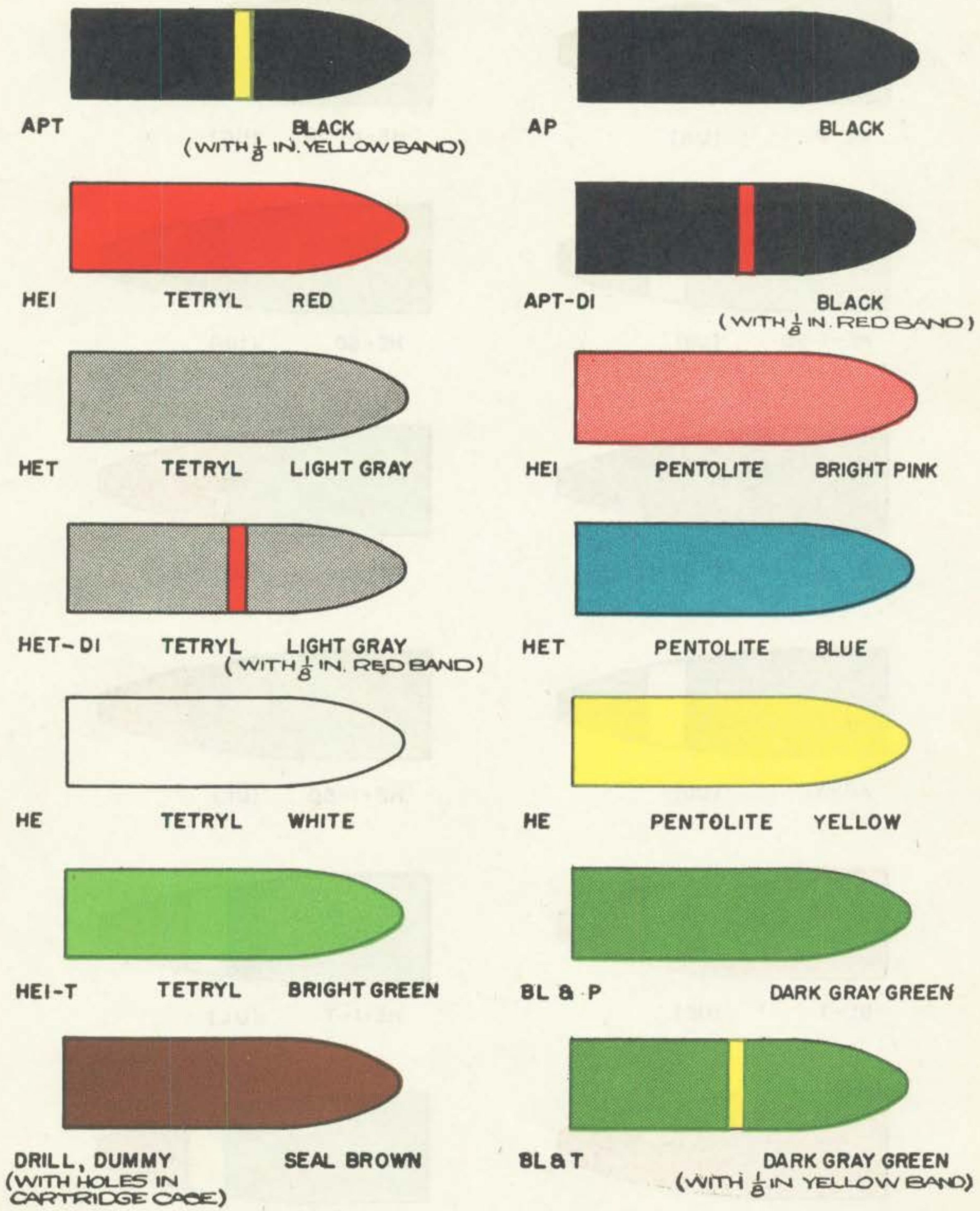

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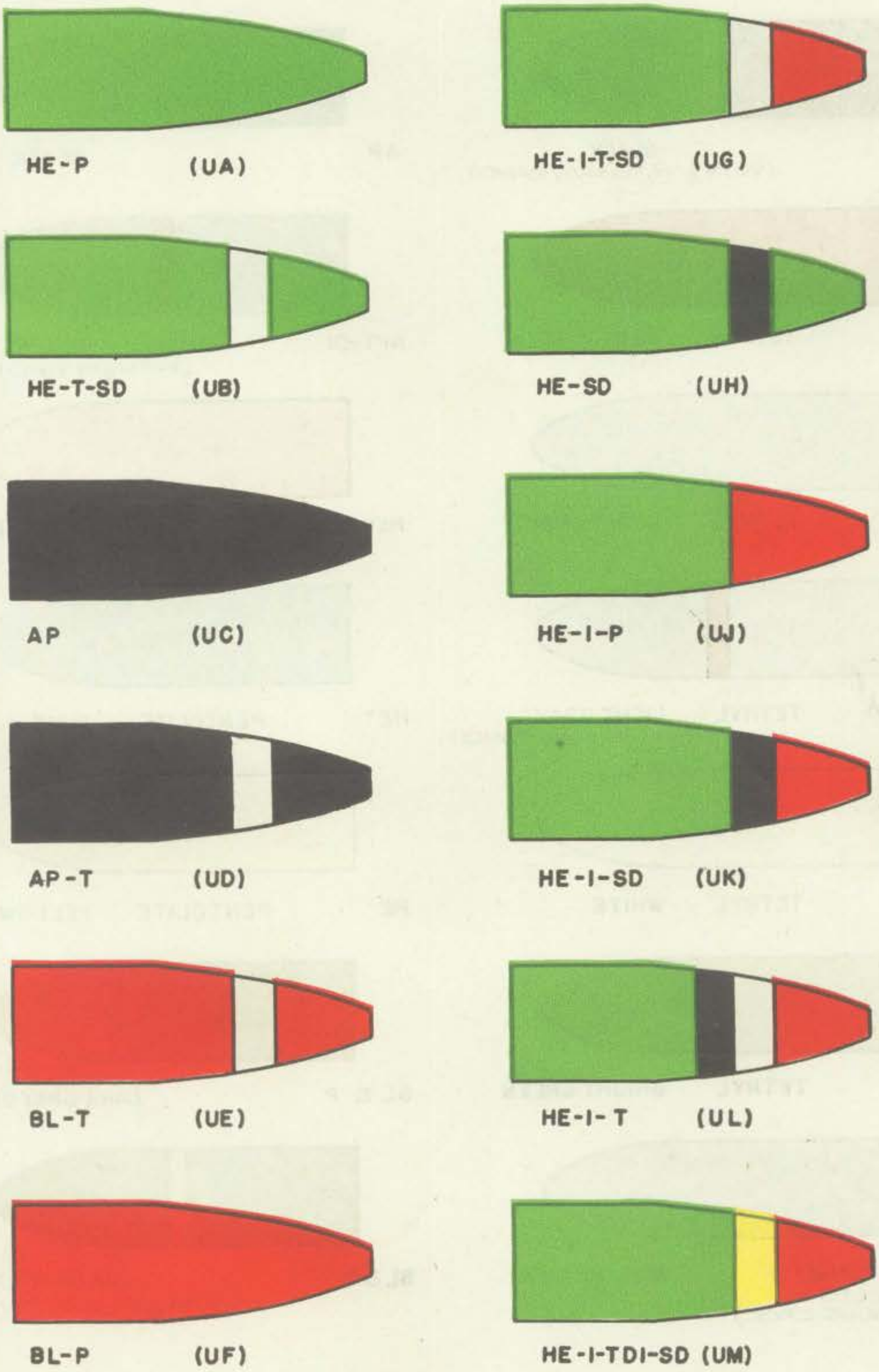
20-mm. ANTIAIRCRAFT PROJECTILE COLOR CHART



RESTRICTED

40-mm. PROJECTILE COLOR CHART

10—46256-1 U. S. GOVERNMENT PRINTING OFFICE

Chapter XX. MARKING OF AMMUNITION

General instructions.

20–1. (*a*) Ammunition and ammunition details prepared by naval ammunition depots are marked for identification purposes as indicated in this chapter.

(*b*) The Navy purchases from the Army, or makes up from components purchased from the Army, several types of ammunition for use of naval landing forces and the Marine Corps. Description and instructions relative to the use of this ammunition are contained in Army publications. The ammunition purchased from the Army is marked in accordance with Army instructions and, to make the descriptions contained in Army publications applicable, these types when made up at naval ammunition depots are marked in accordance with the Army drawings.

20–2. The instructions for marking and painting projectiles for the United States Naval Service as furnished by manufacturers are contained in Ordnance Pamphlet No. 368, part I.

20–3. Where shipment of ammunition, explosives, or ammunition components by rail is involved, the regulations of the Interstate Commerce Commission, govern the packing, marking, and shipping of these items.

20–4. It is important that the marking on assembled ammunition be not obliterated and that, if ammunition be once removed from its containers and subsequently replaced therein, care be exercised that the markings on the ammunition and on the container agree.

20–5. Projectiles issued for target practice which have been painted various colors aboard ship must have all paint removed by the ship concerned before being turned into an ammunition depot.

Smokeless powder containers.

20–6. Smokeless powder is packed at the factory in standard airtight smokeless powder packing boxes. The current standard is a galvanized steel box designated as Mark 7. There remain in service a considerable number of zinc-lined wooden boxes. The latter are painted slate color with a suitable paint. Cold water paint conforming to Navy Department Specifications 52P1b is satisfactory for the purpose. Galvanized boxes are unpainted. Smokeless powder packing boxes are marked with black block letters three-fourths inch high as follows:

On the end containing the hand hole:

Caliber of gun for which powder is intended (mark of gun if essential for identification).

Index number of powder.

On one broad side of box:

"Smokeless powder for cannon."
Manufacturer's designation of lot (The abbreviation indicates manufacturer and the caliber for which intended).
Gross weight ----------; net weight ----------.

On one narrow side:

Index number.
Shipping directions.

NOTE.—New powder being shipped for proof is marked "firing sample for proof," and no index number shown.

SAMPLE MARKING

End containing handhole: 16"/45 SPD 2605.

Broad side of box: SMOKELESS POWDER FOR CANNON
I. H. I. Lot 24
Gross Wt. ---------- Net Wt. ----------
Narrow side of box: SPD 2453
FOR U. S. NAVAL AMMUNITION DEPOT
Iona Island, N. Y.

20–7. The arrangement of the legends in this manner allows the top of the box to be completely marked at the time of packing and the other marking done upon the receipt of order for shipment, which also assigns the index. The letters "SP" will indicate that the number following them is the index number of the powder. The prefix to the index number, SP, R, W. D, N, F, B, and X, or combinations of these letters, indicates the composition of the material and is a part of the index number.

20–8. In making shipments of smokeless powder in bulk, a partly filled box is indicated by a white painted handhole cover and a tag with a blue border.

20–9. Shipments of smokeless powder from naval ammunition depots to the Naval Powder Factory for any purpose are marked in accordance with the instructions contained in Ordnance Pamphlet V.

Black powder containers.

20–10. Black powder is supplied to ammunition depots and from them issued to ships or stations in metal kegs or drums having interior bags and conforming to the Interstate Commerce Commission shipping container specifications. The drums are marked to show the manufacturer's data as indicated below:

E. I. duPont deNemours & Co.,
Black Cannon Powder, Lot 1
Net *25* lbs.
Cont. NOs–68541, Date June 1, 1939

Index numbers are not assigned to lots of black powder. The marking on black powder containers indicates the kind of powder, such as:

(*a*) Cannon.
(*b*) Shell.
(*c*) Sphero-hexagonal for torpedo impulse.
(*d*) Sodium nitrate for torpedo impulse.

20–11. High explosives, when shipped in bulk, are packed in wooden boxes with paper liners conforming to the Interstate Commerce Commission regulations. They are marked to show the material, manufacturer, the contract number and date, the lot number, and the gross and net weight, as follows: **High explosives.**

E. I. duPont deNemours & Co., Barksdale, Wis.
Grade "A" TNT., Lot 175.
Cont. NOs–68541 Date June 1, 1939
Gross ______ lbs. Net _________ lbs.

20–12. Naval ammunition depots preparing ammunition will use the following symbols (without the letters NAD) in marking ammunition or ammunition containers:

Hingham	H.
Iona Island	I. I.
Lake Denmark	L. D.
Fort Mifflin	F. M.
St. Juliens Creek	St. J.
Balboa	Bal.
Hawthorne	Haw.
Mare Island	M. I.
Puget Sound	P. S.
Oahu	Oh.

In marking bomb type ammunition to show the point of assembly or loading, the following symbols are used:

Naval Mine Depot, Yorktown	NMD/Y·
Naval Ammunition Depot, Hawthorne	NAD/Haw·

20–13. All bag gun charges are assembled in silk powder bags and are marked by stenciling on each bag in black letters parallel to and on the opposite side from the lacing, the following data: **Marking of ammunition for ships; bag gun charges.**

Caliber of gun (mark or (SC), (LC), if required).
Index number of powder.
Weight of smokeless powder contained in bag.
Proportion bag bears to full (special or target) charge.
Initial velocity.
Symbol of ammunition depot.
Month and year of assembly.
Code number __________.

One word names have been assigned to designate initial velocities and corresponding powder charges for guns for which more than one velocity is used as follows:

(1) *Service* designates normal designed velocity of the gun. Abbreviation SER.

(2) *Special* designates the reduced velocities assigned to 14''/ 50-caliber, 14''/ .45-caliber, L. C., and 8''/ 55-caliber guns which are only slightly reduced below the service velocities. Abbreviation SPEC.

(3) *Target* designates the reduced velocity generally used for gunnery training. Abbreviation TAR.

(4) *Spotting* designates the very much reduced velocity used for certain guns at spotting practices. Abbreviation SPOT.

(5) *Special*, *Target*, and *Spotting velocity* charges are issued only for gunnery training or experimental firing.

For table of calibers and velocities consult latest circular letter on ballistic data.

20–14. The dyed ignition ends of bag gun powder bags are marked in black letters, three-fourth inch high, as follows:

Ignition __________ grams.

20–15. No paint containing oil is used in marking bags and care must be taken not to blur the stencil.

Powder identification tags.

20–16. Identification tags are used with all smokeless powder charges. The following data must appear:

Caliber of gun, Mark (SC or LC) if required.
Index of powder.
Weight of powder contained and proportion of full (special or target) charge
Initial velocity.
Weight of ignition (if ignition is contained in primer, state "primer ignition").
Fahrenheit readings of wet and dry bulb thermometers (see Ordnance Pamphlet No. V, art. 202).
Ammunition depot (where prepared).
Date.
Code number __________.
Initials of weigher.
Initials of checker.
Initials of gauger.
Initials of gunner in charge.
Initials of inspector of ordnance in charge.

20–17. The identification tags are made of ignition cloth (powder bag silk cloth, light) for bag charges and cartridges and of linen for ammunition containers. An exception is made in the case of 1″1-inch cartridges where the necessary data is printed on light paper and the slip is inserted in the cartridge case by the automatic loading machinery. For bag charges the tag is placed under the lacing cord before final tightening and is in addition to the data stenciled on the bag. For case ammunition the tag is placed in the case on top of the powder under the wad.

20–18. In addition to the identification tag, case ammunition has the index number of the powder stenciled on the head of each cartridge case, using a thin mixture of shellac and lamp black. The head of a reformed case shall be stamped with an "R" after the first round and a "*" for indicating each subsequent firing.

Powder tanks.

20–19. The current standard powder tanks are of aluminum or sheet steel. The latter tanks are parkerized and painted with black paint or cadmium plated. Older power tanks are either of copper, with wooden reinforcing strips, or of galvanized steel.

20–20. Each powder tank containing all or part of a charge is marked with a circular band of white paint 2 inches wide, if practicable, around the edge of the cover and has stenciled upon this band (or on the cover) in black letters the caliber of the gun, whether LC or SC, the index of powder, the proportion of full (special or target) charge contained, and initial velocity.

Heavy paper linen cloth or silk cloth tags

20–21. Each powder tank has wired to it a tag giving the information shown on the powder identification tag attached to the powder bag, as covered by paragraph 20–16, above.

Projectiles (empty).

20–22. The cavities of projectiles are painted as prescribed in Ordnance Pamphlet 368, part I. As issued to ships the ogivals of projectiles, except 1″1-inch AA, for a distance of 1 caliber from the point toward the bourrelet, are painted with distinctive colors to indicate the kind of projectile filler.

Exterior paint.

The remainder of the exteriors, except the bourrelet, band and base, is painted with distinctive colors to indicate the type of projectile.

20–23. Bourrelets, bases, and base plugs of all projectiles are not painted, but are coated with vaseline to protect the surface from rusting. Rotating bands are not painted. Cannelures of rotating bands are fitted with graphite and tallow. Projectiles assembled in case ammunition are not painted in the rear of the band. The Army makes a practice of painting the complete projectile for some types, and, when these types are used in naval service, the paint need not be removed. (See par. 20–1.)

20–24. The standard colors used in painting projectiles are shown in Ordnance Pamphlet 368, part I, plate 1. The paint used conforms to the Navy standard specifications for paint.

20–25. The distinctive colors mentioned in the preceding paragraph for indicating the type of projectile and kind of filler are as follows:

Armor-piercing projectile—black.
Common projectile—slate.

Antiaircraft, antiaircraft-common, field and bombardment projectiles—dark green.
Shrapnel—white.
Illuminating—light blue with white star.
Target projectile (i. e. blind loaded or blind loaded and traced)—unpainted, or red.
(Projectiles originally painted to indicate a type other than target may be painted red when issued for target purposes.)
Explosive "D"—yellow.
TNT—dark green.
Black powder—Slate.
Gas—red (with geometrical figure). (The geometrical figure will be of a size which can be inscribed in a circle one-half the diameter of the projectile and with such shape and color as will indicate the kind of gas-producing material used. The meaning of the geometrical figures and colors will be known only to the manufacturer, the Bureau, the inspector, and the ammunition depots).
Blind loaded and plugged, or traced—unpainted or red.

(The notes on use of red to indicate target projectiles apply equally to the use of red to indicate blind loading.)

Army types of ammunition are painted in accordance with the drawings approved by the Chief of Ordnance, War Department. Description of the painting and marking of ammunition purchased from the War Department is contained in Army Technical Regulations describing the ammunition. For ammunition to be made up from components purchased from the Army, prints of the Army drawings will be supplied. The general system followed by the Army is as follows:

Yellow—for all high explosive projectiles and fragmentation grenades.
Red—for projectiles having a service bursting charge of black powder.

(For Army ammunition classed as "low explosive.")

Blue—for practice ammunition containing a small charge of explosive or an inert filler.
Black—for solid shot.
Gray—for chemical ammunition. Identification as to type and persistency indicated by stenciling in green or yellow at present; formerly, in red or yellow.

The above system is used in the marking of both the ammunition and the containers.

20-26. The burster charge of projectiles loaded with mixed filler, TNT and black powder, or explosive "D" and black powder, is indicated by painting the original slate color (common projectiles) for one-half caliber distance from the point toward the bourrelet followed by a band of dark green (or yellow) one-half caliber in width.

20–27. The painting and marking of 1".1/75-caliber antiaircraft projectiles do not conform to the foregoing but they are marked as indicated below: Painting and marking of 1".1/75 projectile.

(*a*) Projectiles are marked with a painted dot (one-quarter inch to one-half inch diameter) on the forward portion of the body of loaded projectiles to denote burster charge (yellow dot for Explosive "D").

(*b*) Projectiles are marked with a painted dot (one-quarter inch to one-half inch diameter) on the body of the projectile just forward of the rotating band to denote tracer loading (red dot for red flame tracer).

(*c*) Projectiles are stamped by the manufacturer on the base with 0.1-inch letters as follows: "1".10 AA Mk.—Mod.—Lot—" and last two figures of year of specification and manufacturer's initials.

(*d*) Projectiles are stamped by the manufacturer on the band with 0.08-inch letters as follows: "1".10 AA Mark—Mod.—" and inspector's initials and stamp, lot number and the last two figures of year of specifications.

(*e*) The exterior of projectiles are not painted, and are not marked or stamped other than in the manner described above. On blind loaded projectiles the dot denoting explosive (yellow) is omitted. When tracers are not loaded the (red) dot denoting tracer color is omitted. Projectile cavities are coated with approved standard projectile cavity paint as required for other calibers.

20–28. Projectiles fitted with night tracers or tracer fuzes have a white band 1 inch wide painted around the ogival of the projectile which is below the color indicating the burster charge. If the color indicating the burster charge would extend to the bourrelet, the white tracer band is painted on the ogival next to the bourrelet. For shrapnel fitted with tracers the tracer band is painted black. The color of tracer is indicated by a number of appropriately colored dots on the tracer band.

20–29. Nose fuses are never painted, but the tip of 21-second combination (time-percussion) fuzes are painted red to distinguish them from time fuzes. (The foregoing provision is a reversal of the marking formerly used.) Red noses on 45-second time fuzes have no significance, and such painting may be disregarded. Removal of red paint on 45-second time fuzes or on waterproof protecting caps covering such fuzes is found not to be necessary.

20–30. For nose-fuzed projectiles the band indicating the burster charge begins immediately below the fuze and extends to the bourrelet if that distance be not more than one caliber.

20–31. The spotting color of spotting projectiles is indicated as follows: Spotting projectiles.

(1) By a band 1 inch wide the same color as the spotting color painted around the projectile beginning 1 inch in rear of the burster color.

(2) On spotting projectiles fitted with tracers the spotting color band is located adjacent to and in the rear of the tracer color band.

(3) No color (white) spotting projectiles are not marked to indicate spotting.

(4) In addition to the spotting color bands, spotting projectiles are marked by stamping on the inlet covers a letter to indicate the spotting color as follows:

R—red.
B—blue.
G—green.
O—orange.

20–32. When projectiles are loaded the depot stamps on the base and stencils around the body parallel to the band the following data:

Mark(s) and lot number(s) of fuze(s) and tracer(s).
Weight of bursting charge, mark and color tracer.
Symbol of depot.
Month and year of loading.

The stenciling is in white for all projectiles except shrapnel, where it is in black. The total weight of the projectile complete and ready for firing is stamped on the base of projectiles, 3-inch and larger, after the abbreviation "compl." which is stamped on the base by the manufacturer. Stamping data relative to fuzes and tracers are omitted when readable on the fuzes or tracers.

For some types of Army projectiles (75 millimeter and 155 millimeter guns) the weight of the projectile is indicated by the number of crosses or squares painted thereon. The number of crosses or squares indicates the weight limits, and the range tables for the weapons give the correction to be applied for the indicated weights. When projectiles are repainted, care is taken not to obliterate these markings.

1.1-inch cartridge cases.

20–33. 1".1 cartridge cases, in addition to the case identification stamping by the manufacturer, have stenciled on the base in two places, in black ink, the index number of the powder contained.

Marking of cartridge tanks.

20–34. Cartridge tanks having bodies of galvanized steel or aluminum are not painted except when necessary to remove old stenciling in which case aluminum paint is used on both types of tank. When containing fixed ammunition, the bottom of the cartridge tank is painted a color to indicate the character of the projectile, while the cover is painted a color to indicate the kind of bursting charge, the colors used being those listed in paragraph 20–25. When containing catapult charges or semifixed cartridges, the bottoms and covers of cartridge tanks are not painted.

Cartridge tanks for fixed ammunition are marked on the body with the following data:

Caliber of gun (and mark if required).
Number of rounds (*if more than one*).
Character of projectile and weight.

Mark(s) and lot number(s) of fuze(s), mark, lot, and color of tracer.
Kind of bursting charge.
Index number of powder.
Weight of charge.
Initial velocity.
Mark, lot number, manufacturer, and date of primer.
Symbol of depot at which assembled.
Month and year of assembly.
Code number ----------.

The cover of a cartridge tank containing fixed ammunition is marked with the following:

Caliber of gun.
Number of rounds (*if more than one*).
Index of powder.

Cartridge tanks containing semifixed cartridges are marked on the body with the following:

Caliber of gun.
Index of powder.
Weight of charge.
Initial velocity.
Mark, lot number, manufacturer, and date of primer.
Symbol of depot at which assembled.
Month and year of assembly.
Code number ----------.

The cover of tanks containing semifixed cartridges are marked with the following:

Caliber of gun.
Index of powder.

Cartridge tanks fitted with tracers have a white band painted on both the cover and the bottom. Cartridge tanks have ammunition tags wired to the covers, giving the full details of the assembly contained, including lot numbers of all components.

Cartridge tanks containing catapult charges have the following data:

Mark of catapult.
Mark of catapult gun.
Weight of plane for which charge is to be used.
Mark of primer, lot number, and date of manufacture.
Weight of ignition.
Weight of charge.
Index of powder.
Code number ----------.

In the assembly of catapult charges the identification tag is secured to the distance pieces so that the charge can be identified should the stenciling on the exterior of the cartridge case or tank become obliterated. The tag is attached to the distance piece assembly so that it must be removed with the assembly before loading in the gun.

1.1-inch ammunition boxes.

20–35. (*a*) 1".1/75-caliber ammunition boxes are made of galvanized steel drawn and welded construction with handles on two ends, and with detachable covers secured by four quick-acting hinged hasps. A rubber gasket bearing on a knife edge is fitted between box and cover to insure airtightness. These boxes and covers are not painted, except when necessary to remove old stenciling in which case aluminum paint is used. A tube assembly (see 20–35 (*e*) below) made of aluminum tubes spot welded to each other and held together by a welded aluminum band around the assembly is provided in the box to support the projectiles and cases against damage. A cork pad is provided between the base of the cases and the inside of the cover to protect primers and restrain the cartridges from jolting.

(*b*) One side of the box has the following markings stenciled in black:

(No. of cartridges) 1".1/75-caliber cartridges.
Service or target (as applicable).
Projectile mark: L&F or BL&T or BL&P (as applicable).
Fuze: Mark ---------- or dummy fuze plug (as applicable).
Burster charge—Explosive "D" or inert loaded (as applicable).
Tracer—red or not loaded (as applicable). Starter and Tracer.
Primer—Mark ------ date ------.
Powder index ----------.
Weight of charge ---------- grams.
I. V. ---------- f. s.
Depot ----------.
Date ----------.
Code No. ----------.

(*c*) On each end (with handles) of the box, the following stenciling in black letters:

Caliber of gun; number of rounds.
Index of powder.
Suggested abbreviated markings as follows:

36 Service ctgs. 1".1/75 cal.
Proj. Mk. I–2 L&F Exp. "D," red tracer.
Fuze Mk. 12–2.
SPDN 2579 wt. chg. 112 gms. I. V. 2700 f. s.
Primer Mk. 19.
St. J. 6/39.
Code No. 1".1/75 D2579—050111.

(*d*) Each ammunition box has wired to it a tag giving the information required by subparagraph 20–35 (*b*) and 20–35 (*c*) above.

(*e*) The tube assemblies of 1.1-inch/75-caliber boxes are designed to prevent the fuze from touching the bottom of the box if the projectile becomes loosened from the case. 1,300 tube assemblies were accepted which may permit the fuze to touch the bottom of the box under adverse conditions. These tube assemblies are used for inert loaded projectiles only. The contractor delivered these 1,300 tube assemblies with a red band approximately 2 inches wide painted around the outside of the tube assembly approximately 2 inches below the securing band. The boxes containing these tube assemblies were delivered with a red band approximately 2 inches wide painted approximately 4 inches below the cover and with the following markings painted in red on the boxes: "Use for inert loaded projectiles only." This red band must not be painted out as long as the boxes contain the above-mentioned tube nests. In case any of the 1,300 tube nests are transferred to other boxes, the red band is also painted on such boxes.

20–36. Boxes made of wood containing fixed ammunition are painted to indicate the character of the projectile, using the colors listed in paragraph 20–25. **Fixed case ammunition boxes.**

The top and edges of the covers of such boxes are painted to indicate the kind of bursting charge as follows:

Black powder	Slate color.
Explosive "D"	Yellow.
TNT	Green.
TNT–BP	One half width green, other half slate color.
Blind loaded	Red.

Boxes made of wood containing fixed ammunition are marked with black letters as follows:

On one side adjacent to the removable cover or hinged top:

The data prescribed in paragraph 20–34 for the body of the cartridge tank.

On each end:

Caliber of gun; number of rounds.
Index of powder.

20–37. Boxes of made wood containing ammunition fitted with night tracers or tracer fuzes have a white band 2 inches wide encircling the middle of the box parallel to the ends. White boxes containing shrapnel have a black tracer band.

20–38. To each ammunition box there is wired a tag giving in full the data which are required to be stenciled on the side adjacent to the cover. **Saluting ammunition box.**

20–39. Ammunition boxes containing saluting, blank, or signal-gun charges are painted lead color, except the top, which is painted half white and half red, and is marked with black letters as follows:

Top of box:

Caliber and "saluting" (or "blank" or "signal gun").
Character and weight of charge.
Name of depot where prepared.
Date.
Code No. __________.

Front of box:

Caliber and "saluting" (or "blank" or "signal gun").

20–40. Each saluting ammunition box has wired to it a tag giving the information shown on the top of the box. When saluting ammunition is prepared on board ship, new tags are placed on the ammunition boxes giving the initials of the gunner or other officer who supervised the work.

20–41. Tanks containing replacement samples are painted as follows:

(*a*) A red band is painted around the body of the tank, 6 inches wide, and has stenciled on it in white:

Replacement sample.
Index: SPD __________.
Caliber.
Weight of charge.
Weight of sample.

(*b*) The tops and bottoms of these tanks are not painted, but the top is stenciled:

"Replacement sample: SPD __________."

20–42. Tanks containing catapult charge wads or torpedo impulse charge wads are issued unpainted but have stenciled on the body of the tank adequate data to identify the contents.

Drill ammunition.

20–43. Tanks containing dummy charges and cartridges are painted half black and half white. When dummy cartridges are issued in wooden boxes, the boxes are painted with the lower half black and the upper half white. Containers for dummy ammunition are marked:

Dummy charge (or cartridge).
Caliber of gun.
Code number __________.

Aircraft bombs.

20–44. Aircraft bombs are painted and marked as follows:

Exterior surfaces—(*a*) Priming coat of aluminum for bomb bodies, tail vanes, and miscellaneous components such as suspension bands.

(*b*) Finishing coat for bomb bodies, tail vanes, and suspension or trunnion bands, as follows (all colors to be in accordance with Ordnance Pamphlet 368, part I, plate 1):

(1) (A) *Fully high explosive loaded.*—Yellow, stenciling in green. (If any other high-explosive filler than TNT is adopted, distinguishing markings will be adopted.)

(B) *Partially high explosive loaded.*—Approximately one-half of bomb body (the end containing explosive) is painted yellow, the remainder (containing inert material) is painted black. Stenciling is in green on the yellow portion of the bomb. Tail is same as for fully loaded bomb.

(2) *Inert loaded (except water-filled bombs).*—Black in accordance with Ordnance Pamphlet 368, part I, plate 1, stenciling in white.

(3) *Water-fillable.*—Black, stenciling in white.

(4) *Miniature practice.*—Unpainted.

(5) *Gas or smoke loaded.*—Gray, stenciling and other markings in accordance with special instructions.

(*c*) Finishing coat for painted bomb crates and tail vane crates as follows. All colors to be in accordance with Ordnance Pamphlet 368, part I, plate 1. (Note: On galvanized crates paint one of the metal bands of the crate on all four sides, and paint a 2-inch stripe across each end of the crate, using the appropriate color as specified for painted crates.)

(1) *Fully or partially loaded high explosive loaded bombs.*—Green, stenciling in yellow.

(2) *Inert loaded bombs.*—Black, stenciling in white.

(3) *Smoke or gas-loaded bombs.*—Gray, stenciling and other markings in accordance with special instructions.

Both the priming and the finishing coats, as well as the cavity paints, are applied by the manufacturer on procurement. Bombs, crates, etc., painted not in accordance with the painting instructions prescribed herein, will be so painted by the depot prior to issue.

Service bombs painted to indicate high explosive, gas, etc., which are ordered issued *empty* for drill or "mock-up" purposes are repainted to indicate inert loaded and clearly stenciled to indicate their condition, as required by subparagraph (b) (2) above:

Marking.—(*a*) The following information is stenciled on each bomb body after it is painted and prior to issue, in letters approximately 1 inch high for all 500-pound bombs and larger; and in letters not less than one-half inch high for all bombs smaller than the 500-pound size:

---------- lb. Bomb; Mark ------ Mod. ------
TNT Grade ------. NMD/Y (or NAD/H, etc.).
Auxiliary Booster (if in place).
Month/Year. B. L. O. No. -----------.
Bomb No. ------------ (Same as stamped number on nose).
Code No. -----------------.

(Note: When bomb is partially loaded include, after the grade symbol, the weight of explosive contained. Example:

500-lb. Bomb, Mark 9
TNT Grade A—20 lbs. NMD/Y (or NAD/H, etc.).

(*b*) Bomb tail vanes when shipped separately have the following information stenciled on them:

For ____________ lb. bomb, Mark ____________ Mod. ____________.
Dwg. No. ________________ (of tail vane).
Code No. ________________.

(*c*) Bomb crates are stenciled as follows:

One (two, three, etc.) ____________ lb. Bomb(s).
Mark ____________ Mod. ____________.
TNT Grade ____________. NMD/Y (or NAD/H, etc.).

(*d*) Bomb tail crates are stenciled as follows:

One (two, three, etc.) tail vane(s) for
____________ lb. Bomb, Mark ____________ Mod. ____________.
Crate Dwg. No. ____________.

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