TRAINING COURSES

FOR

ORDNANCE RESERVE OFFICERS

PICATINNY ARSENAL

LOADING PLANT COURSE

No. 1

RESERVE OFFICERS'

LOADING PLANT COURSE

PICATINNY ARSENAL

- 1940 -

RESERVE OFFICERS'

LOADING PLANT COURSE

INDEX

Subject

1. Responsibilities and Duties of the Inspector at a Loading Plant. Bain

2. Chemical and Physical Properties of High Explosives. Bain

3. Ammunition Tests. Bain

4. Ammunition Specifications. Vanderbilt

5. Physical Testing of High Explosives - Proving Ground Methods. Goldsworthy

old School List

6. Physical Testing of High Explosives - Laboratory Methods. Hopper

7. Safety Requirements in Ammunition Manufacture. Davis

8. Preparation of TNT and Amatol for Loading. Bain

9. Loading by Casting and Extrusion. Bain

10. Equipment and facilities required for handling shell and explosives in loading plants. Bain

11. Loading of separate loading and semi-fixed propelling charges. Bain

School Ldg

12. Loading and Assembling of Time Fuzes. Taylor

13. Loading and Assembling of Detonating Fuzes. (Restricted). Taylor

14. Packing, Storage and Shipment of Ammunition. Clothier ?

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 1. Responsibilities and Duties of the Inspector at the Loading Plant.

The term Inspector used herein refers to a representative of the Ordnance Department assigned to the duty of inspecting the material and the loading of this material as prescribed in the contract.

If data or information given in this discussion should conflict with the information listed in the General Inspection Manual, the General Inspection Manual shall prevail. All inspectors should read the General Inspection Manual and become thoroughly familiar with all its requirements. A number of the basic requirements of this manual will be emphasized herein:

a. All communications between the contractor and the contracting officer shall be through the inspector, and shall be forwarded in triplicate. All important communications between the contractor and the inspector shall be in writing and shall be forwarded in duplicate.

b. If the contractor so desires and notifies the contracting officer through the inspector, the details of the contractor's operations will be held as confidential.

c. Provided any conflicts exist between the requirements of the contract, the drawings, the detail specifications, and the general specifications, the requirements shall prevail in the following order:

(1) The requirements of the contract.
(2) The drawings.
(3) The detail specifications.
(4) The general specifications.

d. The inspector is responsible for the general routine of the Inspection Office and will supervise the work of sub-inspectors. He is the only person authorized to confer with the contractor on questions relative to the material or process involved.

e. The inspector must not interfere with manufacturing operations and should bear in mind that his duties do not include responsibility for production, or for manufacture of material.

To inspect successfully, the Inspector must have the latest information pertaining to all materials used and be versed on the latest test requirements of the materials, which in all cases are described in the applicable specifications. In order to facilitate inspection, he should be or make himself so familiar with these various materials as to be able to recognize them at sight. He should know and understand their characteristics, properties, use and purpose, in order to be able to prevent possible misapplications. He should determine when and where allowance can be made for slight defects in materials, which will not affect the finished product. Raw and finished materials must be inspected in general for conformity in quality, dimensions and appearance.

In order to be able to perform the foregoing duties thoroughly, the Inspector will secure or establish inspection limits in accordance with prescribed drawings, specifications, and general inspection manual, or in line with his knowledge of the work. He must, of necessity, be thoroughly familiar with the interpretation of his manufacturing information in order that he may be able to tell whether or not manufacturing processes are being properly followed. He should know the proper sequences in which operations must follow one another for best results and be familiar with working conditions, manufacturing methods and requirements. It is his duty to see that the right materials and proper information are used and that workmanship is up to standard in quality. He should not, however, insist upon work that is unnecessary.

Under normal conditions of operations at the loading plant all of the metal parts and explosives will be supplied under separate contract, and only components which have passed the specifications for that particular item will be received. Therefore, the duties of the inspector in the loading plant will consist chiefly in making certain that all explosive material has been loaded in the manner prescribed, and that the component after loading functions satisfactorily.

There are detail specifications covering each item of loaded ammunition, and these specifications specify the exact tests that are to be conducted. In addition, the contractor will carry out shop tests in order to make sure that each component is satisfactory before assembly is made. It is advisable for the inspector to make such contacts as necessary in order that the information gained from the shop tests will be a matter of record. For instance, concussion and percussion primers are usually submitted to a shop test before assembly. If such shop tests show a high percentage of failures and the contractor uses such primers in the finished ammunition, then it is quite likely that failures would be obtained in the completed components. Inspection of this type is of considerable value as the final inspection covers only a limited number and thus the results of shop tests will give valuable data on the general condition of the completed lot.

In many cases an inspection of the method of loading is required in addition to carrying out the actual tests. Particular emphasis should be placed on the procedure employed in the loading of shell by the casting method. In the detail specifications covering shell loaded by the casting method, it is required that split shell shall be loaded from time to time, and that these shell should be loaded according to the same procedure that is employed with the other shell. In such cases, it is the inspector's duty to make certain that no special attention is given to the loading of these split shell. If this should be done, then the examination of the cast charge in the split shell would give no indication as to whether the charges in the other shell have the same characteristics. In this particular case, the contractor knows ahead of time which shell is to be examined and may give special attention to that shell. One other point which is called to the attention of the inspector in the specification, but which may be over looked, is the requirement that the shell shall be free from moisture at the time of loading. Particular attention should be paid to shell which have been brought into the loading room from a cold atmosphere. Condensation is quite likely to take place on the inside of the shell. These shell should not be loaded until such condensation has been removed.

Provided the inspector is thoroughly familiar with all specifications and insures that the contractor has complied with all requirements, there is little likelihood of imperfect ammunition being produced. It is, therefore, the inspector's duty to make certain that all tests have been conducted in the manner prescribed. This can be done by rigid observation of the drawings and specifications covering all items.

The Inspector should help maintain morale in the organization with which he is connected. He should be fair and impartial to all. Make just decisions and give unbiased opinions on questions submitted to him. He should make workmen feel that he thoroughly understands the quality of the work required and insist that this quality be met. Show appreciation for suggestions made. Recommend to foremen, employees who do good work as well as calling their attention to those whose work is of a poor quality.

He should use tact:

a. When making decisions where opinions govern the case in hand.

b. In using only constructive criticism.

c. In avoiding arguments with the workmen. He should confine himself to concise statements in explaining why work cannot be accepted and point out defects in a friendly manner.

He should:

Promote good will by working in harmony and cooperating with all supervisors with whom he has dealings.

The Inspector should never make an issue about points that are of little importance. He should extend encouragement and help to new men by showing appreciation of good work.

He should be trustworthy, consistent in his approvals and rejections, and should control his temper. He should display a proper dignity, yet be friendly and pleasant.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 2. Chemical and Physical Properties of High Explosives.

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

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

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

where it becomes worthless.

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

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

Trinitrotoluene (TNT).- Trinitrotoluene known as TNT and Triton is a crystalline powder varying in color from a light yellow to a buff. There are two grades of this material now specified for use in ammunition; viz., Grade I and Grade II. The Grade I has a melting point of not less than 80.2°C., and

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

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

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

EXPLOSIVE D. (Ammonium Picrate).- Explosive D has a crystalline structure and varies in color from a lemon to an orange color. It is the least sensitive of all military explosives and is used exclusively as a bursting charge for armor piercing shell. Explosive D has a drop test of approximately 24" with a 2 Kilogram weight. It does not melt on heating but explodes when heated to a temperature of approximately 300°C.

It is more soluble in water and more hygroscopic than any other of the standard explosives used, except amatol. It is loaded by means of a hydraulic press or by ramming to a density of 1.45 min.

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

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

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

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

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

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

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

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

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 3. Ammunition Tests.

After a lot of ammunition has been completed, it is submitted to the inspector for acceptance tests. The tests which are to be conducted are fully outlined in the specification pertaining thereto, and in the Proof Officer's Manual. The specifications and manual will be available to all personnel who are charged with the responsibility of conducting these tests.

In order to become more familiar with the method of testing and to present a picture of the various tests which are required, there are listed in this discussion certain particular tests which represent various types of ammunition. The material contained herein has been taken from specifications and from the Proof Officer's Manual.

1. Primers.- Percussion Primers, such as the 100 grain, M1, 100 grain, M1B1, M21, M22 and M23 receive sensitivity tests for functioning and non-functioning, also a Proving Ground test. For these tests, fifty-five primers are selected at random from each lot, ten are subjected to non-functioning test, ten for functioning test, and thirty-five for Proving Ground test. In the non-functioning test, the primers are inserted in a fixture and tested by dropping a one-pound weight, 3 inches on the firing pin. To pass this test, all primers must fail. In the functioning test, the primers are tested in the same manner except the height of drop is 12 inches. In this test, all primers are required to fire. In the Proving Ground test of the thirty-five remaining primers, the primers may be tested in conjunction with the tests of other components but may be fired in empty cartridge cases. The lot is rejected subject to retest if:

a. Any primer fails to function.
b. More than one body splits or otherwise seriously deformed.
c. Any portion of any primer becomes detached.
d. Any hangfire or blowout occurs.

A retest may be conducted if in the original test:

a. Not more than two primers fail to function.
b. Not more than three bodies split or otherwise are seriously deformed.
c. Portions become detached from not more than two primers.

If in the retest, using double the number of primers, the primers meet the requirements of the original test, they will be accepted.

Complete details of these requirements are given in Specification 50-48-10.

2. Adapter and Boosters:- In addition to determining whether the explosive in the adapter and booster meets the density requirements shown on the drawing, the adapter and boosters are subjected to a fragmentation test. In this test an improvised fuze is attached to the adapter and booster and the assembly placed in a light wooden box, or in a strong pasteboard carton in such a manner that there will be a minimum air space of two inches around the adapter and booster. The box or carton is then imbedded in sand contained in a tub or some other suitable vessel. After firing, the sand is sifted and the fragments collected for examination. Complete detonation is assumed to have occurred if no undetonated explosive is found, and if no recovered fragments of the booster casing weighs more than ten percent of the weight of the total casing. Not more than two incomplete detonations will permit a retest. In the retest, complete detonation must be obtained for acceptance.

3. Loaded Shell:- Shell loaded by the casting method with TNT, 50/50 Amatol, and Trimonite are subjected to a Proving Ground test as follows:

Safety.- Forty percent (to the nearest shell) of the number of sample shell from each lot shall be equipped with dummy fuzes (and dummy boosters when required) and fired for land impact. The powder charge used shall be such as to give 12-percent excess chamber pressure over the rated maximum pressure for the gun. Observation shall be made for premature burst and behaviour upon impact.

Functioning.-After the completion of the safety test, the remainder of the sample shell shall be equipped with service fuzes (and service boosters when required) and fired with full service charge. Observation shall be made for premature burst and satisfactory functioning.

Retest.- A retest, using double the number of samples used in the original test, may be made, for shell of calibers 75 to 155 mm inclusive only, if requested by the contractor, provided no premature burst occurs and if not more than two shell fail to function satisfactorily. No retest will be allowed for shell of calibers 8 to 16 inches, inclusive.

(Note.- In case failures occur in only one phase of the test, retest shall be limited to that phase).

4. Fuzes, 21 Second A.A.- 21 Second A.A. Fuzes, as submitted for acceptance test, will be tested as follows:

Non-arming test of concussion primer assembly.- The test shall be conducted as follows:

Remove the concussion primer assembly from each of 20 sample fuzes. Place each concussion primer assembly removed in a fixture, Fig. 1. Gradually apply to the head of the plunger screw, an axial load equal to the non-arming load required by the drawing. A punch slightly less in diameter than the head of the plunger screw shall be used. The test shall be conducted so that the speed at which the load is applied shall not exceed 1/8 inch per minute. Note the number of assemblies that pass through the concussion resistance ring.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided not more than two assemblies arm in the above test.

Arming test of concussion primer assembly.- The test shall be conducted as follows:

After subjecting the sample concussion primer assemblies to the non-arming axial load prescribed on the drawing, subject each to a gradually applied axial load equal to the arming load required by the drawing. The test shall be conducted so that the speed at which the load is applied shall not exceed 1/8 inch per minute, and a record of the number which fail to pass through the ring.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided not more than two assemblies fail to arm, that is, fail to pass completely through concussion resistance ring.

Sensitivity test of concussion primer assembly.- Twenty sample concussion primer assemblies (less concussion resistance rings) that have been subjected to the arming test, shall be subjected to test as follws: or tested in a testing fixture satisfactory to the inspector. Insert each concussion primer assembly, with concussion plunger screw up, in an adapter with firing pin in place, and place into adapter plug in the bottom of Primer Sensitivity Testing Fixture. Drawing 81-3-44. Insert firing plunger in Type B Body, Drawing 81-3-46, and place body in Type B Firing Pin Holder, Drawing 81-3-46. Insert firing pin holder with body and firing plunger into weight-cup support cover so that the firing pin holder firmly contacts the upper face of the adapter, as shown by assembly. Adjust the height of drop of a steel ball weighing 4 ounces, plus or minus 0.08 ounce to 6 inches. Release the ball.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided not more than two primers fail to fire with loud and uniform reports.

Jolt and jumble tests of fuzes.- The tests shall be conducted as follows:

Jolt.- Assemble ten of the sample fuzes to an adapter and then assemble to Jolt Testing Machine, Drawing 81-3-30. Give each fuze 1750 jolts in each of the three positions.

Jumble.- After completing the jolt test, subject each of the fuzes used in the jolt test, to a jumble test. Place one at a time in Jumble Machine, Drawing 81-3-35, and give the machine 7200 complete revolutions at the speed specified on Drawing 81-3-35. Examine the fuzes upon completion of this test.

Retest.- A retest, using double the number of sample fuzes used in the original test, may be made, if requested by the contractor, provided none of the explosive elements explode; not more than one fuze comes apart, is partially or fully armed, or has any of the inner parts, including explosive elements, broken, deformed or displaced in such a manner as to make the fuze unsafe to handle or prevent normal functioning.

Proving ground tests.- The tests shall be conducted as follows:

Assemble 35 of the sample fuzes in 3-inch M42 practice loaded shell with M20 boosters and fire as indicated in Table I, using the standard service charge. Fire 2 of the fuzes at the first setting and elevation combination for functioning only. Fire 22 of the fuzes, 11 at each of the second and third setting and elevation combinations. Fire 11 of the fuzes at one of the last three setting and elevation combinations (use the last three setting and elevation combinations in rotation with subsequent lots). Consider the first round of each eleven round group at any setting a sighting shot and disregard its time in computing the mean time and dispersion of group. (Note.- When Class A fuzes are tested, the magazine charge, consisting of 95 grains of black powder, shall be removed from the proving ground samples and replaced with a magazine charge of 20 grains of black powder.)

Retest.- A retest, using 200 fuzes may be made, if requested by the contractor, provided not more than one premature burst occurs.

A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided:

Not more than one fuze fails to function from each group.
Any group of fuzes has a dispersion greater than that specified in Table I.
The mean burning time of any group does not meet the requirements of Table I.
(Note.- In case failures occur in only one phase of the test, the retest shall be limited to that phase.)

5. Fuzes, Point Detonating.- Fuzes except for the M46 are tested as follows:

Sensitivity test of detonator assembly.- The test shall be conducted as follows:

Remove the detonator assembly from each of 20 sample fuzes and subject to test. Assemble in Fixture, Testing, Detonator Sensitivity, Drawing 81-3-55, or other fixture satisfactory to the inspector, and test for functioning.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided not more than one detonator assembly fails to function satisfactorily.

Test of interrupter.- The body assembly shall be removed from each of 20 sample fuzes from which the detonator assembly has been removed. The inspector shall assure himself that each body assembly meets the arming and non-arming requirements prescribed on the drawing. These tests are conducted by spinning the fuze at the speed specified. Lots of fuzes, represented by sample fuzes not meeting this test, shall be rejected subject to correction and retest.

Test of firing pin support.- The firing pin support from each of the 20 sample fuzes from which the detonator and body assembly have been removed shall be subjected to test as follows:

Determine by any method satisfactory to the inspector, that the twenty samples of the firing pin supports meet the requirements under the minimum and maximum loads prescribed by the drawings. In this test the supports are tested for crushing and non-crushing at the loads specified. The test shall be conducted so that the speed at which the load is applied shall not exceed 1/8 inch per minute.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided not more than one sample fails to meet the requirements prescribed on the drawing. If, in the retest, any of the samples fail to meet the minimum load requirement prescribed on the drawing, the lot of fuzes which the samples represent shall be rejected. If any of the samples fail to meet the maximum load requirement prescribed on the drawing, the lot of fuzes shall be rejected, subject to correction and resubmission for test.

Sand test of lower detonator.- The test shall be conducted as follows:

Subject 10 sample fuzes to test. Use Sand Test Bomb, Drawing DP-15695. Fill the bomb body with new standard Ottawa sand that passed through a No. 20 Bureau of Standards sand sieve having openings of 0.0335 inch and a wire diameter of 0.0165 inch, but remained on a No. 30 Bureau of Standards sand sieve having openings of 0.0223 inch and a wire diameter of 0.011 inch. Secure the cover in position on the bomb body; assemble adapter (Fig. 2) to cover. Remove plug, interrupter spring and interrupter from one of the sample fuzes and reassemble the plug to the fuze. Assemble one of the sample fuzes to the adapter. Place plug on top of fuze. Place barricade in position. Fire the detonator by dropping the weight. Screen the sand by placing on a No. 30 Bureau of Standard sand sieve having openings of 0.0223 inch and a wire diameter of 0.011 inch, and shaking for 3 minutes using a mechanical shaker. Weigh all the sand that passes the sieve.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided no detonator crushes less than 155 grams of sand.

Jolt and jumble tests of fuzes.- The tests shall be conducted as follows:

Jolt.- Assemble each of 10 of the sample fuzes to an adapter (Fig. 3) and then assemble to Jolt Testing Machine, Drawing 81-3-30. Give each fuze 1350 jolts in each of the three positions.

Jumble.- After completion of the jolt test, subject each of the fuzes used in the jolt test, to a jumble test. Assemble in Jumble Fixture (Fig. 4) and place, one at a time, in Jumble Machine, Drawing 81-3-35. Give the machine 3600 complete revolutions at the speed specified on Drawing 81-3-35. Examine the fuzes upon completion of this test.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided none of the explosive elements explode and not more than one fuze comes apart, is partially or fully armed, or has any of the inner parts, including explosive elements, broken, deformed, or displaced in such a manner as to make the fuze unsafe to handle or dangerous to fire.

Proving ground tests.- The proving ground tests shall be conducted as follows:

Fire 5 of the sample fuzes in the 75 mm Gun with a maximum pressure between 40,000 pounds and 42,000 pounds per square inch, with a projectile weighing approximately 13 pounds, or in some other suitable weapon which will give the same setback per unit weight. Conduct the firings against one inch (1") wood bursting screen placed at least 400 feet from the muzzle of the weapon.

Fire 15 of the sample fuzes in the 77 mm Pack Howitzer, using first zone propelling charge for impact on firm ground at a range of approximately 3600 yards.

Retest.- A retest, using double the number of samples used in the original test, may be made, if requested by the contractor, provided no premature burst occurs (see par. H-3), not more than 2 fuzes fail to burst the projectiles with high order detonation in the original test, upon impact with the wood bursting screen before penetration of projectile through screen, and not more than 2 fuzes fail to burst the projectiles with high order detonation after land impact.

(Note:- In case failures occur in only one phase of the test, retest shall be limited to that phase.)

6. Complete Rounds.- Complete rounds such as the 3 inch AA are tested as follows:

Sampling.- All samples shall be selected by the Government Inspector as follows:

a. Twenty complete rounds from each lot.

b. When a lot comprises a group of small lots, at least one sample, so far as practicable, from each lot of the small lots represented in the group.

Proving ground test.- The tests shall be conducted as follows:

Velocity.- Fire five of the sample complete rounds in a 3-inch A.A. gun, for which the round is standard and measure the velocities. Set the fuzes for time, preferably 5 seconds, and make observations on the functioning and detonation.

Safety.- Disassemble five of the sample complete rounds and reassemble with powder charges adjusted to give pressures 12 percent in excess of the maximum permitted service pressure. Fire in a 3-inch A.A. Gun, for which the round is standard, and make observations for evidences of premature bursts in the gun or in flight. Set the fuzes for time preferably 5 seconds, and make observations on the functioning and detonation.

Functioning.- Fire 10 of the sample complete rounds in a 3-inch A.A. gun, for which the round is standard, and observe time to point of burst and the character of detonation. Set the fuzes for 10 seconds and elevate the gun to an angle of 45°.

The foregoing illustrates the kind and number of tests which are conducted on various types of ammunition and ammunition components. The procedures given are not intended to be considered authoritative; all tests should be conducted in accordance with the detail specification pertaining to the component in question.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 4. Ammunition Specifications.

General

One of the important parts of the War Department's plans for industrial preparedness is the preparation of adequate standard specifications for procurement.

In order to properly execute a contract for the Ordnance Department, a private manufacturer or a Government Arsenal should have the following:

a. The contract.
b. A complete set of assembly and detail drawings of the article to be manufactured.
c. A complete set of specifications covering the article itself, the component parts, and the necessary raw materials.
d. In the case of an intricate component, a "Description of Manufacture", which gives in detail one method by which the article can be made, may be of value. However, the "Description of Manufacture" is not mandatory.

Classes of Specifications

The following specifications are used by the Ordnance Department:

a. Federal Specifications.- Federal Specifications, which are used by the several Executive Departments for the procurement of supplies, are prepared under the direction of the Director of Procurement by the Federal Specifications Executive Committee.
b. United States Army Specifications.- United States Army Specifications are used for the procurement of all items of equipment and supply which are not covered by Federal Specifications. These specifications are prepared under the direction of the Assistant Secretary of War by the Department principally interested in the development, or having a paramount interest in the supply of the article or material.
c. Tentative Specifications.- When an Ordnance establishment has occasion to use a specification for a material or article and no specification exists for that item, a tentative or "XS" specification is prepared by the establishment concerned. Tentative or "XS" specifications are usually eventually printed as United States Army Specifications.
d. Engineering Department Specifications.- Specifications prepared by Ordnance establishments, for items of plant equipment and for materials used in maintenance work, which will not become United States Army Specifications are known as Engineering Department or "ED" Specifications.

History of War Department Specifications.

Specifications have been written in the War Department for many years, and some of the early pamphlets still available, although not officially in force, are of value historically and for reference purposes. Specifications, before the World War, were written to be all inclusive and were issued as printed pamphlets, some of considerable volume. They contained much information of a business and legal nature, now included in contracts and in "Instructions to Bidders", and material of a general specification nature, now included in such specifications as "General Specifications for Ammunition" and "General Specifications for Metals".

During the World War many specifications of the GA and EA series were produced to cover items of new issue which had not been included in the pre-war pamphlets. In the stress of War, specifications of varying degrees of excellence, from very poor and incomplete, to remarkably good and complete specifications were produced. In the latter case, much material of a description of manufacture nature was included.

Relation of Drawings and Specifications

The present method of preparing specifications for each item, based, in the case of ammunition and ammunition components, on carefully prepared drawings, has been in existence for over fifteen years. In that time a new drawing system has become standardized and several hundred specifications have been produced.

The drawings and specifications combined contain the technical requirements and give details of the required tests. The drawings and specifications should not be considered separately. Neither is complete without the other. An exception to this occurs in the case of specifications for chemicals where no drawings are required and the specifications contain the technical requirements and give in detail the required tests.

Requirements for Specifications

Basic principles for writing specifications, as given in Army Regulations 850-25 and certain policy letters and bulletins, are as follows:

a. The specification will be divided into eight sections. (Discussed more in detail later).

b. The specification will contain no information which is on the drawing and vice versa.

c. The specification will not tell the manufacturer how to make the article.

d. The specification will contain a statement of the requirements (which are not on the drawing) and will give the details of the tests to which the article will be subjected in order to determine its satisfactoriness.

e. The specification will be complete, but as brief and concise as possible.

f. The specification will not contain any contractural features, such as, time of delivery, method of payment, etc.

g. A specification will be prepared for each complete round of ammunition, each component of ammunition and each raw material entering into the ammunition.

h. A separate specification for the manufacture of the metal parts, and a separate specification for the loading and assembling of these parts into complete units will be prepared for fuzes (except time fuzes) and similar components which in an emergency would be procured by placing separate contracts for the metal parts and for the loading and assembling.

Army Regulations 850-25, Ordnance Department Bulletin No. 43, and Section IV, Outline of Form for Federal Specifications, outlines in detail a form for specifications, a brief outline of which follows:

Section A - Applicable Specifications.

In this Section a reference is made to all of the drawings (including testing fixture drawings) and specifications which the contractor needs in order to produce the article. In other words, this first section forms an index of the documents which the Contracting Officer must furnish the manufacturer with the contract.

Section B - Types, Grades, Classes, Etc.

When a specification contains more than one type, grade, class or composition, this section lists those types, grades, classes, etc., that are covered by it. If there is but one type, then the specification so states in this section. If there is more than one type, grade or class, etc., each is listed with a brief explanation as to how one differs from the other.

Section C - Material and Workmanship.

This section contains general requirements as regards material and workmanship which is not necessary to cover by tests other than visual examination. It is a section in which the writer of the specification can convey to the manufacturer information as to the quality of the product which he expects to obtain.

Section D - General Requirements.

In this section are listed all of the requirements which are common to all of the types, grades, classes, etc., listed in Section B, providing there is more than one type, grade, class, etc., and providing these requirements are not already stated on the drawings. When there is but one type, grade, class, etc., the following statement appears in this section:

"See Section E".

Section E - Detail Requirements.

Where there is but one type, grade, class, etc., mentioned in Section B, all of the requirements not on the drawings are listed in this section. When the specification covers more than one type, grade, class, etc., those requirements which apply distinctly to each are listed separately in this section. This is one of the most important sections in a specification and much thought and effort are necessary in order to insure that the detail requirements are properly and completely stated.

Section F - Methods of Sampling, Inspection, and Test.

This section is subdivided as follows:

F-1. Inspection.

The general specification which applies to general conditions of inspection is listed.

F-2. Size of Lots.

Twenty thousand is the quantity which has been selected as the maximum size for lots of complete rounds and components of fixed and semi-fixed artillery ammunition whenever possible. The size of lots for metal parts has recently been increased to 100,000, maximum.

F-3. Sampling.

The number of samples required for testing purposes are stated.

F-4. Testing.

Under this heading everything pertaining to the tests to which the article is subjected is listed. Tests are given which cover requirements on the drawing as well as those listed in Sections D and E of the specification. The tests first listed cover the requirements stated on the drawings, then the requirements given under general requirements and finally those under detail requirements in the specification. The tests prescribed must be logical and fair to both the manufacturer and the Government.

Section G - Packaging, Packing, and Marking.

Any information regarding the methods to be used in packing and marking the article is given under this section. For many Ordnance items there are packing and marking drawings which give the details. In other cases, the methods of packing and marking to be followed must be given in detail under this section in the specification. Whenever it is necessary to include a Data Card with shipment, the information which is to be placed on this card is given in this section together with instructions on where to place the card for shipment.

Section II - Notes

This section contains information of a general explanatory or informatory nature which is not properly a part of the preceding sections. Information to assist in determining whether the specification is applicable, and in selecting the type, grade, or class, etc. appropriate to the articles or material required forms a part of this section; also, information as to the intended use of the articles or material, if desirable.

Detail Procedure in Submission and Approval of Specifications

The specifications for aircraft ammunition and artillery ammunition; such as, bombs, bomb fuzes, pyrotechnics, grenades, grenade fuzes, primers, projectiles, artillery fuzes, complete rounds, etc. and specifications for raw materials, except metals, which enter into the manufacture of ammunition are assigned to Picatinny Arsenal for preparation as tentative or "PXS" specifications. When a specification is listed to be written, it is first prepared by the Technical Group of the Arsenal as a tentative specification and assigned a PXS number. After approval by interested department heads of the Arsenal, it is forwarded to the Chief of Ordnance for consideration and approval. When approved in the Office of the Chief of Ordnance, it is either sent through the Assistant Secretary of War for printing as an Army Specification or if the Department believes that sufficient information is not yet available on the item to warrant printing, the specification may be held in the PXS form and manufacturing establishments and private manufacturers permitted to use it. If the specification is printed, it becomes a regular standard United States Army Specification and the PXS specification upon which it is based is cancelled. It may happen that the item covered by the specification is of interest to other procuring branches of the Government. In this case, the specification is sent to the Federal Specifications Executive Committee. This Committee considers the possible use of the specification by other Government branches and revises it, if necessary, to include the requirements and to meet the needs of all branches concerned. When approved by this Board, the specification is printed as a Federal Specification and automatically supersedes the Army Specification covering the same item. Except for the basic raw materials, most of the specifications used by the Ordnance Department in ammunition are Army Specifications.

Some time usually elapses between the preparation of a tentative specification in the PXS form and its issue in printed Army or Federal form. In the meantime, the tentative specifications are quoted on drawings and used in current manufacture. Picatinny Arsenal tentative specifications are revised from time to time as experience dictates.

It often happens that it becomes necessary to revise a printed Army Specification covering some component of ammunition. When this occurs the Arsenal prepares the revision as believed desirable and submits it to the Chief of Ordnance in the tentative form carrying a PXS number. If the revision is approved, the specification is again printed, under the same basic number as before, with a letter affixed thereto, embodying the changes.

Study of Typical Specifications.

In order to illustrate the principles covering the preparation of ammunition specifications given herein, several typical old and new specifications are listed for reference purposes. The absence of instructions on how to manufacture the article will be evident from the new specifications.

Specifications are prepared primarily for use in a national emergency. They are, therefore, not always applicable to peacetime production. Those provisions which are necessary for wartime manufacture and which are not needed at other times may be waived by the Chief of Ordnance. No attempt is made to have two specifications, one for peacetime and one for wartime.

A determined effort has been made during the past few years to bring ammunition specifications up to the standards outlined. Several hundred specifications have been prepared which may be considered modern. There are many others to be written. The specification and revision of specifications is a never ending process made necessary by the constantly changing designs and the additional knowledge obtained by research and development work.

Rewritten by:
H. Vanderbilt,
Chief, Specification Section.
March 12, 1940

<u>List of References</u>

1.	Specification for the Manufacture, Inspection and Test of Detonating Fuzes, Mk. III.	-EA-108-4
2.	Specifications for the Manufacture, Inspection and Test of Detonating Fuzes, Mk. IV & Mk. V.	-EA-109-5
3.	Specification for Complete Rounds of 1 Pdr. Sub-caliber Ammunition for Seacoast Cannon.	-GA-123-0
4.	Specifications for Assembling and Packing Complete Rounds of Shrapnel Ammunition.	-EA-133-3
5.	Specifications for Anti-Aircraft Time Fuzes.	-EA-159-1
6.	Booster, M20, Loading, Assembling & Packing.	-50-16-5A
7.	Booster, M20 Metal Parts for.	-50-47-3A
8.	Bomb, Practice, 100 lb. M38 (Metal Parts Assembly).	-50-75-1A
9.	Bomb, Photo-flash, M12	-50-55-7
10.	Rounds, Complete, Shrapnel, for Guns, 3 inch A.A., M1917, M1925, M1, M2, M4, M1918, M1 and M3 Loading (Base Charge) Assembling, Marking and Packing.	-50-21-5
11.	Fuze, 21 second Combination, Model 1907ME1.	-PXS-642 (Rev. 1)
12.	Loading, High Explosive Shell with Trinitrotoluene (TNT) Casting Method.	-50-15-5A
13.	Fuze, Bomb, Nose, M103, Loading, Assembling, and Packing.	-50-17-12
14.	Signal, Ground, Red Star Cluster, M6A1.	-PXS-716 (Orig.)
15.	Quickmatch.	-50-14-5
16.	Ammonium Nitrate.	-50-11-59B
17.	Cloth, Cotton, Mercerized.	-PXS-694 (Rev.1)
18.	General Specification for Ammunition Except Small Arms Ammunition.	-50-0-1A
19.	Metals; General Specification for Inspection of.	-QQ-M-151A
20.	Army Regulations.	-#850-25
21.	Army Regulations.	-#340-15
22.	Ordnance Department Bulletin.	-No. 43
23.	Outline of Form for Federal Specifications.	
24.	Index of U. S. Army Specifications and Federal Specifications.	
25.	Index of PXS Specifications.	

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 5. Physical Testing of High Explosives
Proving Ground Methods.

INTRODUCTION:

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

EXPLOSIVE TRAIN FIXTURE - Ref. No. 1.

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

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

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

History.

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

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 7. Safety

The Safety program at the Arsenal is organized to conform with well directed plans of American Industries wherein great success has been attained in efforts to eliminate accidents. Industrial Safety programs have been pronounced successful from both humanitarian and money saving aspects. It is extremely gratifying to review statistics which show a great reduction in loss of human life and number of lost time accidents in recent periods as contrasted to statistics which reveal the dangerous conditions which existed in industry only a generation ago. The money cost of accidents is tremendous. The opportunity to eliminate this expense has given impetus to industrial safety movements. Insurance is furnished to cover risk of compensation payments provided inspectors of the insurance companies have access to the plants to assist in maintaining safe conditions. It is estimated that the non-insurable cost to industry of lost time accidents is four times as great as the insurable loss of compensation payments for medical service and lost time. The non-insurable loss caused by accidents consists of damage to equipment, lower efficiency of substitute workmen, time required by supervisors to instruct substitute workmen, production curtailment, etc.

The Arsenal Safety work is covered by the three "E"s of Safety which are engineering, Education and Enforcement.

ENGINEERING:

The term engineering is here used in a broad sense and applied to safety work includes the application of knowledge of the behaviour of explosives and ordnance materiel when manufactured, handled and stored so that safe conditions are established. The contact of explosives with high temperature is carefully avoided. Most explosives are found to be unsafe when exposed to temperatures much higher than the boiling point of water. Especial precautions are taken regarding exposure to open flame, electric sparks, frictional sparks, frictional heat, high pressure steam temperature, light bulbs, soldering equipment and hazardous static conditions. The engineering drawings for new operations and Arsenal operating practices are carefully scrutinized to detect and eliminate conditions which might be hazardous.

In addition to explosives material the Arsenal operations require the use of equipment with various mechanical and electrical hazards. The power house and distribution system with its steam and electric generating equipment require careful engineering control to maintain safe conditions in coal and ash handling, prevention of rupture of high pressure steam equipment and protection of personnel from contact with electrical circuits.

Mechanical hazards exist in the machine shop where metal parts are made, using commercial machine tools. Engineering control of safety in the machine shop includes studies of the use of belt and machine guards, protection from exposure to electrical equipment, slippery floors, and foreign objects in eyes of operators. These machine hazards are present in other departments of the Arsenal, sometimes in conjunction with explosive hazards.

Inflammable liquids are used in the manufacture of explosive materials and various operations in loading and packing. The storage and use of inflammable liquids are carefully controlled to prevent fires and explosions that might occur from ignition of these materials alone or in conjunction with explosive material.

The transportation system consists of a railroad, cranes, shovels, tractors, automotive cars and trucks. The use, maintenance and repair of transportation equipment involves dangers which may be overcome by safety engineering studies.

EDUCATION:

The properties of explosive materials are well understood and the details regarding their proper use have been learned by operating personnel from many years of experience. Foremen and supervisors give needed information to new employees and carefully oversee all work to eliminate unsafe conditions and practices. The number of accidents which are caused by unsafe practices are far greater than the ones which are caused by unsafe conditions which can be corrected by safety engineering. Therefore, it is recognized that the Arsenal's safety program should emphasize strongly the elimination of unsafe practices. The education of the individual workers to appreciate the importance of safe practice should be undertaken by management with the cooperation of the Safety Division. It is not likely that many new conditions will be discovered that cause accidents because practically all of our accidents of a conditional nature are catalogued under some well known heading, but new ways are being developed for getting workers to function more safely and eliminate unsafe working procedures.

ENFORCEMENT:

The enforcement of safety regulations contained in Ordnance Safety Manual No. 7224 and in Arsenal Regulations is a function of management. The successful maintenance of safety consciousness in an industrial group requires the utmost skill in human engineering. Supervisors are prone to emphasize production and might be lax regarding utmost precautions regarding safety of the plant. Workmen may regard the following of safety regulations as effeminate especially those of minor importance and prefer to appear brave and ignore precautionary advice. The enforcement of safety regulations to induce workmen to follow proper and safe practices which they know they should follow requires diplomacy of the highest type.

In addition to the three "Es" the Arsenal is restricted regarding the quantity of explosive material permitted in each area, building and room. In storage of explosives the maximum quantity is set for each magazine based upon distances from other buildings so as to limit loss of government property if an explosion should occur in one locality. The quantity-distance tables are given in the Safety Manual. The data is collected from reports of many explosions and furnishes a basis for limiting the storage of explosives so that too large a quantity will not be placed too close to other material. The personnel are limited in storage operations to a reasonable number required for doing the work. The various kinds of explosive materials are segregated in storage so that the greatest ultimate safety can be maintained.

In addition to elimination of unsafe practices and conditions in explosives manufacture, the quantity of explosive material is limited regarding each building and each room of the manufacturing buildings. Safety studies include quantity necessary for the job, contacts between rooms, proximity of service magazines, and allowances for freight cars. The properties of explosives such as sensitivity, rate of burning, stability and possibility of fire or detonation are included in safety studies. The personnel allowances for each room of manufacturing areas where explosives are handled are posted upon the wall in plain view with the explosives allowance for the room. The quantities of inflammable liquids are carefully regulated throughout the Arsenal so as to conform to necessary amounts for each location.

New and unusual operations where explosives are involved, or new modifications of existing procedures are carefully scrutinized by the Safety Division. It is the unusual operation that may allow for unsafe conditions or practices to appear.

Because the subjects of sanitation, toxicity, health and ventilation involve personnel safety, they are also covered by the activities of the Safety Division.

A complete set of records are maintained in the Safety Division concerning accidents in connection with which property is destroyed or injury is sustained by personnel. An individual report is made for each injury, minor or lost time. Unusual accidents are investigated by the Safety Division and a special report made with all details. These endeavors are valuable to help prevent recurrence of accidents. Monthly reports include "frequency rate" of disabling injuries which is given as the number of injuries per million man hours of exposure and the "severety rate" which is the number of days lost per thousand man hours of exposure. These figures are directly comparable to records of industrial plants connected with the National Safety Council.

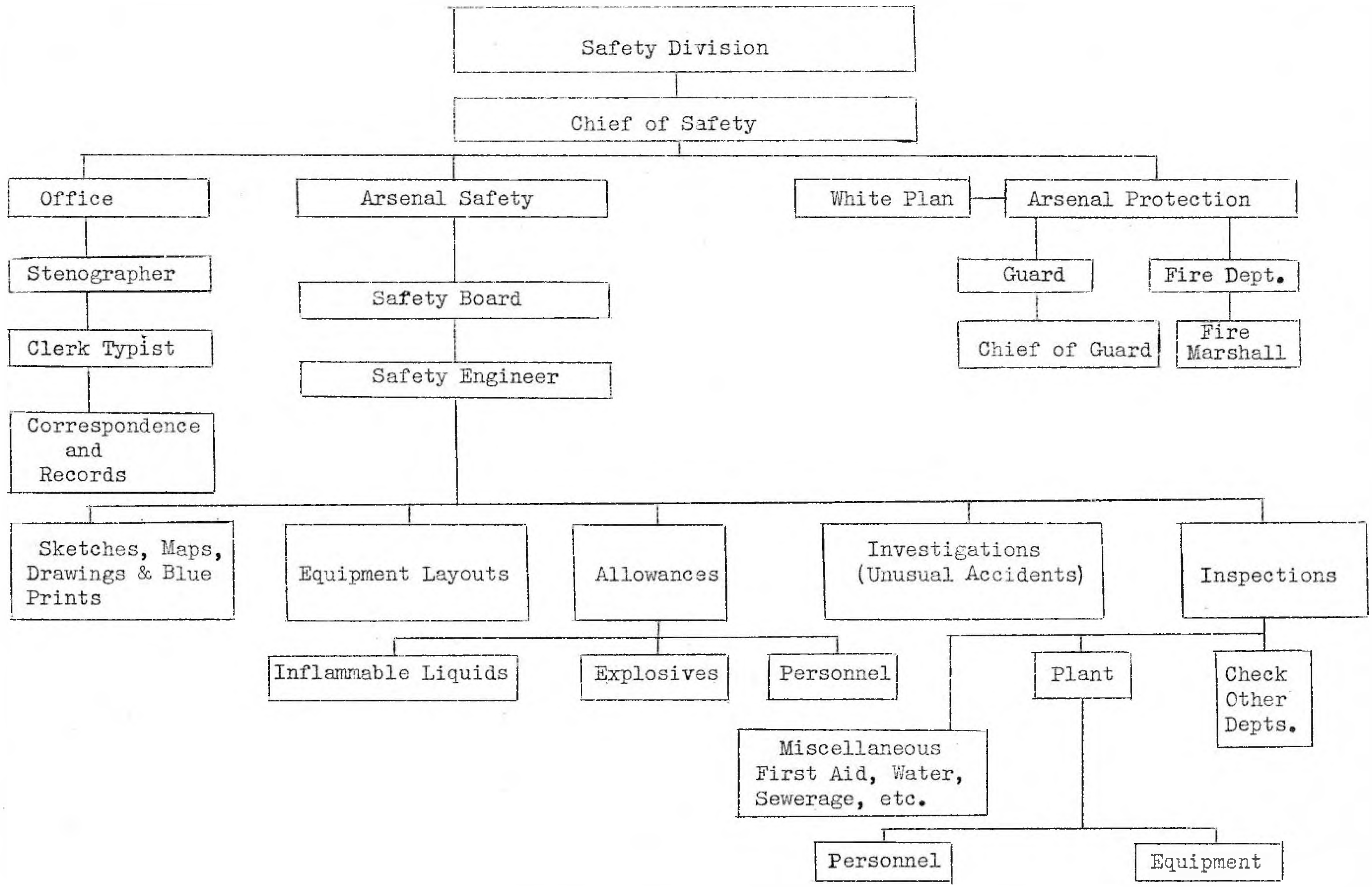
The records of the Arsenal showing lost time accidents in the various departments furnish evidence to show that safety programs are only as effective as the management of the department desires. Our records show that explosives departments on the Arsenal have better records that the non-explosives departments. This proves that under conditions admittedly more hazardous, intensive safety control produces a reduced accident rate.

The enforcement of traffic regulations and protection of personnel on the roads of the Arsenal is a function of the Guard force, a part of the Safety Division. Police duty to protect the Arsenal property is performed by the Guard force. Fire protection is a function of the Safety Division.

The type of shoe required for use in explosive buildings is selected so that the production of sparks caused by charges of static electricity may be prevented and abrasive friction between shoe and floor to cause heat will be reduced to a minimum. The shoe should have a leather sole, sewed; rubber or leather heel with no exposed metal in heel or sole. Nail holes in heel should be plugged with rubber cement to prevent carrying pebbles into buildings.

Visitors are instructed to leave buildings in an orderly manner in cases of fire or fire drill. Where danger of high explosive detonation exists personnel should be 850 feet from the hazzard.

The accompanying chart shows the organization of the Safety Division and lists the major activities involved.


Safety Division
Chief of Safety
Office
Arsenal Safety
White Plan
Arsenal Protection
Stenographer
Safety Board
Guard
Fire Dept.
Clerk Typist
Safety Engineer
Chief of Guard
Fire Marshall
Correspondence and Records
Sketches, Maps, Drawings & Blue Prints
Equipment Layouts
Allowances
Investigations (Unusual Accidents)
Inspections
Inflammable Liquids
Explosives
Personnel
Plant
Check Other Depts.
Miscellaneous First Aid, Water, Sewerage, etc.
Personnel
Equipment

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 8. Preparation of TNT and Amatol for Loading.

RECEIVING EXPLOSIVES.

TNT will be received at the Loading Plant packed in boxes of 50 or 100 lbs. capacity. On these boxes will be stamped the lot number, contract number, and the date of manufacture. A record should be made of this information, as it will be required on the data card covering the loaded component and packed with it. If the boxes are in good condition and show no evidence of having been subjected to weathering conditions, and if the date of manufacture is within one year, it will not be necessary to make analysis for moisture content.

The ammonium nitrate will be received packed in drums of approximately 50 gal. capacity. These drums may be of the Hackney type, i.e., all steel returnable drums with air tight cover held in place by detachable rims, or single shipment containers. The drums will be marked in the same manner as that described for TNT and a record should be made of this information. Both types of containers are moisture tight, and if the ammonium nitrate is of recent manufacture no further analysis for moisture is required.

MELTING TNT.

The handling of the TNT prior to melting depends upon the process used for melting. If the melting is to be carried out in a steam jacketed kettle, the TNT should be screened through a No. 12 U. S. Standard Screen prior to its being placed in the melting kettle. This precaution is necessary in order to avoid the possibility of any foreign material being caught in the agitators in the kettle. If the TNT is to be melted in continuous melting equipment where it is placed on steam coils, it will not be necessary to carry out any prior screening, but a screen should be placed between the collecting pan and the cooling or amatol mixing kettle.

Irrespective of the method of melting TNT, provision should be made so that the temperature of the material never exceeds 105°C. in order to avoid discoloration and possible decomposition. This is normally controlled by the use of low pressure steam (not over five pounds) on the melting equipment.

HEATING AND DRYING AMMONIUM NITRATE.

Under normal conditions the ammonium nitrate can be used as taken from the shipping container. This material, at the time of packing, contains not more than 0.25% moisture and will not absorb any additional moisture if no break has occurred in the shipping container. The extent of the caking in the container depends to a considerable extent on the temperature of the ammonium nitrate at the time of packing and is due probably to the fact that ammonium nitrate changes the form of its crystals on passing through certain definite temperatures, called transition points. Ammonium nitrate which has been procured within the last three years under the latest specification, has shown no excessive caking even after six months storage in sealed containers. Ammonium nitrate exists in five crystalline forms, each of which is stable in a limited range of temperatures. They are as follows:-

	Range of Temperature	Crystalline Form
1.	Below minus 16°C.	Tetragonal
2.	Minus 16°C. to plus 32.1°C.	Rhombic
3.	Plus 32.1°C. to plus 84.2°C.	Rhombic (or monoclinic)
4.	84.2°C. to 125.2°C.	Rhombohedral (or Tetragonal)
5.	Plus 125.2°C. to 169.6°C.	Regular

Above 169.6°C. it occurs only as a liquid.

Of these forms the most important are No. 2, which is stable at atmospheric temperatures and No. 3, which is produced when the preceding form is heated slightly. Form No. 4 is produced when the salt is heated to the boiling point of water, but it does not appear to produce any novel type of behavior in the salt. It is, therefore, sufficient to distinguish between ordinary or "cold" form of the salt and the "hot" form. These forms are easily converted into one another, but as in all similar cases, there may be a great deal of "lag" in the conversion of one form into another. Thus it must be assumed that because the salt had become cold it is necessarily in the ordinary or low temperature form. Conversely, it does not mean that heating above 32°C. will necessarily and immediately convert the substance into the high temperature form. The "hot" and "cold" forms differ in density, the high temperature form being about 3% higher than the low temperature form. The changes of volume which accompany changes of crystalline form, are very effective in permitting a disintegration of the crystalline material, especially if it is subjected to mechanicl agitation. This caking has not been sufficient to make it necessary to run the ammonium nitrate through a crusher; the cakes breaking up when the ammonium nitrate is being prepared for addition to the TNT.

Ammonium nitrate is extremely hydroscopic, and if exposed to the air for any extended length of time, will absorb enough moisture to impair its value as an ingredient in amatol. Thus, should the ammonium nitrate have excess moisture content on account of a break in the container, or for any other reason it will be necessary to first dry the material before it is used for mixing into amatol. The drying of ammonium nitrate in a loading plant is commonly accomplished by means of a rotary drum dryer. These dryers are similar in construction to the drums used for burning lime, the drying medium being hot air forced through the dryer. This air enters the dryer at the opposite end to that at which the ammonium nitrate is added. Under the present plan, it is not anticipated that any drying of ammonium nitrate will be required except that which takes place when the ammonium nitrate is heated prior to its being added to the TNT for 50/50 Amatol, or prior to the adding of TNT to the ammonium nitrate for 80/20 Amatol.

MIXING 50/50 AMATOL.

Normally 50/50 Amatol is mixed in a steam jacketed kettle. this kettle being identical in all respects with the kettle used for melting TNT. The mixing may be carried out by adding cold ammonium nitrate to the melted TNT. However, in order to speed up production it is considered a better practice to add heated ammonium nitrate to the molten TNT. In which case the ammonium nitrate is heated in a Robinson mixer described in a following discussion or a mixer of similar construction. The amount of ammonium nitrate heated at one time depends on the capacity of the mixer. However, the time required is approximately the same in any case. With low pressure steam on the mixing kettle it requires about one hour to bring the ammonium nitrate from 25 to 30°C. up to 90°C. During this time any lumps of ammonium nitrate which may have been present at the time the heating was started are completely broken up. After the ammonium nitrate has been heated, it is added to the molten TNT and stirred only as long as is required to make a homogeneous mixture. It is then ready for drawing off into the cooling pans or, if the temperature is between 80 and 85°C, it can be poured directly into the shell or bomb. After a plant has been in operation it would be good practice to so control the temperature of the ammonium nitrate that after it had been added to the liquid TNT the temperature would range between 80 and 85°C. This would eliminate the necessity of any cooling operations.

MIXING 80/20 AMATOL.

The operations for preparing 80/20 Amatol are practically the same as the ones described for 50/50 Amatol, except that the liquid TNT is added to the ammonium nitrate and the main object is to have the final mixture above 90°C. Higher densities are obtained with every degree of temperature increase above 90°C. After the ammonium nitrate has been heated in the mixing kettle to at least 90°C., the liquid TNT is added and the mixing continued for fifteen minutes. Tests have shown that no additional mixing is gained by running the mixer longer than this time, and that proper mixing is not obtained under fifteen minutes.

Any equipment used in the handling or mixing of amatol must not contain copper owing to the liklihood of a reaction between ammonium nitrate and copper which may produce the sensitive compound cupric-tetramine nitrate.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 9. LOADING BY CASTING AND EXTRUSION.

BY CASTING:

1. The three explosives used in ammunition which are loaded by the casting method are TNT, 50/50 Amatol, and Trimonite. The explosive is melted or mixed according to the procedures described in previous lectures and are then handled in approximately the same manner. The contraction in volume which coours when the material changes from a liquid to a solid depends upon the temperature of the liquid. If TNT is taken directly from the melting kettle at a temperature of 85-90°C. there will be a contraction of approximately 8 percent on cooling. This contraction, if not controlled will produce a cavity in the shell charge and the loading procedure is arranged to eliminate this cavitation from the finished charge. Cavitation which occurs near the base of the shell is of especial danger as the propulsive blow given the projectile upon firing the gun causes the charge to "setback" so sharply against the base of the shell that an explosion may take place. One of the theories advanced as the cause of this explosion is that the rapid compression of the entrapped air raises its temperature to the point where it will ignite the bursting charge and a low order detonation takes place. Cavitation or porosity other than that described above will permit the explosive to pull away from the booster on setback, leaving such a poor contact between it and the shell charge that a low order detonation or even no detonation at all may take place when the booster functions. The first step taken to control cavitation is to reduce the temperature of the molten material as much as possible before it is poured into the shell or bomb. If this temperature is reduced to approximately 80°C., which is the point at which crystals appear in liquid TNT, the amount of contraction will be reduced to about 5 percent. This assists in reducing the amount of cavitation and also reduces the cooling time required after the shell has been filled.

2. The cavitation which results from the 5 percent contraction is taken care of by the use of risers or by manipulation of the charge in the shell or bomb. In order to understand this procedure better, there follows a brief description of what actually takes place when a liquid explosive is poured into the container. When the molten material is poured into the shell or bomb it first solidifies on the interior surface of the container and forms a crust over the top of the liquid. As cooling takes place, the charge gradually solidifies and contracts, so that if no further attention is given there would be a cavity

under the crust in the form of an inverted cone. In order to overcome this, the crust is broken and the charge probed from time to time so that when the charge is finally solidified this inverted cone is exposed, and when the second pour takes place this space is filled with liquid material. Shell up to but not including 155 mm may be loaded in one pour. The shrinkage which occurs in these shell is taken care of by using a riser inserted in the nose of the shell; this riser being filled with the molten explosive. In this way there is sufficient material to fill the shell completely, and the cavitation takes place in the excess material left in the riser. This excess material is remelted and used in loading additional shell. With 155 mm or larger shell at least two pours are used. Each pour is allowed to become solid before the next pour is added.

3. When 50/50 Amatol is used as the main filler the final pour is straight TNT. The depth of the TNT after solidification should be sufficient to completely seal the amatol charge after the booster cavity has been formed or drilled. This sealing is for the purpose of protecting the amatol charge against moisture.

4. Shell loaded with tridite are handled in exactly the same manner as described for TNT and require no sealing. The pouring temperatures for the various explosives are as follows:

TNT	79.5 to 80°C.
50/50 Amatol	80 to 85°C.
Trimonite	90 to 105°C.

LOADING BY EXTRUSION:

5. After the 80/20 Amatol has been mixed according to the procedures described in previous lectures, it is transferred to the hopper of the extrusion machine. The hopper of this machine holds from 200 to 250 pounds. The hopper is steam heated with low pressure steam so that the amatol is not chilled during the process. From the hopper the material is fed into the shell by means of a steel screw operating inside of a steel sleeve. The shell is first placed on the carriage of the extrusion machine and allowed to run forward so that the end of the screw is within two to four inches from the base of the shell. At this point, a trip action on the extruder starts the screw revolving which action feeds the amatol into the shell. As the shell becomes filled, the carriage is forced backward until the shell has been entirely filled with amatol. At this point a second trip action disengages the screw and the shell is removed from the carriage. A counter weight of 200 to 300 pounds placed on the carriage maintains a steady pressure against the extruding amatol and thus consolidates the charge within the shell.

SOME NOTES TO OPERATORS OF EXTRUDING MACHINE

DUTIES OF A FOREMAN - Never forget for a second that you are dealing with high explosives and that other lives may hang on your actions. Become thoroughly conversant with the mechanical operation of machines. Use SIGHT, HEARING, TOUCH, AND SMELL.

SIGHT - Never start machine until you have seen that every oil cup is filled and is running clear. See that belt is tight; that the carriage is running free; that the trip gear, clutch, and all springs are correctly set and in order. See that the agitator in the hopper has all blades tight; that the worm is bedded home in correct position; that tube is firmly in place.

HEARING - Train your hearing to distinguish the ordinary running noises of machine from the extraordinary. When you hear a strange noise, not only stop machine but find out what caused the noise.

SMELL - Sniff as little of the amatol fumes as possible, but distinguish between these fumes and burning oil.

TOUCH - Get your hands acquainted with the working temperature of machine and be able to distinguish when heating is taking place.

SOME DON'TS

Don't rely implicity on steam-reducing valves. Have the temperature of steam taken periodically.

Don't allow dirt or waste amatol in or around the machine. A clean machine always works best.

Don't allow the hopper to empty while work is in progress.

A FEW SNAGS

LOW DENSITY - One can generally tell the state of the mix by the way amatol drops from worm. It should be slightly compressed in appearance and should drop in small sections, corresponding to pitch and profile of worm. Sandy amatol or too cold amatol disintegrates as it leaves the nose of the worm.

SHORT WEIGHT - SOME CAUSES

Physical condition of ammonium nitrate.

Too small a proportion of T.N.T.

Worm not deep enough into the shell.

Worm deep enough in the shell, but shell running back on its carriage before engaging weight (caused by set forward when carelessly operated).

Back weight not sufficient.

Trip gear cutting off too soon leaving too deep a cavity.

NO FEEL TO WORM

Suppose the machine, having stood for some time, it started up and no feed comes, although the hopper is well filled. A bridge of hard amatol has probably formed over the worm. Stop the machine and break this bridge; run the hard amatol through the tube before putting shell on again.

TUBE SUDDENLY COMES OFF

If tube is not properly fixed, constant working of worm and material inside will bring it gradually forward until protrusion of the worm is insufficient.

WORM SQUEALING

If there is not proper protrusion of the worm the amatol is unable to free itself from the mouth of a tube, immediately increasing the density inside the tube until it is impossible for the worm to revolve.

NOISES IN HOPPER

may be occasioned -

(a) After running sometime by hard lumps of ammonium nitrate forming with the rolling action. GET THEM OUT. Get them out by cleaning out the whole hopper.

(b) Agitator arms loose. Stop instantly and clean.

(c) Foreign material in amatol. Stop instantly and clean out the hopper.

WORM HEATING

Worm heating at the back of the hopper may be occasioned by bearing too tight or by the worm not getting home into its bayonet, leaving a little bit of the solid bearing visible in the hopper. This, with a single-threaded worm, runs eccentric and gradually hardens a ring of amatol around it, causing excessive heating.

WORM LIP

Amatol should not be allowed to harden on the lip of the worm. Remember the hard piece of amatol is carrying all the weight and friction.

CAVITATION OF CAST CHARGES:

6. The cavitation which results from contraction can be avoided by following the procedure described above. However, some check should be made to determine whether the manufacturer

is taking all of the precautions required. This check is made by loading at specified intervals shell or bombs which have been sectioned longitudinally. These shell should be loaded in exactly the same manner as the regular lot. After the charge has solidified the two sections are removed and the charge sawed longitudinally with a hand saw. Visual examination of the sawed charge will show whether any excessive cavitation has taken place, and pieces taken from questionable areas and submitted for density tests show whether the charge complies with the specification for minimum density.

BOOSTER SURROUNDS:

7. In all amatol loaded shell a TNT surround must be provided as stated previously in order to prevent the entrance of moisture. The cavity into which the TNT is poured in order to produce this surround may be either formed or drilled. It is ordinarily produced in 50/50 Amatol loaded shell by inserting a former while the charge is still mushy. After the amatol has solidified completely the former is removed. With 80/20 Amatol loaded shell the former is pressed into the charge immediately after the shell has been removed from the carriage. The cavity thus formed is filled with liquid TNT and allowed to solidify, after which the booster cavity is drilled. No control is exercised over the temperature of the TNT used for the surround as the quantity is so small that no ill effects result from using TNT at temperatures above 80°C. The booster cavity may be obtained by forming instead of drilling. In this case the booster cavity former is inserted into the molten TNT while it is still in a mushy condition.

DRILLING AND GAGING BOOSTER CAVITIES:

8. When the booster cavity is formed by drilling, the shell or bomb is placed in a fixture mounted either horizontal or vertical and drilled to the dimensions shown on the drawing. The drills used for this work are straight blades made of steel, and are mounted in a fixture which when the drill reaches the maximum depth contacts the nose of the shell. Any shoulders required on the booster cavity are drilled at the same time by cutters set at the depth required. After assembly of the booster not more than .05 inch should exist between the bottom of the booster and the shell charge.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 10. EQUIPMENT & FACILITIES REQUIRED FOR HANDLING SHELL & EXPLOSIVES IN LOADING PLANTS.

1. The equipment and facilities required in a loading plant may vary from what would be considered primitive to that of an ideal layout. The quantity of the ammunition produced in an emergency could be the same in either case, but if the quantity were the same, then more man power would be required in the primitive plant.

2. In reality very little equipment is required to accomplish the loading. A shell loading plant could produce loaded shell with; a steam coil for melting TNT, a galvanized pail for cooling, a set of scales for weighing and a few hand tools for boring the booster cavity, painting, etc. To operate under these conditions would require more man hours, but there would be produced shell and bombs in the minimum time from M-day, i.e. a substantial production of shell could be attained before a more complete layout would be ready for production.

3. To the simple equipment outlined above, additions and requirements may be added to produce a loading plant modern in all details.

4. The present day loading plant as outlined for future construction and operation, has equipment which makes the plant approach that of an ideal plant. It is this type of plant for which the facilities will be described in the order in which they are used.

TNT SCREEN:

5. This screen may be of the vibrator type (Rotex No. 7) or what is commonly used in TNT manufacture, a revolving screen with inside brush. This is for the purpose of removing any foreign material which may have contaminated the TNT during the unboxing operation. The vibrator type is shown on photostat attached.

MELTING UNIT:

6. This may be either a continuous unit or a batch unit. If the first, it will be made of a series of steam coils so arranged in a horizontal plane, to permit the liquid TNT to pass between the coils and at the same time obstruct the passage of solid TNT. If of the batch type, the melting unit will be a steam jacketed kettle equipped with an agitator. A representative kettle of this type is the 150 gallon double-motion kettle manufactured by the Sowers Manufacturing Company. This kettle is shown on Drawing B.P. 21678.

COOLING PANS:

7. After melting, the charge is run into cooling pans. These pans are of approximatley 300 pounds capacity, have inside baffles attached to the inside of the pan and are provided with mechanical agitators.

AMMONIUM NITRATE DRYER:

8. Although it is anticipated that ammonium nitrate will be received at the loading plant packed in moisture proof containers, there is a possibility that circumstances may alter these plans and it will be necessary to ship the material in wooden boxes or barrels; in which case the moisture content will be increased and drying before loading will be required. The moisture can be removed by passing the material through a rotary dryer such as is shown on the attached sketch.

9. If the ammonium nitrate has caked in the container, it is ground in a standard commercial hammer mill grinder. In such a mill the cake is broken and driven through a screen by means of revolving hammers.

AMMONIUM NITRATE HEATER AND MIXER:

10. This equipment is used for heating ammonium nitrate for 50/50 Amatol and for mixing TNT with ammonium nitrate for 80/20 Amatol. A common type is the Unique Mixer made by the Robinson Manufacturing Company. It is steam jacketed and is provided with a double ribbon agitator, as illustrated on photostat attached.

50/50 AMATOL MIXER:

11. This equipment is the same as the batch molten for TNT except that provision must be made that all bearings or parts are made of metal containing no copper.

TRANSFER OF MOLTEN EXPLOSIVE:

12. Liquid TNT or 50/50 Amatol is transferred from the cooling pans to the shell or bomb by ordinary galvanized buckets.

POURING FUNNELS:

13. Pouring funnels are made of galvanized iron so shaped that one end fits inside the nose of the shell.

EXTRUDING MACHINE:

14. This machine was developed during the World War and is still used for the loading of 80/20 Amatol. A typical machine is shown on DP-26765. It will be noted that it consists essentially

in a jacketed hopper into which the mixed amatol is transferred as required. In the hopper the amatol is continuously mixed until it enters the revolving screw which feeds the amatol into the shell. The shell is held in the horizontal position on a carriage; various sizes of shell being accomodated by the use of 'V' blocks located on the carriage. The carriage is counter weighted so that the pressure exerted on the amatol extruding into the shell can be increased up to 500 lbs. dead load. Underneath the carriage and connected to the clutch is a bar, on which are located the two stops; one to start the screw revolving and one to stop the screw.

DRILLING MACHINE:

15. The booster cavity is usually formed by drilling. Drilling machines are of two types, the vertical and horizontal. The vertical machine is used for small shell such as the 75-mm and 3-inch, and the horizontal drill for 105-mm and larger. The vertical machine is illustrated on Dwg. DP-5201.

SUCTION APPARATUS:

16. Excess explosives such as drillings are removed by means of vacuum. The vacuum is obtained by a Nash Vacuum Pump with dust collector placed in the line. These pumps operate with water seal so no danger is involved if some of the dust enters the pump.

PAINTING BOOTH:

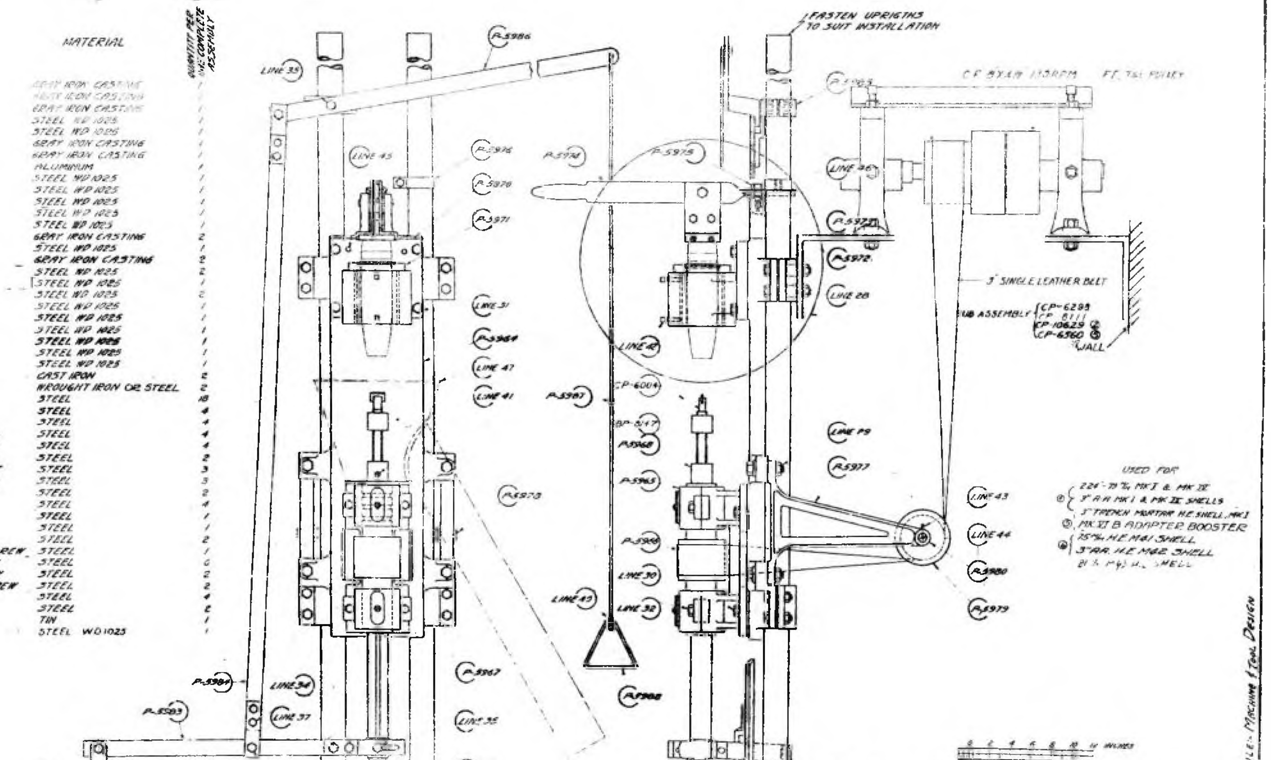
17. If spray painting is used, a painting booth must be provided. A suitable booth is one made by the DeVilbiss Company.

SHELL TRANSPORTATION:

18. Loaded shell are transported within the plant by lift trucks or by roller conveyors, both of which are standard commercial items.

LIST OF PARTS

LINE NO (1)	DRG NO (2)	SYMBOL (3)	NOMENCLATURE (4)	MATERIAL (5)	QUANTITY PER ONE COMPLETE ASSEMBLY (6)
1	P-5964		PLATE, FRAME	GRAY IRON CASTING	1
2	P-5965		BEARING, MAIN	GRAY IRON CASTING	1
3	P-5966		SPINDLE, HOLLOW	GRAY IRON CASTING	1
4	P-5967		KEY, SPINDLE	STEEL WD 1025	1
5	P-5968		SHAFT, FEED (SUPERSEDED)	STEEL WD 1025	1
6	P-5969		SWIVEL, END TRUST	GRAY IRON CASTING	1
7	P-5970		HOLDER	GRAY IRON CASTING	1
8	P-5971		COLLET, 75% SHELL	ALUMINUM	1
9	P-5972		SWIVEL, PRESSURE LEVER	STEEL WD 1025	1
10	P-5973		SHAFT, SWIVEL	STEEL WD 1025	1
11	P-5974		LEVER, PRESSURE	STEEL WD 1025	1
12	P-5975		SCREW, HEX HD SHOULDER	STEEL WD 1025	1
13	P-5976		REST, PRESSURE LEVER	STEEL WD 1025	1
14	P-5977		BRACKET	GRAY IRON CASTING	2
15	P-5978		SHAFT, IDLE PULLEYS	STEEL WD 1025	1
16	P-5979		PULLEY, IDLE	GRAY IRON CASTING	2
17	P-5980		COLLAR	STEEL WD 1025	2
18	P-5981		BRACKET, FEED LEVER	STEEL WD 1025	1
19	P-5982		LINK, BRACKET	STEEL WD 1025	2
20	P-5983		LEVER, FEED	STEEL WD 1025	1
21	P-5984		LINK, FEED LEVER	STEEL WD 1025	1
22	P-5985		HOLDER, FEED LEVER	STEEL WD 1025	1
23	P-5986		LEVER, FEED	STEEL WD 1025	1
24	P-5987		ROD, PULL	STEEL WD 1025	1
25	P-5988		PEDAL, PULL ROD	STEEL WD 1025	1
26			FLANGE, STD 2" PIPE FLOOR	CAST IRON	2
27			2" PIPE × 11'-0" LONG	WROUGHT IRON OR STEEL	2
28			.5-13 × 2.5 HEX HD BOLT + NUT	STEEL	18
29			.625-11 × 3 HEX HD BOLT + NUT	STEEL	4
30			.5-13 × 1.5 HEX HD CAP SCREW	STEEL	4
31			.5-13 × 1.75 HEX HD CAP SCREW	STEEL	4
32			.375-16 × 1.5 HEX HD CAP SCREW	STEEL	4
33			.5-13 × 1.75 HEX HD BOLT + NUT	STEEL	2
34			.375-16 × 2.0 HEX HD BOLT + NUT	STEEL	3
35			.5-13 × 1.0 HEX HD BOLT	STEEL	3
36			.5-13 × 2.0 HEX HD BOLT + NUT	STEEL	2
37			.375-16 × 1.25 HEX BOLT + NUT	STEEL	4
38			STD .625 WASHER	STEEL	1
39			.625-11 HEX NUT	STEEL	1
40			.25-20 HEX NUT	STEEL	2
41			.5-13 × .625 HEADLESS SET SCREW	STEEL	1
42			.375-16 × .75 SQ. HD SET SCREW	STEEL	6
43			.25-20 × .5 SQ. HD SET SCREW	STEEL	2
44			.312-18 × .5 HEADLESS SET SCREW	STEEL	2
45			#6 × 1.5 TAPER PIN	STEEL	4
46			.125 × 1.0 COTTER PIN	STEEL	2
47			FUNNEL	TIN	1
48	BP-847		SPINDLE, DRILL	STEEL WD 1025	1
49	CP-6004		CHART OF STAND DRILLS		
50					



FILE: MACHINE & TOOL DESIGN

T.N.T. AND AMATOL DRILLING MACHINE FOR BOOSTER CAVITY IN SHELLS.

PICATINNY ARSENAL, U.S.A.

ORDNANCE DEPARTMENT U.S.A.

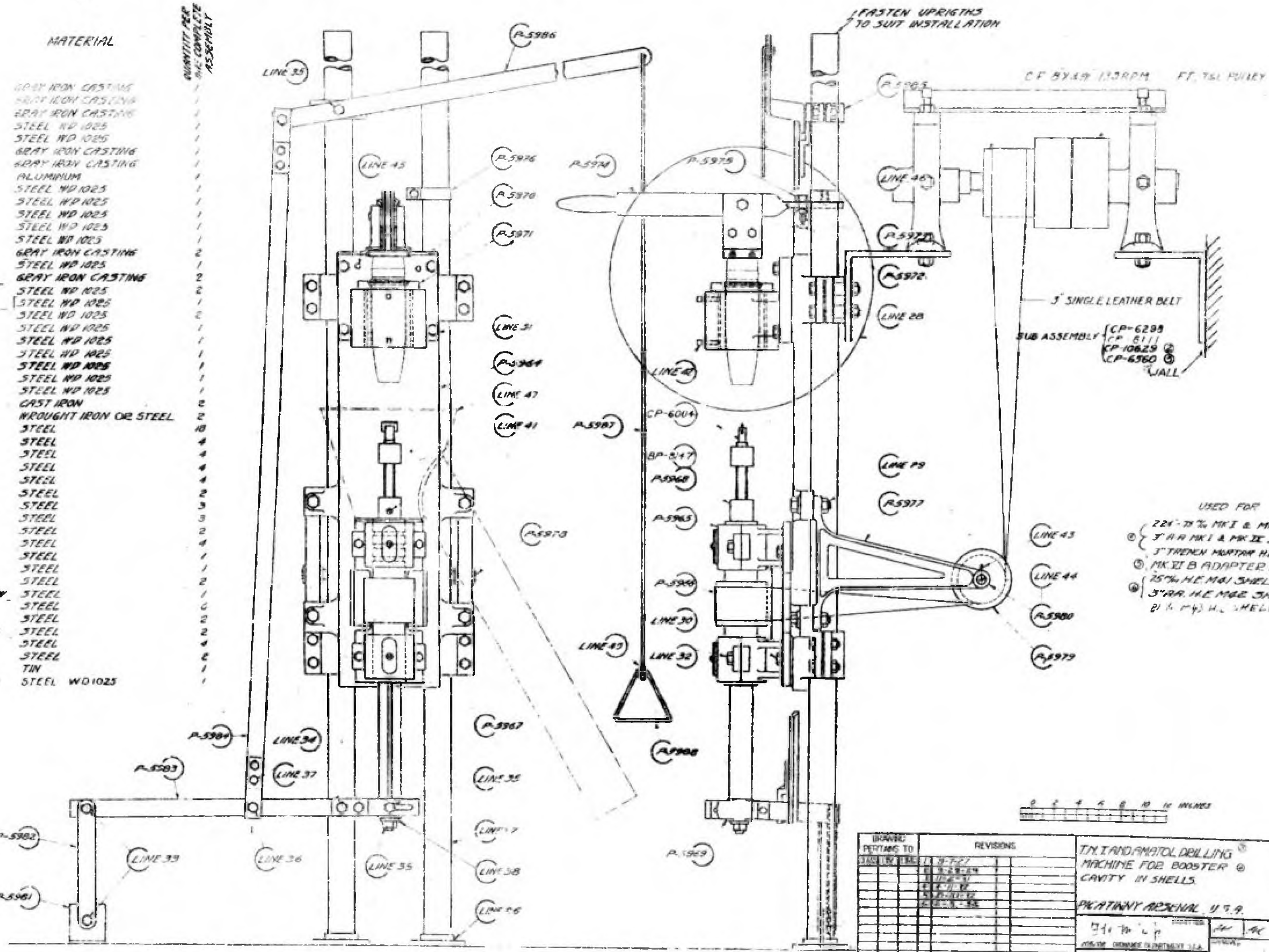
CAPT. ORDNANCE DEPARTMENT U.S.A.

ORDNANCE DEPARTMENT U.S.A.

PERTAINS TO | REVISIONS | CLASS | DIVISION | DRAWING

LIST OF PARTS

1 LINE NO	2 DRG. NO.	3 SYMBOL	4 NOMENCLATURE	5 MATERIAL	6 QUANTITY PER ONE COMPLETE ASSEMBLY
1	P-5964		PLATE, FRAME	GRAY IRON CASTING	1
2	P-5965		BEARING, MAIN	GRAY IRON CASTING	1
3	P-5966		SPINDLE, HOLLOW	GRAY IRON CASTING	1
4	P-5967		KEY, SPINDLE	STEEL WD 1025	1
5	P-5968		SHAFT, FEED (SUPERSEDED)	STEEL WD 1025	1
6	P-5969		SWIVEL, END TRUST	GRAY IRON CASTING	1
7	P-5970		HOLDER	GRAY IRON CASTING	1
8	P-5971		COLLET, 75% SHELL	ALUMINUM	1
9	P-5972		SWIVEL, PRESSURE LEVER	STEEL WD 1025	1
10	P-5973		SHAFT, SWIVEL	STEEL WD 1025	1
11	P-5974		LEVER, PRESSURE	STEEL WD 1025	1
12	P-5975		SCREW, HEX HD. SHOULDER	STEEL WD 1025	1
13	P-5976		REST, PRESSURE LEVER	STEEL WD 1025	1
14	P-5977		BRACKET	GRAY IRON CASTING	2
15	P-5978		SHAFT, IDLE PULLEYS	STEEL WD 1025	1
16	P-5979		PULLEY, IDLE	GRAY IRON CASTING	2
17	P-5980		COLLAR	STEEL WD 1025	2
18	P-5981		BRACKET, FEED LEVER	STEEL WD 1025	1
19	P-5982		LINK, BRACKET	STEEL WD 1025	2
20	P-5983		LEVER, FEED	STEEL WD 1025	1
21	P-5984		LINK, FEED LEVER	STEEL WD 1025	1
22	P-5985		HOLDER, FEED LEVER	STEEL WD 1025	1
23	P-5986		LEVER, FEED	STEEL WD 1025	1
24	P-5987		ROD, PULL	STEEL WD 1025	1
25	P-5988		PEDAL, PULL ROD	STEEL WD 1025	1
26			FLANGE, STD. 2" PIPE FLOOR	CAST IRON	2
27			2" PIPE × 11'-0" LONG	WROUGHT IRON OR STEEL	2
28			.5-13 × 2.5 HEX. HD. BOLT + NUT	STEEL	18
29			.625-11 × 3 HEX. HD. BOLT + NUT	STEEL	4
30			.5-13 × 1.5 HEX. HD. CAP SCREW	STEEL	4
31			.5-13 × 1.75 HEX. HD. CAP SCREW	STEEL	4
32			.375-16 × 1.5 HEX. HD. CAP SCREW	STEEL	4
33			.5-13 × 1.75 HEX. HD. BOLT + NUT	STEEL	2
34			.375-16 × 2.0 HEX. HD. BOLT + NUT	STEEL	3
35			.5-13 × 1.0 HEX. HD. BOLT	STEEL	3
36			.5-13 × 2.0 HEX. HD. BOLT + NUT	STEEL	2
37			.375-16 × 1.25 HEX. BOLT + NUT	STEEL	4
38			STD. .625 WASHER	STEEL	1
39			.625-11 HEX. NUT	STEEL	1
40			.25-20 HEX. NUT	STEEL	2
41			.5-13 × .625 HEADLESS SET SCREW	STEEL	1
42			.375-16 × .75 SQ. HD. SET SCREW	STEEL	6
43			.25-20 × .5 SQ. HD. SET SCREW	STEEL	2
44			.312-18 × .5 HEADLESS SET SCREW	STEEL	2
45			#6 × 1.5 TAPER PIN	STEEL	4
46			.125 × 1.0 COTTER PIN	STEEL	2
47			FUNNEL	TIN	1
48	BP-8147		SPINDLE, DRILL	STEEL WD 1025	1
49	CP-6004		CHART OF STAND DRILLS.		
50					



USED FOR

(2) 2.24"-75% MK I & MK II
3" A.A. MK I & MK II SHELLS
3" TRENCH MORTAR H.E. SHELL, MK I

(5) MK VI B ADAPTER BOOSTER

(6) 75% H.E. M41 SHELL
3" A.A. H.E. M42 SHELL
81 % M43 H.E. SHELL

DRAWING PERTAINS TO			REVISIONS	
CLASS	DIV.	DWG.	1	8-7-27
			2	9-29-29
			3	[illegible]
			4	[illegible]
			5	[illegible]
			6	[illegible]

T.N.T. AND AMATOL DRILLING MACHINE FOR BOOSTER CAVITY IN SHELLS.

PICATINNY ARSENAL U.S.A.

JAN 27, 1924

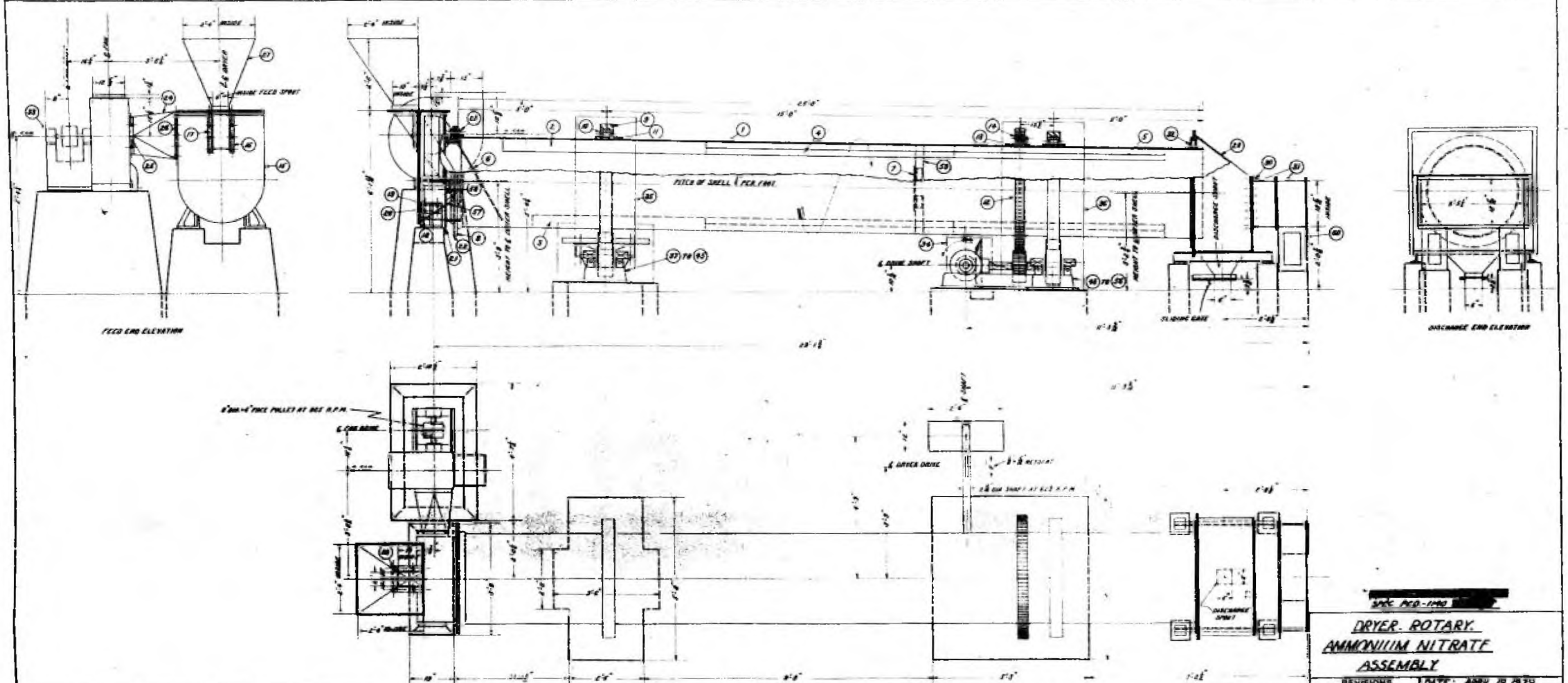
MAJOR, ORDNANCE DEPARTMENT, U.S.A.

CAPT. ORDNANCE DEPARTMENT, U.S.A.

COMMANDING ARSENAL ORDNANCE DEPARTMENT, U.S.A.

CLASS | DIVISION | DRAWING BP-5201

FILE - MACHINE & TOOL DESIGN



[redacted]
SPEC PED-1140 [redacted]

DRYER, ROTARY
AMMONIUM NITRATE
ASSEMBLY

PARTS LIST

NO.	REQ'D	DESCRIPTION	MATERIAL	DWG. NO.
1	1	SHELL	STEEL	[illegible]
2	9	[illegible] FLIGHTS-FIRST SECTION SHELL	"	[illegible]
3	4	[illegible] " " " "	"	[illegible]
4	8	FLIGHTS-SECOND SECTION SHELL	"	[illegible]
5	8	" [illegible] " "	"	[illegible]
6	6	SPIRAL FLIGHTS	"	[illegible]
7	1	BAFFLE PLATE	"	[illegible]
8	1	FRONT RING FOR SHELL	CAST IRON	[illegible]
9	2	TIRES	ROLLED STEEL	[illegible]
10	16	TIRE BLOCKS (8 PER TIRE)	CAST IRON	[illegible]
11	16	" WEDGES (8 PER TIRE)	STEEL	[illegible]
12	1	[illegible]	CAST IRON	[illegible]
13	16	[illegible]	STEEL	[illegible]
14	8	[illegible] TO [illegible]	"	[illegible]
15	1	FEED HEAD	"	[illegible]
16	1	" SPOUT	"	[illegible]
17	8	BOLTS-FEED SPOUT TO HEAD	"	[illegible]
18	1	BOLT " " SUPPORT TO HEAD	"	[illegible]
19	2	FEED HEAD SUPPORTS	CAST IRON	[illegible]
20	8	BOLTS-SUPPORTS TO [illegible]	STEEL	[illegible]
21	1	[illegible] END FEED HEAD	CAST IRON	[illegible]
22	1	[illegible] RING	" "	[illegible]
23	6	[illegible]	STEEL	[illegible]
24	1	FAN FLUE	"	[illegible]
25	8	BOLTS-FAN FLUE TO FAN	"	[illegible]
26	16	" " " " FEED HEAD	"	[illegible]
27	1	FEED HOPPER	"	[illegible]
28	8	BOLTS-FEED HOPPER TO FEED SPOUT	"	[illegible]
29	1	DISCHARGE HEAD	"	[illegible]
30	48	BOLTS-DISCHARGE HEAD TO [illegible]	"	[illegible]
31	1	HEATER COIL (IN SECTIONS)	"	[illegible]
32	1	[illegible]	"	[illegible]
33	1	EXHAUST FAN	"	
34	1	BEVEL GEAR GUARD	"	[illegible]
35	1	[illegible] GUARD	"	[illegible]
36	1	PUMP BASE GUARD	"	[illegible]
37	1	THRUST BEARING BASE	CAST IRON	DP-40430
38	1	" WHEEL STAND	" "	[illegible]
39	2	" " SHAFTS	STEEL	DP-40430
40	2	" " WASHERS	"	DP-40430
41	2	" WHEELS	CAST IRON	DP-40430
42	4	BOLTS-THRUST WHEEL STAND TO BASE	STEEL	DP-40430
43	8	BEARING WHEEL SUPPORTS-CAP AND BASE	CAST IRON	DP-40430
44	16	BOLTS-BEARING WHEEL SUPPORTS TO BASE	STEEL	DP-40430
45	4	BEARING WHEELS AND SHAFTS	"	DP-40430
46	1	[illegible] GEAR BASE	CAST IRON	DP-40472
47	4	PILLOW BLOCKS-CAP AND BASE	" "	DP-40472
48	8	BOLTS-PILLOW BLOCKS TO BASE	STEEL	DP-40472
49	1	MAIN SHAFT	"	DP-40472
50	1	[illegible] "	"	DP-40472
51	1	DRIVING PINION	CAST "	DP-40471
52	1	BEVEL "	" "	DP-40472
53	1	" GEAR	" "	[illegible]
54	1	[illegible] BEARING SOLE PLATE	" IRON	DP-40472
55	2	BOLTS-PILLOW BLOCKS TO SOLE PLATE	STEEL	[illegible]
56	4	" BEVEL GEAR GUARD TO BASE	"	[illegible]
57	1	FEED SPOUT SUPPORT	"	[illegible]
58	2	BOLTS-FEED SPOUT TO SUPPORTS	"	[illegible]
59	4	BAFFLE SUPPORTS	"	[illegible]
60	4	HEATER COIL SUPPORTS	"	[illegible]

REVISIONS

DRAWING PERTAINS TO

DATE: APRIL 19, 1939

DRAFTSMAN | TRACER | ENGINEER

CHECKER | CHIEF DRAFTSMAN

APPROVED

MAJOR, ORD. DEPT. U.S.A.

CAPT. ORD. DEPT. U.S.A.

APPROVAL - SAFETY BOARD

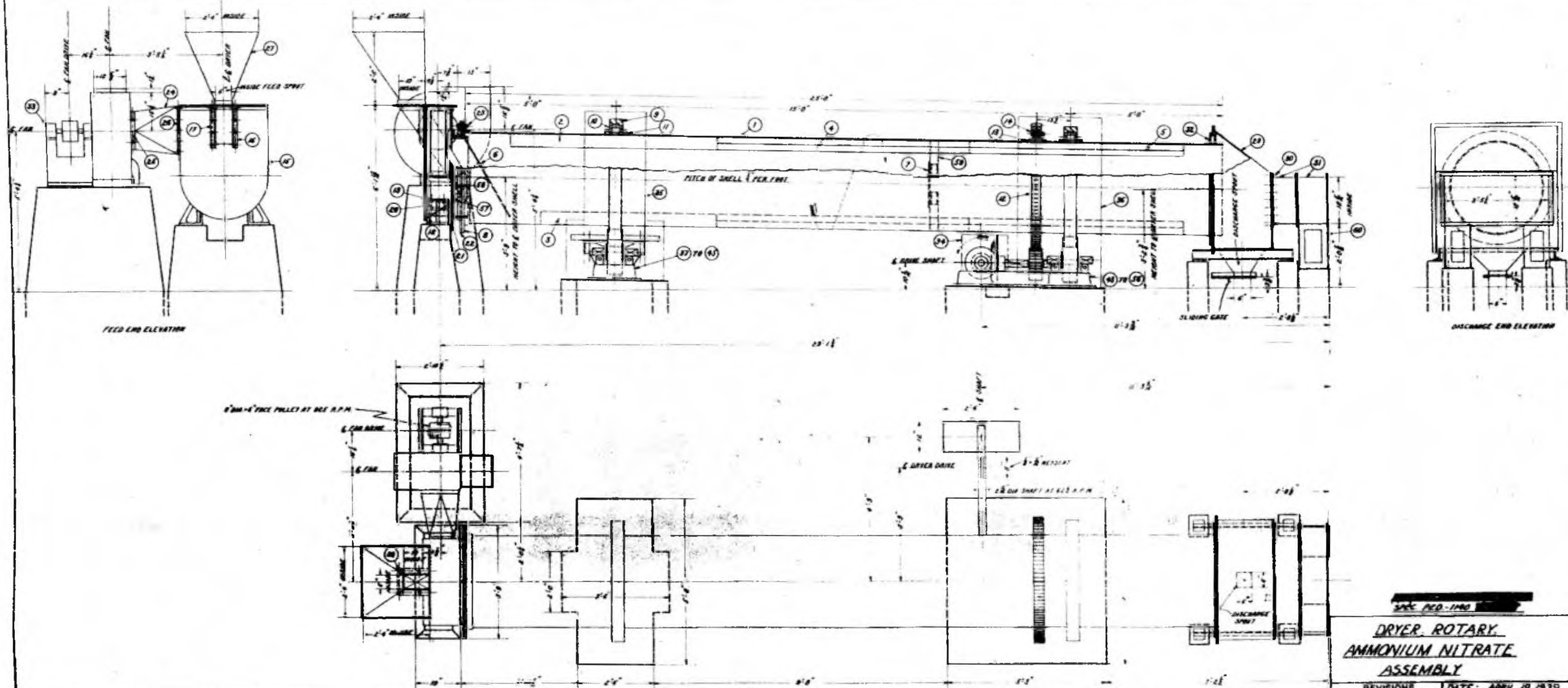
ORD. DEPT. U.S.A.

APPROVED

COL. ORD. DEPT. U.S.A.

PICATINNY ARSENAL U.S.A.

DP-40466



SPEC PED-1140 [redacted]

DRYER, ROTARY
AMMONIUM NITRATE
ASSEMBLY

PARTS LIST

NO.	REQ'D	DESCRIPTION	MATERIAL	DWG. NO.
1	1	SHELL	STEEL	[illegible]
2	8	[illegible] FIRST SECTION SHELL	"	[illegible]
3	4	[illegible] " " " "	"	[illegible]
4	8	[illegible] SECTION SHELL	"	[illegible]
5	8	" [illegible] " "	"	[illegible]
6	6	SPIRAL FLIGHTS	"	[illegible]
7	1	BAFFLE PLATE	"	[illegible]
8	1	[illegible] FOR SHELL	CAST IRON	[illegible]
9	2	TIRES	ROLLED STEEL	[illegible]
10	16	TIRE BLOCKS (IN PAIRS)	CAST IRON	[illegible]
11	16	" WEDGES (IN PAIRS)	STEEL	[illegible]
12	1	[illegible]	IRON	[illegible]
13	16	GEAR [illegible]	STEEL	[illegible]
14	8	BOLTS-GEAR TO [illegible]	"	[illegible]
15	1	FEED HEAD	"	[illegible]
16	1	" SPOUT	"	[illegible]
17	8	BOLTS-FEED SPOUT TO HEAD	"	[illegible]
18	4	BOLTS " " SUPPORT TO HEAD	"	[illegible]

NO.	REQ'D	DESCRIPTION	MATERIAL	DWG. NO.
19	2	FEED HEAD SUPPORTS	CAST IRON	[illegible]
20	8	BOLTS-SUPPORTS TO FEED HEAD	[illegible]	[illegible]
21	1	RING FOR FEED HEAD	CAST IRON	[illegible]
22	1	SEALING RING	" "	[illegible]
23	6	[illegible] BOLTS	STEEL	[illegible]
24	1	FAN FLUE	"	[illegible]
25	4	BOLTS-FAN FLUE TO FAN	"	[illegible]
26	16	" " " " FEED HEAD	"	[illegible]
27	1	FEED HOPPER	"	[illegible]
28	6	BOLTS-FEED HOPPER TO FEED SPOUT	"	[illegible]
29	1	DISCHARGE HEAD	"	[illegible]
30	16	BOLTS-DISCHARGE HEAD TO [illegible]	"	[illegible]
31	1	HEATER COIL (IN SECTIONS)	"	[illegible]
32	1	SEALING RING	"	[illegible]
33	1	EXHAUST FAN	"	
34	1	BEVEL GEAR GUARD	"	[illegible]
35	1	[illegible] BASE GUARD	"	[illegible]
36	1	DRIVE [illegible] GUARD	"	[illegible]

NO.	REQ'D	DESCRIPTION	MATERIAL	DWG. NO.
37	1	THRUST BEARING BASE	CAST IRON	[illegible]
38	1	" [illegible]	" "	[illegible]
39	2	" " SHAFTS	STEEL	[illegible]
40	2	" " WASHERS	"	[illegible]
41	2	" WHEELS	CAST IRON	[illegible]
42	8	BOLTS-THRUST WHEEL STAND TO BASE	STEEL	[illegible]
43	8	BEARING WHEEL SUPPORTS-CAP AND BASE	CAST IRON	[illegible]
44	16	BOLTS-BEARING WHEEL SUPPORTS TO BASE	STEEL	[illegible]
45	4	BEARING WHEELS AND SHAFTS	"	[illegible]
46	1	CROSS [illegible]	IRON	[illegible]
47	6	PILLOW BLOCKS-CAP AND BASE	" "	[illegible]
48	8	BOLTS-PILLOW [illegible] TO BASE	STEEL	[illegible]
49	1	MAIN SHAFT	"	[illegible]
50	1	[illegible]	"	[illegible]
51	1	DRIVING PINION	CAST "	[illegible]
52	1	BEVEL "	" "	[illegible]
53	1	" GEAR	" "	[illegible]
54	1	OUTBOARD BEARING SOLE PLATE	" IRON	[illegible]

NO.	REQ'D	DESCRIPTION	MATERIAL	DWG. NO.
55	2	BOLTS-PILLOW BLOCKS TO SOLE PLATE	STEEL	[illegible]
56	4	" [illegible] TO BASE	"	[illegible]
57	1	FEED SPOUT SUPPORT	"	[illegible]
58	2	BOLTS-FEED SPOUT TO SUPPORTS	"	[illegible]
59	4	BAFFLE SUPPORTS	"	[illegible]
60	2	HEATER COIL SUPPORTS	"	[illegible]

REVISIONS

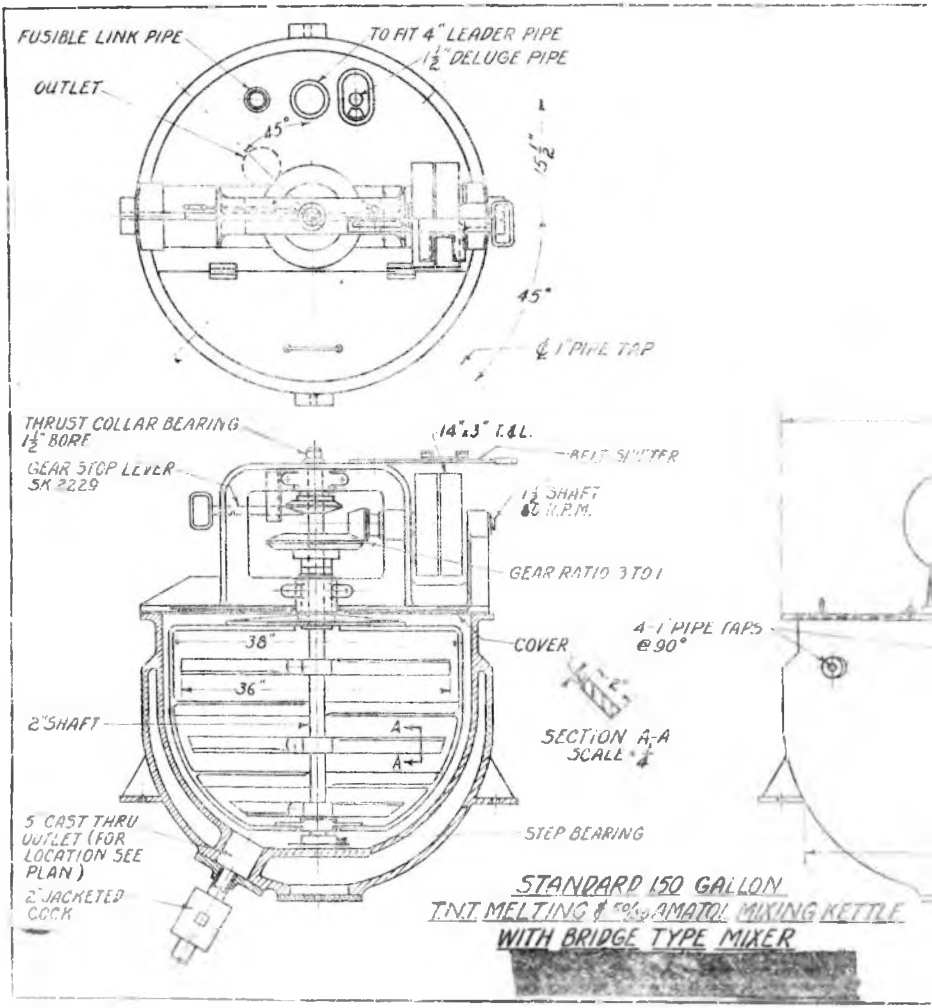
DATE: APRIL 19 1939

DRAWING PERTAINS TO
DP-40467
DP-40468
DP-40469
DP-40470
DP-40471
DP-40472
DP-40473
DP-40474

EXAMINED:
CAPT. ORD. DEPT. U.S.A.
APPROVAL: SAFETY BOARD
ORD. DEPT. U.S.A.
APPROVED:
COL. ORD. DEPT. U.S.A.

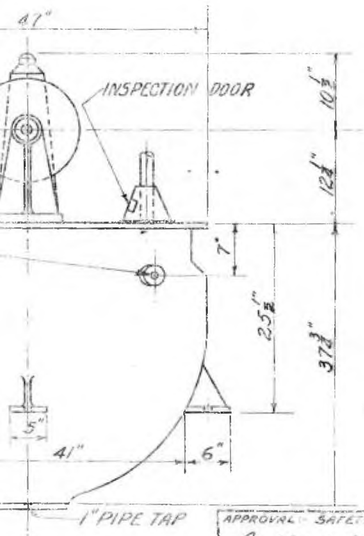
DP-40466

PICATINNY ARSENAL, U.S.A.



STANDARD 150 GALLON
T.N.T. MELTING & 50% AMATOL MIXING KETTLE
WITH BRIDGE TYPE MIXER

[redacted]



SCALE: 1" = 1'-0"

DATE	FEB. 17, 1933

REVISIONS

DRG. PERTAINS TO	
M-2535	

APPROVAL: - SAFETY BOARD
[signature]
MAJ. ORD. DEPT. U.S.A.

BP-21678

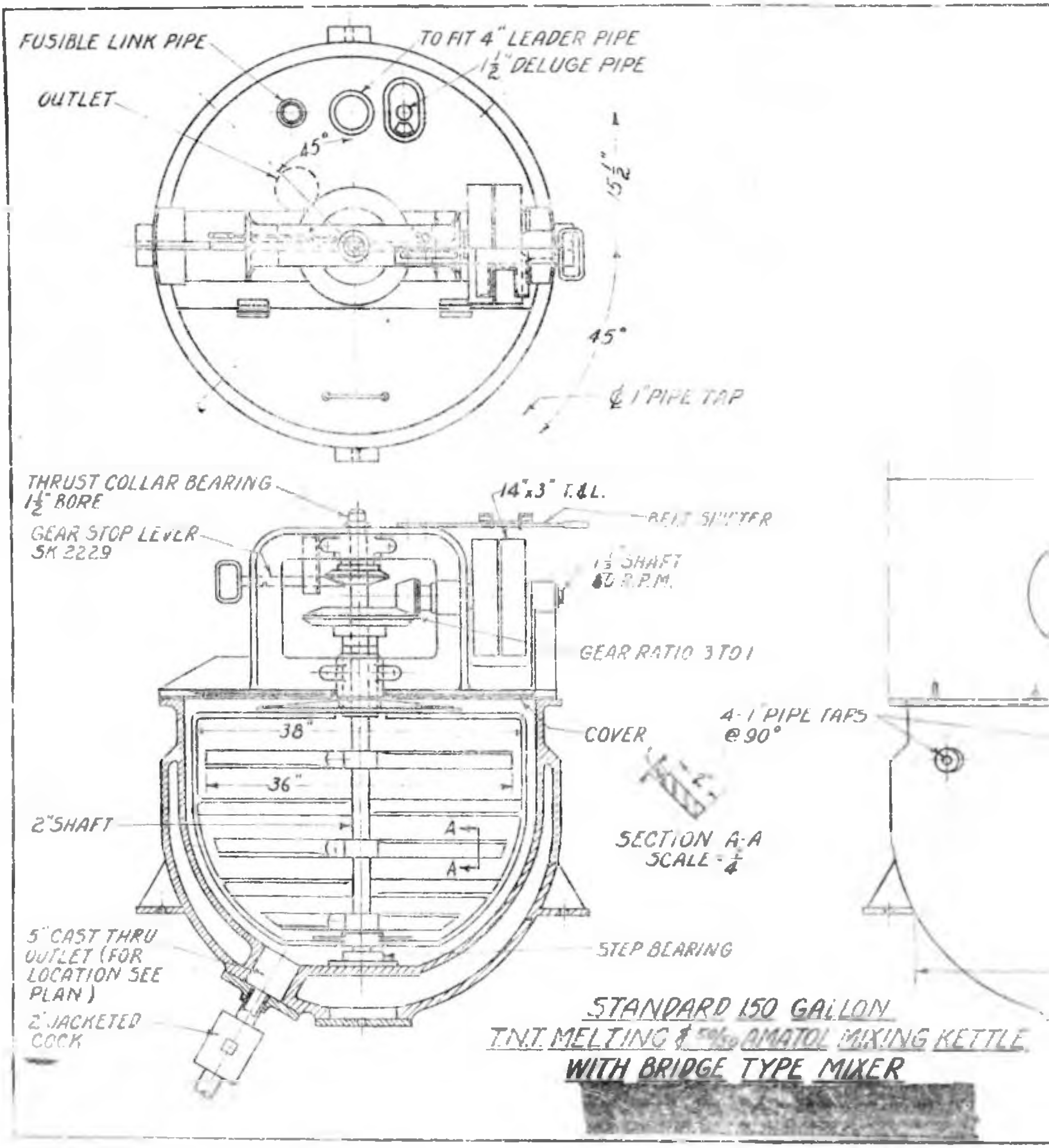
D'FTSMAN	TRACER	ENGINEER
A.G.W.	M.E.L.	A.F.S.
CHECKER	CHECKER	CHIEF D'FTSMAN
A.F.S.	A.G.W.	

SUBMITTED: - ENG. DEPT.
[signature]
LT. ORD. DEPT. U.S.A.

EXAMINED: - LOADING DEPT.

MAJ. ORD. DEPT. U.S.A.

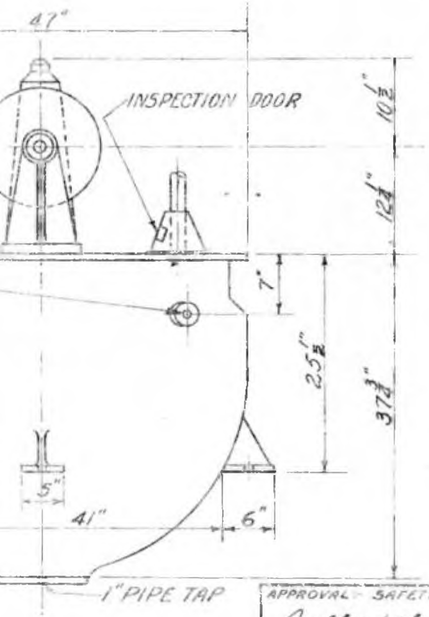
PICATINNY ARSENAL, U.S.A.



FUSIBLE LINK PIPE
TO FIT 4" LEADER PIPE
1½" DELUGE PIPE
OUTLET
45°
15½"
45°
℄ 1" PIPE TAP
THRUST COLLAR BEARING 1½" BORE
14"x3" T.&L.
GEAR STOP LEVER SK 2229
GEAR RATIO 3 TO 1
4-1" PIPE TAPS @ 90°
COVER
38"
36"
2" SHAFT
A
A
SECTION A-A SCALE-¼
2"
5" CAST THRU OUTLET (FOR LOCATION SEE PLAN)
STEP BEARING
2" JACKETED COCK
STANDARD 150 GALLON
T.N.T. MELTING & AMATOL MIXING KETTLE
WITH BRIDGE TYPE MIXER

DATE	FEB. 17, 1933
REVISIONS	

DRG. PERTAINS TO	
M-2535	



SCALE: 1"=1'-0"

APPROVAL - SAFETY BOARD

MAJ. ORD. DEPT. U.S.A.

BP-21678

D'FTSMAN	TRACER	ENGINEER
A.G.W.	M.E.L.	A.F.S.
CHECKER	CHECKER	CHIEF D'FTSMAN
A.F.S.	A.G.W.	

SUBMITTED: - ENG. DEPT.

LT. ORD. DEPT. U.S.A.

EXAMINED: - LOADING DEPT.

MAJ. ORD. DEPT. U.S.A.

PICATINNY ARSENAL, U.S.A.

ROTEX SIFTER No. 7

Code Word REBEL

SPECIFICATIONS

Number of removable sieves—One.

Size of cloth for sieve, 40″ x 84″.

Separations of material—(1) over. (2) through the sieve.

Area of sieve clothing, total—23.3 sq. ft.

Capacity, will equal or exceed that of one 32″ x 14 ft., round or hexagon reel making similar separations.

Capacities for specific materials will be given from tests run with your samples, for which work there is no charge.

Power, ⅓ H. P., empty; ¼ to 2 H. P., loaded.

Pulley, 8″ diameter, 3¼″ face, 1$\frac{11}{16}$″ bore. Speed, 400 to 450 R. P. M., depending on material. Pulley may be changed to either side and run either direction.

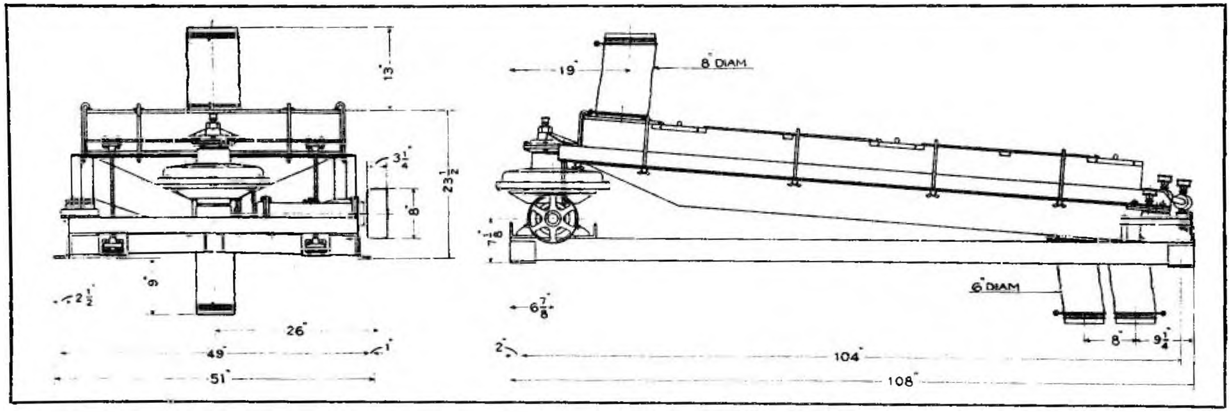
Motor Drive, self-contained, can be furnished to order.

Weight, net, 800 lbs. Domestic shipping weight, 1,100 lbs. Boxed for export, about 1,250 lbs., volume 95 cu. ft.

ROTEX SIFTER No. 57—*Code Word SABOT*

Rotex Sifter No. 57 has a sieve of the same area as **Rotex** Sifter No. 7, but the sieve frame is 28″ wide x 10 ft. long.

Rotex Sifter No. 57 is especially suited for places where the space available is limited in width. Overall dimensions: Width, 36½″. Length, 147⅜″. Height, 26″.



ROTEX SIFTER

Code Word REBEL

SPECIFICATIONS

Number of removable sieves—One.

Size of cloth for sieve, 40″ x 84″.

Separations of material—(1) over. (2) through the sieve.

Area of sieve clothing, total—23.3 sq. ft.

Capacity, will equal or exceed that of one 32″ x 14 ft., round or hexagon reel making similar separations.

Capacities for specific materials will be given from tests run with your samples, for which work there is no charge.

Power, 1/3 H. P., empty; 1/4 to 2 H. P., loaded.

Pulley, 8″ diameter, 3 1/4″ face, 1 11/16″ bore. Speed, 400 to 450 R. P. M., depending on material. Pulley may be changed to either side and run either direction.

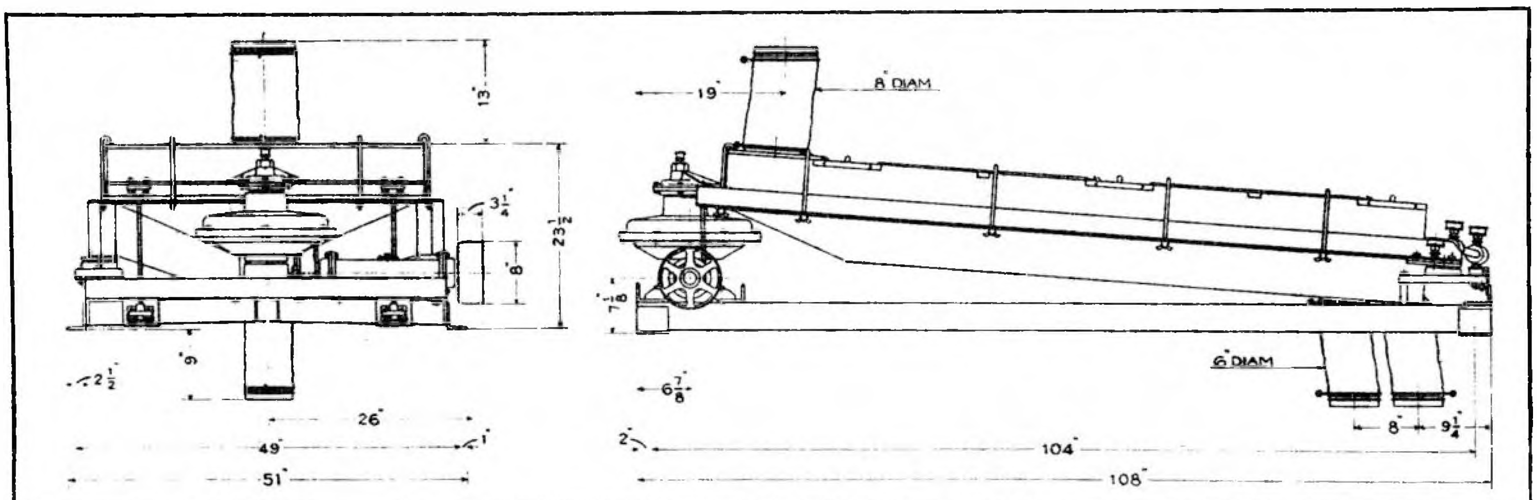
Motor Drive, self-contained, can be furnished to order.

Weight, net, 800 lbs. Domestic shipping weight, 1,100 lbs. Boxed for export, about 1,250 lbs., volume 95 cu. ft.

ROTEX SIFTER No. 57—*Code Word SABOT*

Rotex Sifter No. 57 has a sieve of the same area as **Rotex** Sifter No. 7, but the sieve frame is 28″ wide x 10 ft. long.

Rotex Sifter No. 57 is especially suited for places where the space available is limited in width. Overall dimensions: Width, 36 1/2″. Length, 147 3/8″. Height, 26″.



RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 11. LOADING OF SEPARATE LOADING AND SEMI-FIXED PROPELLING CHARGES.

INTRODUCTION:

Separate loading and semi-fixed ammunition comprise two of the three general types of ammunition now in use by the military services. A propelling charge for separate loading ammunition is an assembly of propellent powder and igniter charge in cloth bags to form zones or sections for use with weapons in which the projectile, propelling charge, and primer are not assembled as a unit before loading in the weapon. A propelling charge for semi-fixed ammunition is an assembly of propellent powder in cloth bags to form the zones for use in weapons in which a cartridge case is used but the entire round, including the projectile, propelling charge, cartridge case, and primer, is shipped as a complete round in one container; the projectile is not permanently fixed to the cartridge case, thus allowing for the removal of certain portions of the propelling charge at the point of fire for zoning purposes. Separate loading propelling charges are used for all weapons of 6-inch caliber and above. Semi-fixed propelling charges are used in the 75-mm Pack Howitzer, 105 mm Howitzer and with the reduced charge with the M48 Projectile in the 75 mm M1897 Gun.

MATERIALS USED IN THE BAG ASSEMBLY:

Since both the separate loading and semi-fixed types of charges are assembled in bags, the material used in their manufacture will be considered. It is the common practice in the case of all charges of the semi-fixed and separate loading types to encase the charge of powder in a silk bag. Several considerations have led to the selection of silk as a material from which cartridge bags and igniter pads are made. Maximum strength of cloth and minimum amount of stretch are essential. The weight and bulk of the cloth must be as low as possible in order to reduce the quantity of smoke developed upon firing.

At the present time there are five grades of cartridge cloth used in the manufacture of the bags for the various standard charges. These cloths differ in weight and strength and in addition to the cartridge bag cloth there is a corresponding number of grades of igniter cloths which differ from the former cloths in the fact that they are restricted as to weight and are made of silk only, while the cartridge cloth may be made from either silk, wool, or mohair, although silk is commonly used. The general characteristics of the several grades of cloth are tabulated as follows:

Grade	Minimum one-way tensile strength of cartridge bag cloth and cartridge igniter cloth	Maximum weight per square yard of cartridge igniter cloth
A --------	165 Pounds	14 Ounces
B --------	125 "	10 "
C --------	90 "	7 "
D --------	60 "	6 "
E --------	30 "	5 "

The heavier grades of cloth are used for the manufacture of bags for the heavier weights of charge, while the lighter cloths are used in the semi-fixed charges and smaller separate loading charges.

Because of the strategic nature of silk, cotton substitutes have been employed wherever possible. There are at the present time, three types or grades of cotton cloth standard as substitutes for the lighter grades of silk cartridge cloth. Work is in progress at present to establish a suitable substitute for the Grade B silk cloth. In order to assure the complete combustion of the cotton cloth, it must be light in weight and contain only a small amount of sizing or filler. In cases where strength is not an important consideration, notably in the semi-fixed propelling charges, an open mesh cotton cloth has been successfully employed. Light weight cotton cloths have also been employed with satisfactory results in such charges as those for the 155-mm Howitzer, 155-mm Gun, and 240-mm Howitzer.

When cotton cloths are used it is found inadvisable to tie or knot the cloth, as is done with the tie straps in the 155-mm Howitzer charge, as these knots are not completely consumed and leave burning embers after the source of ignition is removed. It has been found necessary wherever knots are to be used to employ silk instead of cotton. Igniter pads made from cotton cloth have not been found suitable.

All of the thread and twine used in the manufacture of bags and igniter pads is of silk.

<u>PROPELLING CHARGE DRAWINGS:</u>

Each propelling charge has its own drawing and includes in addition to the form and shape of the pieces entering into the make-up of the bag, the following items:

I. Assembly drawing.

  a. Dimensions of assembled charge.

  b. List of parts and specifications for all materials for the assembly of the finished product.

c. List of drawings relating to the packing, marking and crating of the charge.

d. Weights and yardage of all materials used in the manufacture of the assembled charge.

II. Detail drawings.

a. Detail maximum dimensions of parts.

b. Details of sample marking.

c. Notes on details of manufacture.

In order to understand the dimensions given on the drawings, it is necessary to go into some detail as to how the dimensions are established. The most important dimensions given on the drawings are the dimensions of the assembled charge and all of the detail dimensions are subordinate to these; that is, the detail dimensions may be varied as desired to produce a charge which when assembled will fall within the dimensional limits shown on the drawing for the completed charge. Since the weight and volume of the powder charge varies over a fairly large range with different lots of powder, it is not possible to lay down detail dimensions which can be used in all cases. The detail dimensions shown on the drawings are those which when used with a maximum volume (usually maximum weight) charge, will give a charge of maximum assembly dimensions. It does not follow that when a minimum volume charge is placed in these bags that the resultant assembled charge will fall within the designated limits shown on the drawing; therefore, it may not be acceptable to load a minimum volume charge in a bag made to maximum dimensions.

It is easily seen that it will be necessary to tailor or fit each lot of bags to a particular powder lot. This situation presents many difficulties, the principal one being that the manufacture of the bags must await the completion of the manufacture and test of the powder; however, except in instances where only a meager or no knowledge of the powder to be used exists, past experience can be relied upon to dictate the detail dimensions of a bag which will need only very minor modifications to produce a charge of suitable dimensions.

In order that uniform charges be obtained with any one lot of powder, it is required that the detail dimensions, once established for the lot, do not vary beyond a fixed working tolerance.

The dimensions of the assembled charge for the separate loading type of charges are based upon the chamber dimensions of the weapon for which the charge is intended. These dimensions prescribe a maximum permitted diameter and a maximum and minimum length. In establishing the diameter of the charge, it is necessary to require that there be a clearance between the top of the charge and the top of the powder chamber, after the charge is placed in the chamber, in order that there may be a free passage for the igniter gases from the rear (igniter end) to the front of the charge. If this clearance is not provided, high firing pressures may result from the non-uniform ignition of the smokeless powder charge. Since all powder chambers are constricted somewhat at the forward end of the chamber, it is necessary to base the diameter of the charge upon the diameter of the chamber at the base of the projectile, rather than upon the diameter of the chamber at the breech. Every effort is made to maintain the diameter of the charge one inch less than the diameter of the chamber at the base of the projectile. This clearance in diameter can not, in all cases, be obtained, as the volume of powder used in certain weapons is greater than can be loaded in charges having a clearance of one inch over the entire length of charge. The length of the charge is established from a consideration of the length of the chamber from the mushroom head at the breech to the base of the projectile at the fore end of the chamber. The maximum length of charge, including the igniter pad, is maintained at one inch less than the maximum length of chamber. The minimum length of charge is set at approximately 95% of the length of the chamber. The minimum length dimension of the charge is required in order to prevent an excessive overramming of the charge when it is placed in the powder chamber, which if obtained, might result in poor or at least non-uniform ignition of the powder charges. The assembled charges, therefore, may vary in diameter below a fixed maximum diameter and may vary in length between specified limits, depending upon the weight and volume of the powder used in loading the charges. It is desired that the finished charge be as long and as small in diameter as is compatible with the dimensions specified for the assembled charge.

METHODS OF LOADING:

There are four general methods of loading the smokeless powder charges and assembling the charges. These four methods are outlined as follows:

(1) The powder, in the first case, is loaded loosely in a bag of suitable dimensions to accommodate the charge. In this case the powder is merely poured into the bag through an opening in one of the seams, after which the seam is closed by sewing and the powder charge or increment is completed. This method is used in the loading of all semi-fixed charges and for such separate loading charges as those for the 155-mm and 240-mm Howitzer and 12-inch Mortar. All of these separate loading charges comprise several increments of powder which are tied together by means of the straps fastened to the base increment and tied at the top of the charge. The lighter weights of cloth are used in this type of loading since the weight of charge in each increment is small and the strain on the cloth is not great.

(2) The second type of loading is designated as the laced type of charge. In this case the powder charge is placed in the bag in the same manner as described above. The bag is provided with two lacing strips placed lengthwise on the body of the bag. After the bag is closed by sewing the seam shut, it is laced to reduce the diameter of the charge to the required dimensions. In the lacing of this type of bag the lacing twine is tied in the center and the lacing proceeds toward each end. After the bag has been laced throughout its entire length, the lacing twine is temporarily tied and the bag is rolled to reduce its diameter, after which the lacing is tightened. This procedure is repeated several times or until the charge is reduced to the desired diameter. The lacing operation requires skilled labor for if the lacing twine is pulled too sharply it will break and require the relacing of the charge. This type of charge was used in the past on all types of single and multi-section charges, but is now employed only for the single section charges for the 6-inch and 12-inch Guns and the charges for the 10-inch Gun. The heavier grades of cloth are used for these charges because of the weights of charge and of the strain placed upon the cloth.

(3) The third method of loading consists of placing the powder loosely in a bag and closing as in the first and second methods. On the body of this bag and each end are sewed two tie straps. To one of these straps is tied a silk cloth tape. This tape is then wrapped around the charge in the same manner as a bandage might be placed on a wounded leg or arm. In the actual assembly of this type of charge the bag is placed in a canvas cradle between two rolls and the charge is rotated as the tape is moved lengthwise and at right angles to the axis of the charges. The machine places a uniform tension on the tape which results in a charge much more uniform in diameter than a hand wrapped charge. After the wrapping is completed, the tape is cut and the end tied to the other strap previously mentioned. The knot thus formed is tucked under the wrapping. This type of loading has been used in the past for the multi-section charges for the 12 and 14-inch Guns, but its principal use now is for the 155-mm Gun charge. Light weight cloths are used for both the bag and tape. As previously stated a cotton cloth has also been standardized as a silk substitute. The principal advantage of this method of loading is the speed with which the charge can be loaded. Its disadvantage is that the tape stretches and allows the charge to increase in diameter.

(4) In recent years there has been developed a fourth method of loading represented by the stacked type of charge. This type of loading has resulted from the need to reduce the diameter of the charge. This is accomplished by stacking the powder grains one layer on top of the other over the length of the charge or section. It is used in multi-section charges for the 8-inch, 12-inch, 14-inch, and 16-inch Guns.

The actual stacking procedure is carried out by machine and hand operations in the following steps:

(1) The powder is placed in a hopper and agitated to cause the powder to fall lengthwise in tubes which extend downward to a series of horizontal and movable tables. As the powder grain rests on end on the tables, the latter are quickly moved to one side allowing the powder grain to drop in a series of grooves, still in an upright position.

(2) The grains are then moved forward in the grooves to a movable plate placed directly over a brass tube, the inside diameter of which is equivalent to the required diameter of charge, and which is provided with a movable bottom. When the plate is filled with powder grains, still in an upright position, it is quickly moved to one side and the grains fall to the movable bottom of the tube which has been moved up in the tube to a point just below the under side of the plate.

(3) The tube bottom is then dropped in the tube a distance equivalent to the length of one grain of powder. At this point the first layer of powder is in place and the plate is replaced over the tube and refilled and the second layer of powder is placed in the tube in the same manner as was the first. This process continues until the required number of layers of powder have been placed in the tube. The tube which has been tared is removed from the machine and placed on the scales and the necessary powder required to bring the charge to the desired weight added.

(4) There is then placed over the tube a silk cartridge bag open at one end and fitting the outer diameter of the tube very snugly. The entire assembly is now inverted and the tube is removed leaving the powder in the bag.

(5) The top of the bag is sewed and laced in place and the sides tightly laced to hold the powder grains in their upright position. This completes the loading operation.

The heavier grades of silk cloth are used for the manufacture of the stacked charge. It is necessary in this type of charge to tailor or fit the cartridge bag very closely to the particular charge for which it is intended, since a loose bag will not hold the powder grains in the stacked position. The finished stacked charge is uniform in diameter and will hold closely its original diameter over a long storage period. Typical assemblies of the four methods of loading are shown on Figure I, appended to this paper.

IGNITER PADS:

All separate loading charges are provided with an igniter pad of black powder (Grade A1), the quantity of which is specified on the applicable drawing. These pads are placed upon the base of base section of the charge. In the case of the smaller charges the igniter pad forms the base of the cartridge bag but in the heavier charges a separated pad is provided which is secured to the base of the bag by tying the pad to the base section through four loops equally spaced on the circumference of the base section, with four silk tie straps provided on the igniter pad. In the case of the multi-section charge any section may be considered the base section and hence each section is provided with the four loops. Where only partial charges are shipped in one container, an igniter pad is provided for each container, the extra pads being removed in the field when the charge is placed in the weapon.

In certain cases where single section charges are used, there is provided, in addition to the pad, a core of black powder running lengthwise through the charge. This core is contained in a silk cloth tube which is attached to a pad of black powder at each end of the charge. In order to insure that the charge of black powder is evenly distributed over the base of the smokeless powder charge, the pad is quilted and thus the black powder is prevented from settling to the bottom of the pad. In loading the pads with black powder two methods are used; in the case of the smaller charges the black powder is loaded by hand through a funnel, and in the larger igniters the powder is blown by air pressure in the several pockets provided by the quilting. Because of the hazardous nature of black powder and to distinguish the black powder charge from the smokeless powder charge, all exterior cloth surfaces of the igniter and core are dyed red.

GAGING AND WEIGHING THE PROPELLING CHARGES:

In assembling both separate loading and semi-fixed ammunition, considerable care must be taken to insure that the weight of smokeless powder is that specified on the Loading Authorization for the particular powder being used; otherwise, poor uniformity in the functioning of charge will most certainly result and in some instances an error in weighing on the positive side may give high pressures sufficient to seriously damage or destroy a weapon. For these reasons close tolerances have been set up in the specification (PXS-349, 12-22-37), covering separate loading propelling charges for the weights of the smokeless powder charges. In establishing these tolerances consideration has been given to the accuracy with which the powder could be weighed in production loading, and to the variations which could be permitted in the prescribed muzzle velocity. Since very large and small charges can not be weighed on the same scale or with the same accuracy on different scales the tolerances permitted vary for various weights of charge. In all cases, when the tolerances in weights were established, the maximum weighing tolerance which might be expected with a given charge of powder and suitable scales was increased by from 1.5 to 3.0 times. Thus no difficulty need be expected in meeting the requirements at normal speeds of production. To eliminate so far as possible the chance of human error in weighing, it is required that each charge be check weighed by an independent operator on a different set of scales than was used in the original weighing. To insure that the igniter charge is reasonably accurate in weight, it is required that at least 10% of the igniter charges be checkweighed. In actual practice the original weighing or measure of this charge is volumetric, but the check weighing is gravimetric.

After the loading and assembly of the charge is completed, each charge is gaged in a diameter and length gage to insure that the final dimensions fall within the limits prescribed on the drawings.

During the loading operation, it is necessary to inspect the charges closely to insure that all of the seams have been properly closed, that all loose ends of thread are removed, and that the proper marking has been placed upon the bag. After the assembly of the charge is completed, there is attached to each charge of section in the charge a linen data tag signed by the inspector and bearing the following information:

AMMUNITION DATA TAG

Name and place of manufacturer________________ Date____________
Contract No.____________________ Order No.____________________
(Full or fraction) of charge_________ for______________________
(Size and model of gun in which used)
Kind of propellent_____ Lot No._______ of year_______ Net wt._____
Weighed by______________________ Checked by____________________
Igniter: Kind of powder__________ Lot No._________ Granulation______
Weight_________________________ Distribution____________________
Gross weight (a)____________________ pounds______________ ounces
Weighed by (a)____________________ Checked by (a)________________

BALLISTIC DATA

Weight of charge, net_______________pounds_____________ounces
Weight of ingiter__________________________________Pounds
(Use only one igniter per charge when igniter is not integral part of charge)
Velocity___________________feet per second for model_______gun
Pressure______________________lb. per sq. in.
Weight of projectile__________________________________pounds
(Specify any other guns or projectiles that this charge can be used with at bottom of tag.)
REMOVE TAG BEFORE FIRING

Certified to by__________________
Inspector.

A similar type of data card is used for semi-fixed ammunition. In addition to this data there is also stenciled or printed on each bag the designation of the weapon for which it is intended, the weight of charge, lot number of powder, and the designation of the zone and increment numbers where necessary. In the smaller charges this information is placed upon the end of the charge and on the larger charges it is placed upon the side of the charge. The lot number of the black powder used, weight of black powder charge, and weapon designation, are printed on the end of the igniter pad.

IGNITER PROTECTOR CAPS:

In the case of separate loading propelling charges, it is necessary to provide some means for preventing undue wear of the cloth ends of the charges while stored in the cartridge storage cases. This is accomplished by placing over the igniter end of each charge and both ends of the stacked type and single section charges, a cotton cloth bag provided with a heavy felt pad in its base. This bag is called an igniter protector caps, and was originally used only as a protection for the igniter pad. When the stacked type multi-section charge was developed, it was found that the bag cloth was cut by the sharp edges of powder grains rubbing against the cloth and the sides of the cartridge storage case or against the base of the section immediately above the top of the lower section. To prevent this wear it is necessary to place a cap on the base of each section and on the top section of each charge in each cartridge storage case. The drawings for the igniter protector caps are not shown on the propelling charge drawings but are covered for all size charges on a separate drawing.

There are two types of caps, one with and one without traces. The caps with traces are placed on the base charge in the cartridge storage case, and the traces which are attached to the cap are brought along the sides of the charge and tied over the top section. This procedure provides a means of removing the heavier charges from the storage case. The caps with traces are not used in the packing of the lighter weight charges. The cap without traces is used in all cases except as mentioned above. Each cap has stenciled or printed on its outer surface the designation of the weapon for which a particular charge is to be used and also instructions to remove the cap before firing.

FINAL ASSEMBLY OF SEMI-FIXED AMMUNITION:

After the bags of powder for the semi-fixed type of ammunition are filled and closed they are forwarded to the final assembly line where they are placed in the cartridge case. These bags are not provided with a separate igniter as they are ignited in the cartridge case by means of a standard black powder precussion primer which forms a part of the case assembly.

The methof of loading consists in tying by means of a slip-knot the base increment to the two eyelets provided in the cartridge case and tying the remaining zones by long cord to the base increment. This cord is made sufficiently long to allow all of the increments with the exception of the base increment to fall free of the case. When it is desired to remove one or more increments, the case is inverted and all of the increments with the exception of the base increment will fall free of the case and the desired number may be detached by breaking the tie-string. The remaining increments desired for the particular round may be replaced in the case, the projectile replaced and the round is ready for use. In tying these rounds in place some care must be used in providing the correct length of tying twine and also that the various increments be tied on the twine at proper intervals, since if they are removed, a portion of the twine may extend out of the cartridge case and when the projectile is placed in the case and the round inserted in the weapon , the extending twine may cause the breech block to jam.

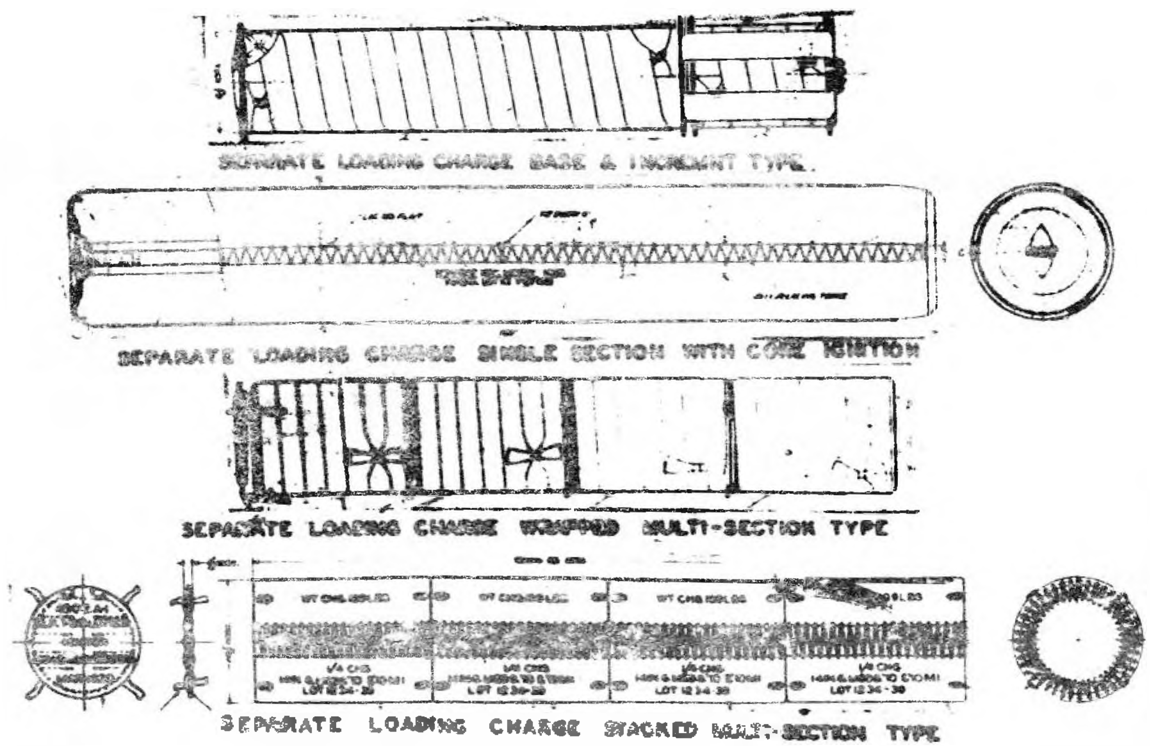

SEPARATE LOADING CHARGE BASE & INCREMENT TYPE.
SEPARATE LOADING CHARGE SINGLE SECTION WITH CORE IGNITION
SEPARATE LOADING CHARGE WRAPPED MULTI-SECTION TYPE
SEPARATE LOADING CHARGE STACKED MULTI-SECTION TYPE

FIG. 1

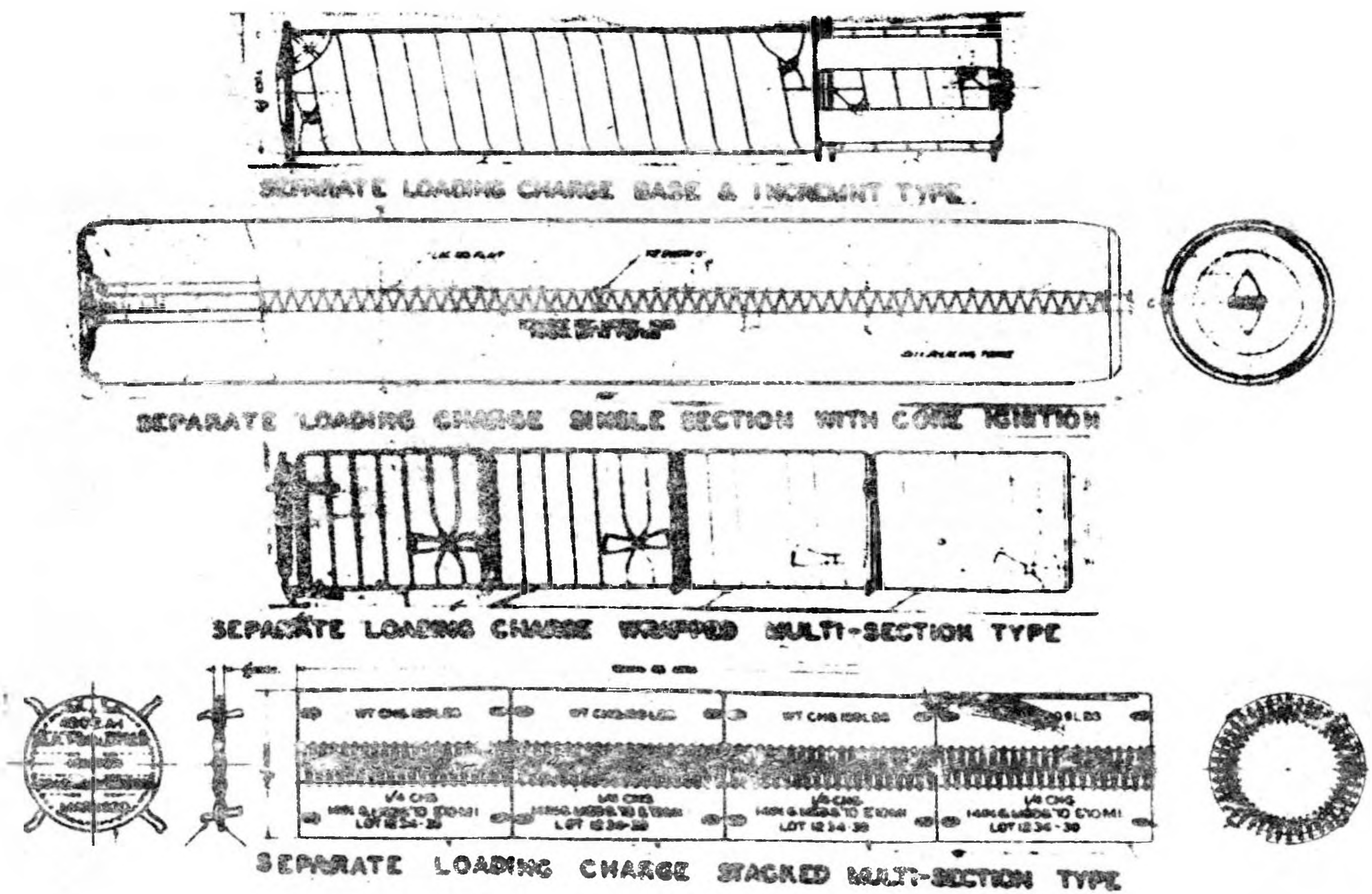
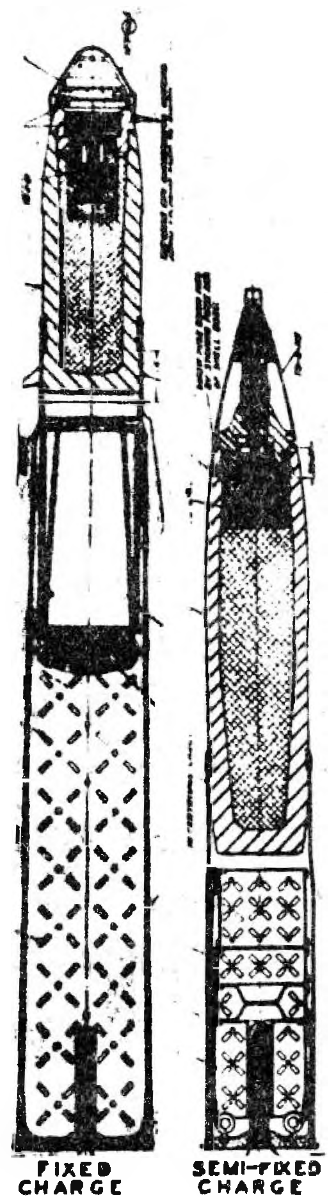
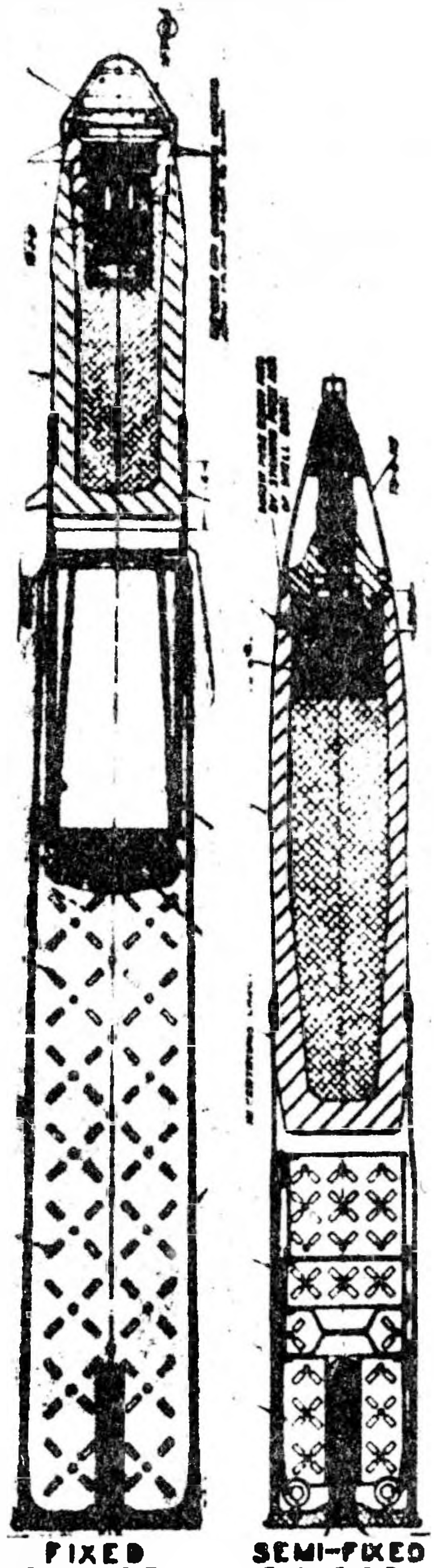

SEPARATE LOADING CHARGE BASE & INCREMENT TYPE
SEPARATE LOADING CHARGE SINGLE SECTION WITH CORE IGNITION
SEPARATE LOADING CHARGE WRAPPED MULTI-SECTION TYPE
SEPARATE LOADING CHARGE STACKED MULTI-SECTION TYPE

FIG. I



FIXED CHARGE

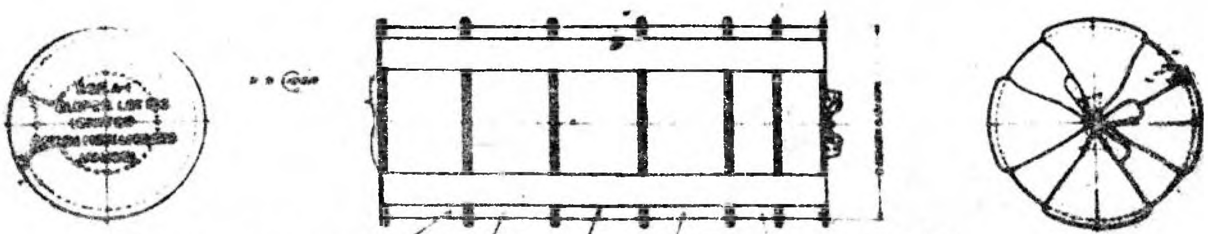
SEMI-FIXED CHARGE



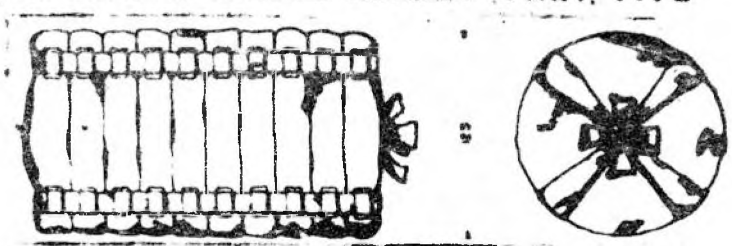
FIXED CHARGE

SEMI-FIXED CHARGE

SEPARATE LOADING CHARGES
INCREMENT TYPE

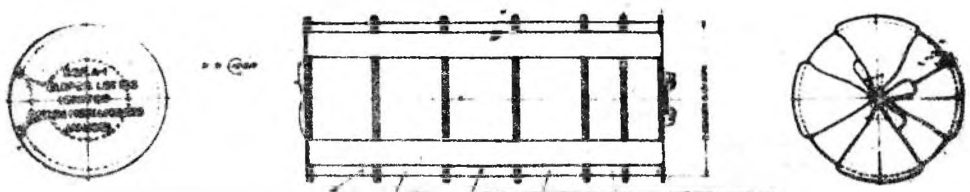


SEPARATE LOADING CHARGE ALIQUOT PART TYPE

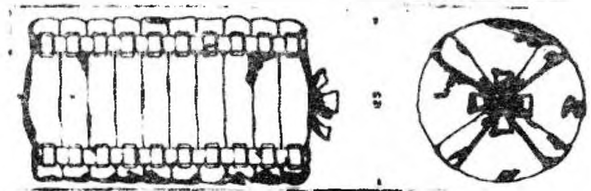


SEPARATE LOADING CHARGE ALIQUOT PART TYPE

SEPARATE LOADING CHARGES
INCREMENT TYPE



SEPARATE LOADING CHARGE ALIQUOT PART TYPE



SEPARATE LOADING CHARGE ALIQUOT PART TYPE

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 12. THE LOADING AND ASSEMBLING OF TIME FUZES

1. Scope: For the purposes to be accomplished by this lecture, all of the manufacturing steps involved in the production of time fuzes will not be covered. The preliminary machining of the metal parts, the manufacture of the primers and of the powders used will be covered in other lectures. Furthermore only those fuzes timed by the burning of black powder will be touched upon. These are the 21 second and 45 second types. The manufacturing processes used in producing these various types are so similar that those involved in the 21 second combination, i.e., the Mod. 1907M only, will be covered, and the differences between it and the other types will be commented upon.

2. Types Manufactured: The time fuzes which we are equipped to manufacture at this Arsenal consist of the following:

a. 21 Second Combination, Model 1907M, for use with shrapnel with the following guns:

(1) 2.95 inch Mountain Guns.

(2) 75 MM. Field Guns, all models.

(3) 75 MM. Pack Howitzer, M 1.

b. 21 Second Mk. III A-I, for use with Shrapnel or shell with:

(1) 3 inch Anti-Aircraft Guns, all models.

(2) 75 MM. Anti-Aircraft Guns, Model 1916.

(3) 105 MM. Howitzer, M2.

c. 45 Second Combination M1907 with shrapnel with:

(1) 155 MM. G.P.F. Model 1918 M I (Fr.).

(2) 155 MM. G.P.F. M1917 and M1917A1.

(3) 155 MM. Howitzer, Models 1917, 17A1 and 1918.

d. 45 Second Mk. XVI (Navy).

(1) For Navy Department, used for Anti-Aircraft and illuminating duty omitting percussion elements. (Reference: Complete Rounds Chart O.O. Form 5981).

3. <u>Powder for Rings, General</u>:

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

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

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

4. Preparation of Black Powder for Ring Loading:

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

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

5. Loading of Rings:

a. Prior to loading the powder into the ring it is necessary to coat the powder groove with shellac and aniline dye composition to prevent subsequent chemical reaction between the powder and the brass. The aniline dye simply permits ready inspection of this operation. The solution used consists of $3\frac{1}{2}$ ounces shellac, $\frac{1}{2}$ gallon alcohol, and .17 ounce aniline dye. This solution is applied by cotton swab. To insure dryness of this shellac prior to loading, the rings are stored at room temperature approximately 72 hours. The shellac must be dry before loading or dispersion in burning time will be increased. Cold rings, i.e., much below 75°F. should never be taken into the loading room for loading because condensate would form and raise the moisture content of the powder placed in the groove. The loading and facing rooms are both supplied with conditioned air constantly maintained at 75°F. and 40% relative humidity in an effort to control and maintain uniform, the conditions under which the rings are handled during loading and prior to shellacking. This atmospheric condition is one comparatively easily maintained and practical for the operators.

b. The prepared ring having been taken to the loading room is stamped with a block number to identify it with the date of loading and with the 300 pound blend used. The block number is an arbitrary number and is cross-referenced in the office record for various other reasons also; such as any change, in practice, of shift, of brass used etc., which will permit the segregation of any rings found unsatisfactory or of different characteristics. The chief value of the block number system is to permit the isolation of blocks causing trouble.

c. The empty ring is then placed in what is termed a loading fixture. This fixture supports the ring around its entire surface except for the opening above the groove into which the powder is to be pressed. The ring, having been secured in the fixture, is now ready to receive the powder. The operator removes the stopper from the $\frac{1}{2}$ pound can above mentioned, dips a scoopful of powder, measures the powder used by striking across the top of the scoop with a brass blade inserted in the under side of the stopper, and dumps the charge into a specially constructed funnel which distributes the powder into the groove in the ring and into the space in the fixture immediately above the groove. The column of powder thus produced is approximately three times the height that it will be after pressing, depending upon the initial fluffiness of the powder. It has been noted that more bridging action takes place in this operation when using conditioned powder than when using drier powder. To break up bridging a vertical needle was attached to the under side of the funnel which, when revolved, accomplished this additional mission. In order that all rings will contain a nearly uniform amount and height of compressed powder, the powder which has thus been dumped into the fixture is then leveled off or distributed with a small metal spreader by pushing the powder around rather than by pressing it into the powder receiving groove (the opening between the punch guide and the powder guide). It is then subjected to gaging, which consists of running a gage into this opening at about midway between the ends thereof and running the gage first to one end of the groove and then back to the other end. The surplus powder is thus plowed out and thrown up on the fixture out of the way of the pressing punch. The compressed height of the powder depends upon the depth of gaging. This gaging is also considered an important operation in that faulty distribution may result in soft ends. If the fixtures used, especially the punch and punch guide, are not good fits they will permit the powder to be blown out by the downward movement of the punch. Such loss of powder is one of the causes of soft ends. The punch is then inserted by hand and is given a preliminary pressing on a hand operated arbor press to insure that the punch is properly aligned before the final pressing. After this operation the fixture is placed in the final press which completes the pressing and consolidation of the powder. All pressing is done in barricaded equipment. The pressure applied in the "final press" is 68,000 pounds per square inch, in the case of the 21 second fuze rings, and 75,000 pounds per square inch, in the case of the 45 second fuze rings. If the brass used in the ring is too soft, i.e., below B-50 Rockwell hardness, the ring will probably be badly distorted in loading and may become a reject. The areas of the grooves and the dead weights necessary to produce these pressures are as follows:

21 second rings (68,000 pounds per square inch)

	Square inches	Dead Weight Pounds
Upper	.552	37,400
Lower (graduated)	.635	43,650

45 second rings (75,000 pounds per square inch)

	Square inches	Dead Weight Pounds
Upper	.755	56,625
Lower (graduated)	.871	65,325

The press which has until recently been used exclusively for the production loading of time train rings in a Richle press of 80,000 pounds capacity, belt driven, cam action, with automatic dial feed table which revolves to place each fixture directly under the ram. This press which makes ten (10) strokes per minute with an 1-1/2 inch stroke of the press requires 32 fixtures and 22 men divided into two crews. Being a fixed stroke press it can readily be seen why extreme care must be used in measuring the powder for each ring. Hydraulic presses are now installed to replace the cam action presses. These hydraulic presses can be set to give times of approach and application automatically controlled over a considerable range. It has been found that a time of approach of three (3) seconds and a time of application of five (5) seconds give the best results. The principle advantage of the hydraulic type over the mechanically actuated cam action presses is that the longer time of pressure application tends toward a more uniform density of compressed powder train which is reflected in a slightly less dispersion in burning times of the completed fuzes.

6. Facing:

a. In the facing room the rings are brought to dimensional thickness by a lathe operation, using two tungsten carbide cutting tools, mounted on the cross slide in a tool post and rigidly fixed to give the required thickness (.322 plus or minus .004) one cutting on each face of the ring. In the case of the 45 second graduated ring it is necessary to install the safety disc before the facing operation. The lower vent, and the hole for the disc are drilled, to prepare the ring to receive the safety disc. After the safety disc has been crimped into place, the ring is faced to dimensional thickness .322 plus or minus .005. Before removing the lower ring from the lathe, the upper face is scored or serrated with a forming tool, held in the turret-head. The ring is then inspected for size, chipped powder face, and distorted metal. A reject here may be saved by again facing until minimum thickness is reached when, if not satisfactory, it is totally rejected and worth only the brass content. Within reasonable limits the thickness of ring apparently does not affect burning time.

b. Prior to leaving the facing room, the powder train face of the ring is shellacked for protective purposes. This shellac must be carefully prepared according to the following formula as it is not desirable to have any other substances, which may affect it later, come into contact with the powder.

Formula for special powder face shellac: Add eight (8) grams of ground shellac to one hundred (100) C.C. of absolute alcohol. All the shellac "cut in" at least forty eight (48) hours and allowed to settle. The clear portion only is usable. This is decanted off.

c. Throughout all operations it is necessary to prevent oil or water from coming into contact with the powder, as such contacts will most certainly cause large dispersions.

d. After facing and shellacking, the rings are removed on rods to the constant temperature magazine for the purpose of drying out the volatiles introduced by shellacking. The temperature is 100-110°F. and the rings are thus stored for 3 days after which they are "processed". This constitutes the first part of the so-called 3-3 treatment. After operating the rings are returned for 3 more days storage at this temperature, this being the second half of the 3-3 treatment.

7. Processing:

a. This phase of the manufacture covers all of the operations on the rings between the shellacking of the finished face and the assembly of the rings. From the Dry House the ring is sent to the processing room where the first operation consists of forcing the rotating pin into the hole provided for it in the machine shop. The operation is followed by the cleaning of the locating hole which has been slightly distorted in the loading operation. This is done by simply allowing a .100 drill to enter and seat in the original location. This hole is used on all operating fixtures where mechanical operations are performed, with the exception that on the older fixtures one of the gas chamber vents is used as an alternate location or work hole in drilling and counter-boring the interior vent of the graduated ring.

b. A box fixture was formerly used that permitted all of the drilling, reaming and counterboring to be done from one set-up within the fixture which is moved from tool to tool. Older fixtures permitted only one operation per set-up, the ring being passed along the line of fixtures. A self-contained machine was also formerly used which did all these mechanical operations in a single set-up and in a single piece of machinery. In that device the ring was placed into the machine and properly located by the locating hole; a movement of the operating lever causes the ring to be held firmly while subsequent movements of the lever cause the various tools to move in and out of the ring until all drilling, reaming, and counterboring are completed. In a later type of self contained machine adopted, all of the drilling operations on the time train rings are performed automatically, the several drill spindles placed at different angles being driven by directly connected motors. With this type of drilling machine it is only necessary for the operator to locate the rings on a revolving table with reference to pins which engage the locating holes of the rings.

c. In this connection, it may be stated that the proper relationship of these holes with respect to each other and with respect to the rotating pin and to the graduations are vital factors affecting the uniformity of burning time of the fuzes. In the case of pellet holes, largeness will result in bettering of the pellet. These relationships are closely checked with gages constructed especially for the purpose. Likewise the loaded components are inspected.

d. The mechanical operations having been completed by the milling of the rotating pin, the ring is cleaned of powder dust, burrs removed, and the rings fitted with the required pellets. Three (3) pellets are used in the rings and one in the body. These pellets are compressed black powder Grade A-5 and are tubular in shape. The processing unit receives these from the component preparation unit which is charged with the duty of their preparation, which consists of inserting in the aperature and extending throughout the length of the pellet, a wick of nitrocellulose (which is more ignitable than black powder, especially when the black powder is highly compressed) to better insure ignition of the pellet. The pressing of the pellet is done elsewhere in the Loading Department. The pellet in the upper ring is now omitted, recent tests having proved that dependable ignition of the powder train is obtained without the pellet. The interior pellet in the graduated ring is retained in place by the vent closing disc which is crimped into the counterbore of the interior vent. This disc is treated, for the protection of the pellet from premature ignition, by an application of the shellac-aniline dye composition over the disc and around the edges thereof. This pellet is used to insure blowing out of the disc, which, if not blown out, would cause a high gas pressure to be built up which in turn would cause exceedingly rapid burning of the train. It has been found in tests made by varying the relative security of the disc that as much as .2 second variation in burning time could be produced. This being almost half of the tolerance, the importance of uniformity of this operation is apparent. In the case of the 21-second fuzes, it has recently been found impossible to control the staking of the interior vent disc of the graduated ring within the narrow limits required. It is necessary to insure against exceeding the maximum securement allowable for the successful blowing out of the vent disc as the lower powder train is ignited and at the same time to provide for the necessary securement to prevent the disc from falling out in the required jolt and jumble test. As a result the current practice is to stake the metal of the counterbore shoulder diréctly around the pellet and to eliminate staking the vent disc in place. A heavy coat of shellac-aniline dye over the vent disc provides the only securement between disc and the counterbore which receives it. A guaranteed metal clearance of .002" exists between counterbore and vent disc. Steps are now under way to provide for the same arrangement in the 45-sec.

graduated ring. The remaining pellet is the exterior pellet which transmits the flame from the upper to the lower train. It is placed in the lower ring over an auxiliary priming charge of loose A-7 black powder. It is held in place by the felt washer of the lower ring the attachment of which will be described later.

e. After the interior pellets are inserted and secured in place the powder face of the ring is again shellacked and an onion skin paper washer termed a "groove cover" applied. The rings are held under tension on the table to set the shellac and to await the next operation which is the insertion of the exterior pellet described above. After the insertion of the exterior pellet, the graduated ring is subjected to felting which consists of applying glue to the serrated top of the ring and then applying the felt washer, the holes of which must be in correct register with the holes of the rings and particularly with the nitrocellulose core of the pellet. Care must also be taken to avoid getting any glue on the pellet. The presence of glue on the pellet or covering the pellet with the felt is apt to result in delay of ignition or a dud. The upper rings are placed on rods and separated thereon by rubber washers which are covered with talc to prevent adhesion of the shellacked paper and the rubber washer. The graduated rings are similarly placed on rods after being felted. The nut of the rod in each case is tensioned to 12-1/2 inch-pounds. The loaded rod is then taken to the constant temperature magazine where the glue and felt is permitted to set at a temperature of 100-110°F. for four (4) hours. At the end of this time tension on the rings is fully relieved in order that the air of this magazine may flow between the faces of the rings for 3 days to properly complete the 3-3 treatment above described. (Par. 7 d).

f. At the end of this three-day period the nuts on the rods are again tensioned to 12-1/2 foot pounds. The rods of rings are then transferred to a standby storage room kept at a temperature of 80-85°F. where they remain until ready for assembly. After the rings from the last day of loading on a lot of fuzes has been in this standby storage at the reduced temperature for at least 24 hours, 10 sets of rings from each block combination are assembled to test fuze bodies and fired statically, all on the same day, as an assembly test. After being assembled for this test the fuzes are stabilized for a period of at least 3 hours at a temperature of 75°F. The results of this test indicate the satisfactoriness of the lot as regards variations in average burning times and dispersion for different days of loading, and the overall dispersion and mean deviation that can be expected in the final Inspectors Static Test for the lot. This Assembly

Test is more severe than any other given the lot of fuzes. For example, if in a lot of 20,000 fuzes, the rings were loaded at the rate of 2,000 sets per day, there would be 10 different days of loading represented in the lot. The Assembly Test would consist of firing 100 fuzes of which 10 were assembled with rings from each of the 10 days of loading. If the rings from a particular days loading burned excessively fast or slow or with excessive dispersion, it would be possible to eliminate that days loading or in other words that particular block combination of upper and lower rings from the lot of fuzes. It has been found that, as a result of the 3-3 day treatment, practically no change in burning time in a block of rings take place, whereas before this so called 3-3 treatment was adopted it was necessary to let the rings intended for a lot of fuzes age or season for at least three weeks before subjecting them to an assembly test due to a speeding up in burning time of as much as .5 sec. in 21-second rings and 2.0 sec. in 45-second rings.

8. <u>Assembly</u>:

<u>a</u>. The rings, having been designated for asembly, are sent to the Assembly Unit, where the groove covers are waxed by being rubbed over an electrically heated steel plate which is kept coated with carnauba wax. They are then inspected and placed upon the body of the fuze which has been previously prepared by the Body Preparation sub-unit.

<u>b</u>. The body is prepared by applying the aniline-shellac composition to the surfaces that will come into contact with powder, the bottom closing screw is screwed in and staked, the body pellet inserted, the felt applied and set, and 95 grains of Grade A-4 black powder jolted into the base charge cavity. A base charge of 20 grains of Grade A-4 black powder is used in the 21-second A.A. Fuze, Mk. III A-2 and is poured into the base charge cavity. The combination fuze alone contains the percussion elements. These are tested for safety and then inserted in the fuze body prior to base charging. The primers and percussion elements are furnished to this division by another division of the Arsenal.

<u>c</u>. The body, being complete with rings, is now ready for the next operation which consists of accurately setting the upper ring set line in position and drilling two lock pin holes into the body shank by means of a multiple drill. The two lock pins are then driven into their holes. The concussion primer with resistance ring is then inserted in the top of the body and the cap screwed

on by hand. By means of a tensioning machine, the closing cap is screwed down to a tension of 60 to 65 inch-pounds and the graduated ring is set on "safe". The cap set screw hole is then drilled in the body and the cap set screw inserted and staked.

d. The assembly of the fuze having been completed by the staking of this set screw, the fuze is then polished by buffing, and lacquered to prevent corrosion. Clear lacquer (Spec. 3-36) is used on the entire surface of the assembly except on the base where the closing screw is covered by brushing with orange shellac. The latter operation is done for the purpose of preventing moisture from getting into the black powder base charge. After the lacquer has dried, the graduated ring is rotated through a small angle and reset in the safe position. This is done for the purpose of breaking the lacquer seal which otherwise would in some cases result in excessive torque required in the fuze setter at the gun.

e. The fuze is then inspected and stamped with the lot number, the initials of the manufacturing plant, and in the case of fuzes for the Navy Department, with the initials of the Chief Inspector, who in this instance is the Commanding Officer.

9. Packing:

a. From the assembly unit the fuzes go to the packing room where they are packed in metal lined boxes, the 21-second fuzes, 80 to the box, while the 45-second fuzes are packed, 25 to the box. After the fuzes are placed in the boxes and soldered, the boxes are tested for air leaks by filling, through the test hole, with air under two (2) pounds pressure. An indicator (mercury column) reveals immediately any loss of pressure which obviously represents leakage. The simple expedient of using shaving soap lather locates the points where resoldering is necessary. The box having been pronounced air tight, the test hole is sealed with solder. The cover of the box is painted with black asphaltum paint and dried. The packing boxes are then closed, sealed, marked and sent to storage.

10. Inspection and Tests:

a. The subjects of inspection and tests were not covered heretofore in this paper in order to avoid confusion, but they are involved in the manufacture from the very beginning and these vital operations run parallel to the ones already mentioned. The inspection of the powders, the metal parts, and the sub-assemblies furnished this division having been accomplished prior to receipt of the items, the first tests performed in these manufacturing operations are the blend tests by which the efficiency of the blend and the correct proportions to be used to get the correct burning times are determined or verified.

b. All blends are verified as to burning time and dispersion by what is known as the "Dry Blend Test". This, as has been referred to in paragraph 4 c, is conducted as follows: Forty samples are selected from widely separated parts of the tumbler. The powder is then exposed in trays to conditioned air for a period of about 5 hours. One set of rings is loaded from each of the samples. Immediately after loading, the rings are faced and operated in conditioned air without application of shellac to the powder face. While still in the conditioned air, the rings are assembled into complete fuzes, registering the felts and groove covers in place, dry. They are then removed to the test house and fired for determination of burning time and dispersion. This serves as a quick, accurate means of disclosing the merits of a blend of powder.

c. Loading tests with representative samples of rings from each day's loading to be included in a lot of fuzes are made before starting the assembly of the lot as outlined in paragraph 8 f.

d. From each loading room the first three rings loaded during each eight hour shift are subjected to a hardness test. The rings are faced so as to present a smooth surface to the punch of the hardness testing machine. The latter is a hand operated Riehle testing machine, with beam set at 250 pounds. The cylindrical punch .081 inch in diameter, makes a slight disc-like impression on a perfect ring, but will puncture a soft one when lowered against the train with sufficient force to raise the beam of the press. The powder train is tested in eleven (11) places equally spaced from one end of the groove to the other.

e. As each one of the several blocks loaded from the powder of a 300 pound blend, has completed its 3-3 day dry processing, ten sets of rings are withdrawn for test purposes. These tests are known as "Assembly Tests". With proper care and uniform treatment each block of rings should burn approximately the same. Thus, one complete lot of about 12,000 fuzes may be obtained from each 300 pound blend of powder.

f. When the lot is completed, five (5) fuzes are selected by the Inspector and fired statically as the official test for acceptance. In case of failure, the blocks causing failure are withdrawn and the balance is used for the selection of ballistic samples for the final test which is conducted at the Proving Ground at Aberdeen in accordance with the Proof Officer's Manual. In the event that the fuzes are found acceptable in the original static test, of course no retest is required and the ballistic samples are forwarded to the Proving Ground immediately.

g. Ten (10) fuzes are selected from each lot by the Inspector and subjected to a jolt and jumble test. These tests are designed to simulate the types of shock that the various components will receive in transportation and handling. The fuzes must withstand these tests without having any:

Explosive elements explode.
Fuze come apart.
Fuze partially or fully arm.
Inner parts, including explosive elements, broken, deformed or displaced in such a manner as to make the fuze unsafe to handle or dangerous to fire.

11. Safety:

a. Due to the presence of black powder in the various operations the matter of safety must be given careful and unremitting attention. No changes in operations are made without considering the effects of the change upon safety conditions. Wherever powder or loaded components are handled no more than the smallest quantities consistent with reasonably efficient operation are allowed to be kept in the vicinity of the operation. In addition to limiting quantities in the immediate proximity it is necessary to guard and protect by cover, barricade, or other means the explosive materials being used. The method of handling the powder in the loading rooms has been mentioned. Recently, the mere fact that the rubber stoppers were in place on these two cans prevented a serious accident in a loading room where every other bit of powder and powder dust on the table, walls and ceiling fired, destroying all evidence of the initial cause and yet doing no injury to personnel and equipment. Powder dust must be removed frequently in order to reduce the strength of a possible flash. In drilling holes in powder a breakage of the drill frequently fires the ring. This cannot be avoided but the extent of the fire can be minimized. "Eternal vigilance is the very body and soul of safety".

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RESERVE OFFICERS'
LOADING PLANT COURSE

Subject 13. Loading & Assembling of Detonating Fuzes.

Picatinny Arsenal has manufactured and loaded many different types of Point Detonating and Base Detonating Fuzes and Boosters for use with minor, medium and major caliber projectiles and fuzes for bombs. The manufacturing methods and difficulties in connection with the loading and assembling of some of these fuzes will be briefly described.

In the assembly of intricate detonating fuzes, many parts are used which must be assembled in their proper sequence and in correct relationship to assure the desired fuze action.

Operations involving the assembly of component parts in a definite sequence wherein any one part may be obscured from view by a succeeding part are checked by an inspector, or another operator acting as an inspector, to assure the presence of and the correctness of the assembly.

Safety, insofar as the operating personnel are concerned, is all important. All operations involving the loading and assembling of loaded components are performed behind barricades which afford sufficient protection to assure safety to the operator.

Base Detonating Fuze, M38A1

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

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

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

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

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

6. The first operation performed is the marking operation which includes all of the identification data stamped on the body using a #8 Bliss press. The next operation is the assembly of the metal parts in the body. The detonator holder is tightened and then the distance from the bottom of the detonator cavity to the top of the firing pin is gaged to make certain that a clearance exists in every fuze.

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

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

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

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

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

Fuze, P.D., M46

1. The M46 P.D. Fuze from a loading and assembling standpoint presents considerably less difficulties than the Mk. III P.D. Fuze which it replaces.

2. The loading of the upper detonator is described under the subject "Primers and Detonators".

3. The lower detonator is of the compound loading type, i.e., a lower layer of tetryl and an upper layer of lead azide. The loading operation is as follows: A tetryl pellet of a predetermined weight is inserted in the detonator casing. The detonator casing is then placed in a semi-automatic dial feed press. The dial carries the detonator casing behind a barricade wherein the tetryl is reconsolidated to a fixed height by a punch attached to the press ram. An inner barricade attached to the ram descends with the punch and surrounds the detonator at the moment consolidation takes place. The second stage of the loading consists of charging the lead azide into the detonator casing, using a special gang charging machine. The machine is barricaded and is operated by remote controls, as operations involving lead azide are extremely hazardous.

4. Subsequent to charging the lead azide, a shellac impregnated muslin disc is inserted above the lead azide and then a felt washer is placed above the disc. The detonator retainer is inserted in the detonator casing and then the entire detonator assembly (Fig.2) is placed in a special semi-automatic dial feed press and crimping machine. The detonator is carried from the loading station, through a barricade, to the pressing and crimping station. The lead azide is consolidated by the punch which exerts pressure on the flange of the detonator retainer. After consolidation takes place, and while the punch is still holding the detonator retainer down tightly against the flange of the detonator casing, a set of crimping jaws close in around the detonator casing, thus securing the detonator retainer in position.

5. It will be noted from the method of loading the lead azide that the density is controlled entirely by the amount of lead azide used. It is therefore necessary to carefully check the volumetric loading equipment.

6. The head is received from the Metal Shops and is assembled in the following manner: First, the heads are visually examined to see that the firing pin hole is drilled through and the interior and exterior surfaces, including threads, are free from dirt, corrosion, or foreign matter. Threads are examined to see that they are not stripped or burred. After examination the heads are placed in trays, thread end down. The firing pin is assembled to the firing pin support with the large hole of the latter toward the point of the firing pin. This assembly is then inserted into the head and on it are successively placed a closing disc washer and a closing disc. (Fig.3). The closing disc is roll crimped in the fuze head on a dial feed machine. The head assembly is placed in a receptacle on the dial which rotates it to the crimping position where spinning rolls descend and crimp the head. (Fig.4). The heads are examined at frequent intervals to see that this operation is being properly performed.

7. The upper detonator is placed in the head, disc end first and after visual inspection, the cork cushion is inserted. (Fig. 5). The retaining screw which completes this sub-assembly is then inserted and securely tightened by means of an air driven screwdriver. With a pneumatic staking machine a force of 925 lbs. is applied to secure the screw in the head assembly.

8. The first operation on the body assembly received from the Metal Shops is to stake the interrupter plug in the body at two points 180° apart (Fig. 6), using a pneumatic staking press. The data are stamped on the body by placing it vertically in an automatic dial feed marking machine. The stamped bodies are then ejected to a hopper from which they are removed for an arming test. For this purpose two spinning machines rotating at 1800 RPM and 1300 RPM respectively are provided.

9. The next operation involves assembling the head and lower detonator and socket assemblies to the body. (Fig. 7). The head assembly is started into the body one or two threads. The lower detonator washer is assembled to the detonator and the detonator inserted in the detonator socket, which is then started on the body two or three threads. These mating components are placed vertically in a semi-automatic assembling machine where the head and lower detonator assemblies are simultaneously tightened to the body. In this operation the body is held stationary while oppositely rotating chucks advance and engage the surface of the head and the wrench slots of the socket, thereby screwing the members firmly in place. In another operation the head and lower detonator assemblies are simultaneously staked to the body.

10. In order to ensure proper fit in the adapter booster, the fuze assembly is inserted into a friction controlled power operated machine which checks the length from the flange to the bottom of the socket, concentricity, and the fit of the threads.

11. Next, a felt washer is assembled to the detonator socket and then seated by means of a perforated block. The head of the fuze is colored white to establish its identity as a non-delay fuze. This operation is performed in the following manner: A container is filled to the proper height with lacquer enamel; the fuzes are placed in special trays, nose down, and each tray is pushed along a track to a point directly over the container. A foot treadle attachment is operated to raise this reservoir to such a height as to properly coat the heads with enamel. The fuzes are permitted to remain over the container for a short time in order to allow the excess enamel to drip off. They are then pushed along the track and over a wooden roller in order to remove any drippings and surplus lacquer from the tip of the heads.

12. The fuze is subjected to a visual inspection for appearance and to determine that all operations have been accomplished, after which, the

fuzes are placed in trays in the tin liners. The lid is soldered on the liner and the liner is then tested for air tightness. The liner is then coated with black asphaltum paint and allowed to dry.

Fuze, P.D., M48

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

2. Loading of the detonators and delay elements is described in other lectures of this series.

3. The M48 head assembly is similar to the M46 and M47 assemblies. Upon receiving the heads from the metal parts manufacturer they are visually examined for compliance with the drawings. They are then placed thread end down in wooden trays and transferred to an operator who successively inserts a firing pin and support assembly, a closing disc washer and a closing disc. It is then necessary to crimp the closing disc in the head. For this purpose a tool containing two formed rollers which is attached to the spindle of a drill press is used.

4. As with the M46 Fuze the next operation is to insert a cork cushion, a detonator and retaining screw and stake the latter into the head. Staking is performed in a pneumatic press.

5. Identification data is stamped on the fuze body by means of a dial feed marking machine.

6. This fuze has a centrifugally operated interrupter which effectively blocks the central flash hole until lineal set-back forces have ceased. To ensure safe, as well as, dependable functioning, the interrupter is required to arm at a speed of 2,000 RPM and remain unarmed at 1500 RPM. Compliance with these requirements is verified by means of two spinning machines, arranged with mirrors so that a light will be visible through the flash hole when arming occurs.

7. The next operation is to place an ogive on the body, aligning the small hole in the ogive with the setting sleeve on the body. A head assembly is then inserted in the ogive, screwed and tightened. To ensure that all parts stay in place the ogive is pneumatically staked.

8. First of the numerous steps in assembling the plunger body is insertion of a relay cup assembly into each of a tray of 50 bodies, using a tubular inserting tool to facilitate seating. After checking for the presence of relay cups, a delay holder then a washer and a primer assembly are placed in each body. Next a primer cover is inserted and the plug is screwed and seated into place. The plunger body is then inspected and into both of the two side holes one plunger centrifugal pin, one centrifugal pin spring and one spring retainer are entered and temporarily retained by a spring clip. In these and subsequent operations, great care must be observed that all parts are properly assembled into the body as otherwise there is a possibility of accidental firing of the delay element.

9. Next the delay firing pin assembly, plunger support and plunger restraining spring are placed on an assembling pin and inserted far enough into the central hole of the plunger body for the pin to project beyond the end of the body. These parts are temporarily held in place by means of a nut. A gilding metal housing is then slipped down over the plunger body and the spring clip is removed. To complete this assembly, the plunger body is placed in a jig, a small hole is drilled and the brass lock pin is inserted and crimped.

10. After performance of an arming test the component is ready to be gaged and placed in the fuze body. Finally the closing screw assembly is inserted, seated in the body and staked.

11. The fuzes are then hermetically sealed in tin liners and are packed in wooden boxes for storage or shipment.

Fuze, P.D., M52

1. The M52 Point Detonating Fuze, which along with the M53 Point Detonating Fuze, replaces the M45, is a superquick fuze for use in connection with 81 MM Trench Mortar Ammunition.

2. It consists of four important sub-assemblies: The head assembly, containing the firing pin assembly; the body assembly, containing a safety pin and a set back operated safety device; the slider assembly, having a detonator assembly crimped therein; and finally, the booster assembly, containing a 5.6 oz. pellet of tetryl. (Fig. 1).

3. The detonator assembly consists of two parts, the upper detonator and the intermediate detonator, consisting respectively, of charges of lead azide primer mixture (dry loaded) and lead azide. Preparation of this assembly is described in the section entitled "Detonators and Friction Primers."

4. Booster pellets are manufactured in Type "R" Stokes Tablet Machines as described in the section dealing with tetryl pellet manufacture.

5. The body and firing pin assemblies are received complete from the Metal Components Plant.

6. The Loading Department's first operation is to stamp the production date on the head, using a roll feed marking machine. The stamped components are ejected to a box.

7. Assembly of the slider consists of placing one cork cushion in the detonator cavity and then inserting and seating the detonator assembly, making sure that the colored end is inserted first. (Fig. 2). The detonator is retained by a circular crimp produced in a standard Picatinny Arsenal pneumatic staking press. (Fig. 3). This last operation produces external burrs which are removed in a small pneumatic broaching machine. (Fig. 4).

8. Next, loaded tetryl lead cups are inserted in each of a tray of bodies. (Fig. 5). The cups are fixed in position by placing the assemblies under the ram of a pneumatic staking press, which imparts a circular crimp. In order to prevent the loss of time which would occur if an assembly operator were required to untangle a pile of slider springs before proceeding with the assembly, an additional operator separates the springs and places them individually on a rack consisting of two rows of finishing nails set in a wooden strip. (Fig. 6). Spring racks, and trays of sliders, plugs and bodies are placed where they are conveniently accessible to the next operator who successively places a slider, a spring and a plug into each body assembly. The plug is screwed down about two threads, by means of a special self-seating screwdriver. The body assembly is completed by means of an air driven screwdriver which firmly seats the plug in place. To provide greater security the plug is staked using a pneumatic press.

9. The booster assembly operations are relatively simple. First, a felt disc is inserted into the booster cup and on it is placed one tetryl pellet. The loaded cups are transferred in a tray to an operator who attaches each to a body assembly, screwing them on only two or three threads. The remainder of the thread length is coated with Pettman cement and assembly is completed by means of a friction chuck attached to the spindle of a drill press. (Fig. 7).

10. The head is assembled in a foot treadle operated jig. (Fig. 8). The operations are as follows: A firing pin spring is assembled to a firing pin and the latter is inserted in the large opening of the head. The head is then placed, nose down, in the base of the jig and the foot treadle is depressed so as to lower the clamping arm, compressing the spring and causing the firing pin to protrude through the end of the head. The firing pin lock pin may then easily be inserted to complete the assembly. (Fig. 9).

11. The heads are placed in trays and transferred to an operator who starts the assembly into the body, one or two threads, by hand. Here, as before, the work is completed on a drill press, using a friction chuck. Finally, the head is staked to the body.

12. The pull ring is assembled into the end of the cotter pin and secured against the side of the fuze by means of 1/2 x 3/4 inch strip of adhesive tape. The complete fuze is then carefully inspected.

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

Manufacture of Tetryl Pellets

1. Tetryl pellets are used extensively in connection with loading of fuzes and boosters.

2. Although the manufacture of tetryl pellets has for some time been carried out with only minor difficulties, it has in the past caused as much trouble as any other single component in the complete round of ammunition. In pressing tetryl pellets it is necessary to have mixed with the loose tetryl some form of lubricant to ease the action of the dies. Several years ago stearic acid was used for this purpose. Stearic acid not only serves as a good lubricant but has excellent binding qualities; that is, it holds the compressed grains of tetryl together so as to insure uniform density throughout the pellet. However, under atmospheric conditions similar to those existing in the tropics it has been found that stearic acid melts and forms a coating over the tetryl crystals. This condition is objectionable in that the stearic acid densenitizes the tetryl to such an extent that it may not initiate detonation of the main explosive charge of shell or bombs. For this reason the use of stearic acid was discontinued some years ago and natural flake graphite substituted therefor. Although graphite is a very good lubricant it does not have the same binding properties as stearic acid. In fact, if anything, it will cause a bridging of the tetryl while under compression. At the time this change was made the Loading Department at Picatinny Arsenal had considerable difficulty in manufacturing tetryl pellets of the proper and uniform density. After considerable study it was found that a coarser granulation of tetryl than had previously been used with the stearic acid

binder was necessary when using the graphite lubricant. Without going into detail it may be stated here, that this involved several months of experimentation in the tetryl plant before the coarser crystals could be consistently obtained.

3. Since the destruction to be expected from a detonation of tetryl is very great, the amounts used in any single process are limited to the minimum amount consistent with safety and economical operation. All operations requiring it are properly barricaded to limit the effects of a detonation and minimize the propagation of fire. The floors, walls and ceilings of the plant are frequently washed down to prevent the accumulation of explosive dust.

4. Tetryl for us in the manufacture of booster pellets is screened through a 10 mesh (Tyler) screen and foreign material removed, after which, the tetryl has admixed to it in a tumbling barrel 2 percent of graphite which as previously referred to serves as a lubricant for the dies of the pelleting press. Tetryl for use in the manufacture of lead and small detonator pellets is screened through a 28 mesh and held on a 40 mesh Tyler screen. By controlling the granulation of these close limits more uniformity is obtained in the weight and density of the pellets.

5. For the manufacture of large pellets, the presses used are of the Stokes type R. In this type, the pressing is performed entirely by the upper ram, the lower ram serving only as a knockout punch. Small pellets such as are used for leads or detonators are made with the Type "E", "F", or "N" Stokes presses.

6. After trial runs to permit adjustment of the press for production of pellets having the required size and density, 2 pounds of tetryl with graphite admixed is placed in the hopper of the press. The operator leaves the booth and starts the unit. The hopper is automatically shaken to deliver the proper charge in the die. The charge is compressed and the finished pellet ejected. The cycle is then continuously repeated. The pellets are checked for height, weight and density for compliance with drawings and specifications.

Booster, M20

1. The M20 Booster presents no difficult nor unusual loading or assembling operations. Azide-tetryl detonators similar to those in the M52 P.D. Fuze are now used in this booster. The tetryl booster pellets are manufactured on Stokes pelleting presses, as described in the section dealing with tetryl pellet manufacture. The rotor of the booster cannot be tested statically since arming is dependent upon setback as well as upon centrifugal force. However, the centrifugal pin is tested for arming and non-arming by the metal parts manufacturer before inserting the setback pin. Malfunctioning resulting from causes within the booster has never been reported.

2. The M20 Booster was originally designed as a part of the M39A1 P.D. Fuze but was separated from the fuze when it was decided to use the booster unit in connection with either a time or point detonating fuze. The fuze designation was then changed to M39A2. The M39A2 fuze has recently been superseded by a new design known as the M48 P.D. Fuze which has proved to be a satisfactory substitute.

3. The following loading and assembly operations are performed upon the metal parts received byt the Loading Plant:

<u>a</u>. With varnish shellac one paper disc is attached to each of a tray of rotor covers.

<u>b</u>. Closing cups in which a tetryl pellet has previously been consolidated are inserted and crimped in each of a tray of bodies.

<u>c</u>. Operators then assemble the rotor, lock pins, rotor cover and screws and tighten and stake the latter. Insertion and staking of the detonator into the rotor is performed in one of the buildings of the Detonator Line.

<u>d</u>. After placing one paper disc in the bottom of each booster cup a pellet is inserted and the assembly is screwed and staked to a body.

<u>e</u>. The boosters are gaged for thread diameter, concentricity of cup in body and overall length and are then packed and sealed.

4. In order to insure safety and dependable functioning, representative boosters are selected from each lot and are subjected to jolt and jumble and firing tests.

Adapter and Booster, Mk. IIIB

Loading and Assembling

1. Adapter and Booster, Mk. IIIB is used in 75 mm H.E. Shell, Mk. IV, fuzed with M46 and M47 Point Detonating Fuzes. Four tetryl pellets are required for each booster; two hollow pellets, one solid pellet and one solid pellet having a radius on the bottom.

2. The two hollow pellets assembled in the nose end of the casing form a cavity within which the detonator of the fuze is located in a subsequent operation. The manufacture of these pellets is described under the subject "Manufacture of Tetryl Pellets."

3. The following is a short description of the procedure that is followed in loading, assembling and packing these boosters:

The booster casings are inserted in trays for convenience in handling. The tetryl pellets are inserted in the casings, care being exercised that the pellets are assembled in the correct sequence. The distance from the top of the casing to the face of the pellets is gaged to determine the number of felt washers required to fill the void between the fuze socket and the pellets. The required number of felt washers is then placed on the fuze socket. The loaded casing is inspected to insure the presence of pellets after which the fuze socket is inserted a short distance. Glue is applied to the under side of the fuze socket flange and the socket is then seated either by hand or on a Mandrel press, if necessary. After inspecting to determine that the socket is in place, glue is applied to the threads of the casing. When the glue becomes tacky, the adapter is assembled to the casing, by hand and tightened by means of an assembling fixture, consisting of a vise and a pin wrench which engages slots in the adapter. By means of a pneumatic press the casing is staked to the adapter in two places and then the adapter threads and concentricity of the fuze socket are checked on a friction drive gaging machine. A dial feed rotary marking machine, which has replaced the older reciprocating type, rapidly stamps the identification data on the beveled surface of the adapter and ejects the components to a hopper, from which they are removed and gaged for length. The exterior surface of the booster casing and the bottom of the adapter are coated with shellac varnish, using a saturated varnish brush in conjunction with a friction driven spindle. A closing plug is inserted into a wrench in an assembling machine and assembled into the adapter. Two felt washers are assembled over the casing and seated around the base of the adapter. The adapter boosters are then ready for packing into shipping boxes which have been prepared with all the necessary marking.

M100 and M101 Adapter Boosters

1. The adapter boosters as used in bombs are in essence composed of only two parts: the container for the tetryl booster charge and the adapter which fastens the booster to the bomb and accepts and retains the fuze. It is usually closed with a plug to keep the fuze well clean and prevent its threads from being damaged.

2. The M100 and M101 are made up of components that are identical except for two items: The tetryl pellets and the chipboard liner. The M101 Adapter Booster has booster pellets of a smaller diameter than the M100. Since the same steel booster case is used with each booster a chipboard liner is required to take up the space left by the smaller tetryl pellet diameter. The

loading and assembly except for this change is identical.

3. The steel booster case assembly is received complete from the Metal Components Department. An operator places the tetryl pellets in an inclined brass trough. From this trough the pellet column is slid into the chipboard liner in the M101 or into the steel booster case of the M100 booster. The chipboard liner is then inserted into the steel booster case for the M101.

4. In a tray provided for the purpose an operator places the detonator socket assembly, open end down. A felt washer is placed over the small end followed by the tetryl ring pellets in sufficient number to project above the end of the detonator socket. The same requirement is set for the tetryl pellets in the liner so that the tetryl will always be in contact throughout the length of the column and not interrupted by an air space when the ring pellets rest on the top of the chipboard liner. Such an interruption might be the cause of failure of the explosive train. This assembly of the detonator socket is then inserted and threaded in the end of the booster case and the assembly tightened with a wrench, the case being held in a vise with wooden jaws designed to protect the casing. With the case still in the vise an operator rolls in the socket end of the booster case. The machine used for this purpose is a pipe thread cutter with the cutters removed and rolls substituted.

5. After the rolling is completed the assembly is painted by hand on the booster case surface. Care must be taken to keep paint clear of the brass top of the detonator socket. The entire booster assembly is gaged for length.

M102 Adapter Booster

1. The M102 Booster is made up of a booster casing, an adapter and a closing plug. The loading and assembly involve for the most part simple operations that follow in sequence.

2. A felt pad is dropped into the booster casing and a tetryl pellet placed on top of it. The adaptor assembly is next made up. A closing cup assembly with a tetryl charge in it and its end coated with acidproof black paint, is inserted in the small hole in the base of the adapter, and the adapter crimped in an air operated press. After coating the threads with Pettman cement the booster casing is screwed onto the adapter and tightened in a fixture with a hand friction wrench. The operator gages the height of the booster case above the flange of the adapter. The assembly is then painted with orange shellac varnish. To facilitate the painting the booster is placed on a rotating spindle whose speed is slow enough to allow an operator to coat the surface and end without touching the threads. The closing plug whose threads have been lightly coated with shell grease is threaded into the top of the adapter and tightened, handtight, with a wrench. After visual inspection they are packed and stored.

3. The loading of the closing cup assembly is described in the article on Primers and Detonators.

M107 and M108 Adapter Boosters

1. These boosters consist of two main assemblies: the booster case assembly and the adapter assembly. The M108 is the same as the M107 except that it has a longer booster case and more tetryl pellets.

2. An operator after coating the threads with glue screws the booster case plug into the booster case, after which it is tightened in a turning fixture by means of the wrench holes. A felt disc is dropped into the booster casing to form a soft seat for the tetryl pellets which are pushed in. The tetryl loading is done at a separate table to confine the dust as much as possible.

3. The lead cup, its end painted with acidproof black paint, is inserted in lead cup holder and crimped in a pneumatic press to maintain it in its place. The holder threads are coated with glue and the holder screwed into the adapter. These parts are then tightened in a turning fixture.

4. The booster case assembly and the adapter assembly are now threaded together. This operation must be done soon after the threads of the lead cup holder are coated, otherwise the glue will congeal and block the threads. The assembly is tightened in a fixture using a friction wrench and gaged for height above the adapter top. The assembly is then rolled over inked letters to imprint the ammunition data on the surface of the booster casing subsequent to which the overall length is gaged. Two set screws with conical points are then screwed into the flange end of the adapter and after threading in the closing plug these screws are tightened. To make its removal easy the closing plug is coated on its threads with shell grease. The booster is then visually inspected and packed. The description of the loading of the lead cup will be found in the article on Primers and Detonators.

Fuze, Bomb, Nose, M103

1. A general description of the features of the M103 Nose Bomb Fuze appears in the ammunition design lecture pertaining to demolition bombs. The processes for loading and assembling the various components differ but little from those given for other types of bomb and artillery fuzes. In particular, the manufacture of such parts as detonators, primers and tetryl pellets conforms to the standard practice as described in the sections entitled "Detonators and Friction Primers" and "Tetryl Pellet Manufacture" respectively.

2. This fuze, embodying an integral booster, is somewhat more intricate than the M105 Bomb Fuze.

3. As with other fuzes assembling involves several operations performed on pneumatic or Riehle presses. The delay pellet, the relay assembly, the primer, the detonator and the booster closing cap are all loaded, seated and crimped in barricaded presses.

4. It will be noted that some similarity exists between the vane cup assemblies of the M103 and M105 fuzes. In both a vane driven gear train containing a large eccentrically mounted gear rolling within an internal gear is used to give the large speed reduction necessary for adequate delay in arming. "Safe" dropping is made possible by the provision of 13 arming discs, short cylinders which prevent motion of the striker until the vane cup has been withdrawn sufficiently to permit their ejection. Ejection is accomplished by a flat spring into the ends of which are assembled two discs. The remaining eleven are loosely seated around the periphery of the coiled spring.

5. The slider is constrained to move in a channel formed in the fuze body separated from the booster cavity by a brass slider plate containing the instantaneous and delay tetryl closing cups. This slider plate, located by lugs, is retained by one screw.

6. The brass booster case containing two tetryl pellets is screwed and staked to the body.

7. In order to save space, fuzes and vanes are packed unattached in wooden boxes holding lots of 25, the fuzes in metal containers, adhesive tape sealed and rustproofed with black asphaltum paint, and the vanes wrapped in Kraft paper.

Fuze, Bomb, Nose, M104

1. The M104 Fuze is a special "semi-allways" functioning fuze for use in the 23-lb., M40 Fragmentation Bomb.

2. Following is a description of the operations involved in loading and assembling this ammunition component. No attempt is made to explain the construction or functioning of the fuze as these matters are covered in the ammunition design lecture pertaining to Fragmentation Bombs and Fuzes. Certain of the operations may be classified into groups.

3. First, are those operations pertaining to the delayed arming mechanism (perhaps the word "train" would be more applicable in this particular fuze). The process begins with the insertion and seating of the sealing washer, the delayed arming plunger, plug, disc and washer in the body. The latter is retained by a circular crimp formed in two operations.

4. Next to be performed, is an operation not related to the delayed arming mechanism; the insertion and crimping of the slider guide cup.

5. The black powder delayed arming charge, the body pellet and the nitrocellulose pellet igniter charge are then placed in their respective positions. The delay firing pin is assembled to its spring and pressed into the body and the arming pin is inserted. Thus the firing pin is ready to release upon withdrawal of the arming pin. A cotter pin prevents premature firing.

6. Subsequently, operations are performed on the primer holder and time train ring assemblies. The primer is inserted and crimped into the primer holder, a perforated brass disc. This is then assembled and staked into the body with the primer facing downward towards the firing pin.

7. It has been found that cloth washers used under the time train rings of fuzes are not completely compressed when tension is first applied in the assembling process. This permits a gradual "creep" which eventually results in a loosening of the assembly. To overcome this condition all body washers are now planished. As performed at this Arsenal, several washers alternating with metal separators are stacked in a special fixture on an Olsen testing machine and a load of 104,000 lbs. is applied. The planished washers are then punched for the body pellet, primer holder and the ring locating pin holes and finally glued to the surface of the body.

8. In the next three operations the booster lead cup and cover are assembled and crimped in the body. Following this, the time train ring locating pin is seated and staked in the body. The time train ring may then be located on the body washer.

9. Then, in succession, the firing pin and head assemblies are placed in their respective positions and tightened in a tensioning fixture. The head assembly is secured by a lock screw.

10. The booster assembly, consisting of an aluminum cup containing a paper disc and a tetryl pellet is next screwed and staked to the body.

11. Next this slider assembly is loaded and inserted in the slider cavity, the slider spring and plug are seated and the latter is staked in the body. Finally, the slider lock, slider lock spring and the slider lock screw are assembled and secured in the body with a stake, thus completing the assembly.

12. These fuzes are individually packed in metal containers, hermetically sealed with a soldered strip and are rust proofed with black asphaltum paint. The standard packing box holds two layers of 25 containers.

M105 Nose Bomb Fuze

1. The loading and asembly operations of this fuze are fairly simple although the fuze itself is in some respects rather intricate. The vane and vane cup assemblies containing these intricate parts are received complete from the Metal Components Department. The remaining operations necessary for the fuze assembly are easily accomplished and follow in sequence.

2. The first operation is to insert a Winchester #4 primer in one of the small central holes in the body. A hand operated press is used, the force used being governed by the weight attached to the balance arm of the press. The body is then placed by the operator in a wooden rack which holds five fuzes and the depth of the top of the primer gaged. The rack is then passed to an operator who after inverting them puts a delay holder, threads coated with NRC, in the body. The next operation consists of inserting the body in a special fixture and screwing in and tightening the delay holder. To insure proper functioning the depth of the top of the primers is gaged. A sub-assembly made up of the setting pin assembly into which a #4 Winchester primer has been pressed in an Arbor press, is inserted into the body. By means of a special fixture which both holds and positions, the setting pin is pushed home in an air actuated press. Following this the body is placed in a fixture under a drill press and a small hole is drilled in the body and into the setting pin. A small pin is inserted, pressed in, and staked to prevent its dropping out. This pin acts to maintain the setting pin assembly in the body and in the correct position. It is worth noting here that since this setting pin is rather important to the effective operation of the fuze, it is tested for functioning both before and after assembly to the body. In subsequent operations and in packing, the pin is set on delay for safety in handling in the plant. On a separate table the vane cup assembly is placed in a rack and the discharge spring and discs inserted in the annular recess in the vane cup. This assembly is attached to the body by pushing the brass shear pin through the hole in the body side and through the striker projecting downward from the vane cup assembly. In a small arbor press the end of brass pin is pushed to one side to prevent it from working out.

3. After the setting pin assembly has been made the detonator holder assembly is placed in the body. Care must be taken to insure that the small pin projecting from the body enters the hole provided for it as a locating means. To secure the detonator holder to the body a detonator holder housing is placed over the detonator holder and screwed into the body. The threads are coated with Pettman cement before assembly to make the joint tight. The fixture in which this housing is tightened is an ordinary set-up as used throughout the Arsenal with the exception that a thick cylindrical shell of lucite is used to surround the detonator holder while it is being worked on, and protect operating personnel in case of explosion. After this assembly is complete the fuze is gaged for length from both ends to the shoulder, the

threads are gaged and the entire fuze visually inspected.

4. The loading of the relay and detonator holder is accomplished in a building separate from that used for the assembly of the fuze proper. The brass piece for the delay is loaded with two pellets of black powder, pressed after each increment using a constant weight on the counterbalance. This pressure is very important in that the pressure determines the length of time of burning and the delay. The loading of the detonator holder is a rather simple matter, requiring only 3 separate operations: load and crimp two delay charges, load and crimp the detonator in a hand operated press with a counterbalanced weight to fix the press. The manufacture of the relays and the detonators will be described in the article on Primers and Detonators.

M106 Fuze, Bomb, Tail

1. The loading and assembly of the M106 Tail Bomb Fuze is essentially concerned with a simple plunger type in which a miner's fuze is used as a delay element. It does, however, present some points of difficulty for which adequate precautions must be taken to secure effective operation of the fuze as a whole.

2. For purposes of loading and assembly, the M106 fuze may be grouped into three sub-assemblies: the body containing the Ensign Bickford safety fuze for the delay, the firing pin assembly, and the detonator holder assembly The firing pin is received already assembled in the holder and secured by the arming pin. After visual inspection of the tag, arming pin, and cotter pin, the firing pin holder plug is started into the arming pin end of the firing pin holder, and tightened in a fixture using the wrench holes in the plug face. Subsequent to this operation, a small hole is drilled in the firing pin holder and into the plug and a pin inserted and crimped to prevent its falling out. An ordinary drill press permanently set up in the production line, is used for the hole and an air operated press deforms the end of the pin to lock it in. Following this operation an operator inserts a special spring into the firing pin end of the assembly and holds it down by threading the primer holder into the firing pin holder. This completes the firing pin holder assembly.

3. It has been found expedient to load the primer holder itself in a separate building. Hand operated presses are used and the various components handled in fixtures which follow the work rather than stay at a particular operation. The first operation is to press in a black powder pellet. On top of this a brass washer is placed and pressed in, and followed by the primer which is crimped in by deforming a raised ring of metal on the detonator holder. Previous to insertion, the primer is coated with NRC compound.

4. The Bickford fuze in the body assembly requires rather elaborate handling before it is ready for use. Long pieces are cut from the spool

approximately the required length plus a small amount to be removed later. To facilitate cutting, the fuze is passed through powdered talc giving a sharp, clean face on the fuze ends. The talc prevents the asphalt from adhering to the knife. The fuze is then inserted in the upper fuze collar on which the fuze retainer has been placed. This assembly is made permanent by squeezing the collar on its smaller diameter in an air operated press. The squeezing serves two purposes: to keep the collar tight on the fuze and to hold the fuze retainer on the collar during assembly, by means of the ridges this process raises along the surface of the collar. After this operation the fuze assembly is taken to an air conditioned room where the collared end of the fuze is daubed with a priming composition. After being allowed to dry for at least 2 hours and preferably overnight, the fuze assembly is coiled around a steel mandrel and after removal is inserted in the fuze body. Care must be taken to so shape the ends that they project from the body along the axis of the body. Previous to inserting the coil, the body closing plug, its threads coated with Pettman cement, is screwed into the body and tightened using the wrench holes in connection with a special turning fixture. The coiled fuze is inserted in the body and the free end left to project a specified distance from the body through a hole in the body closing plug.

5. To facilitate handling from this point on, an empty primer holder with its smaller diameter threads removed, is threaded into the open end of the body. This temporarily holds in the fuze coil enabling the operators to work on the free fuze end. Due to the fact that repeated handling such as the fuze has received up to this point, tends to fray the cloth casing and break out pieces of the powder center of the free end, a small predetermined length is cut off from the total length. The cutting is done by pushing the free fuze end of the body assembly through a hole in a steel plate and bringing a steel knife edge down along the plate face, leaving a clean surface on the end of the fuze. The lower fuze collar is put on this free end and the fresh surface of the fuze is pushed into the open end of the lower detonator charge. This assembly is put in a fixture under a pneumatic power press and squeezed just as the other end was to retain the collar from slipping off. The fixture used for this operation, in addition to serving this function, also by means of stops, gages the length of the assembly from shoulder on the collar to the closed end of the detonator cup. This operation finishes the work on the body assembly.

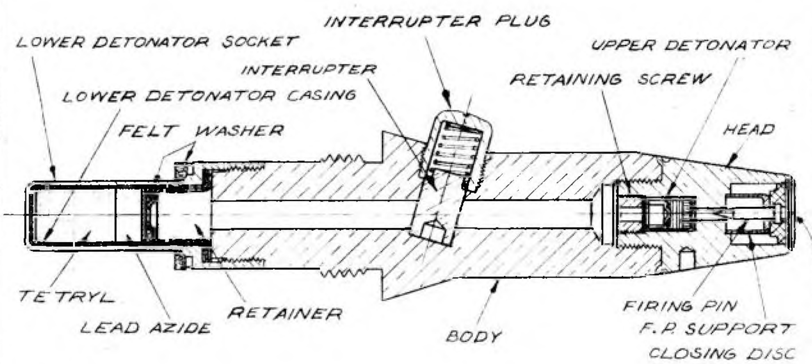
6. The detonator holder assembly consists of a detonator holder fitting down on the detonator cup, and retained, collar fashion, by the body cap which threads down on the end of the body assembly. The detonator holder has a small pin projecting from the side fitting against the body assembly end. This pin enters one of the wrench holes drilled in the body closing plug, preventing the detonator end of the fuze from being twisted and damaged when the body cap is turned to tighten it.

the body cap is turned to tighten it.

7. The body with the detonator holder assembly loosely threaded on it is picked up by an operator, the dummy primer holder removed, and the remaining body assembly threaded into the firing pin holder. The next operator puts the whole assembly in a vise that holds the firing pin holder tightly and using the wrench holes in the end of the body cap the entire assembly is tightened until the turning fixture lifts a weight off its support. To secure this assembly and to prevent the threads from backing off at the bottom edge of the body where it fits around the firing pin holder a small hole is drilled and a pin inserted and later staked to secure it in its place. To secure the body cap to the body, the cap is crimped at its lower edge. Both the pin staking and the crimping of the body cap are done in a barricaded air operated press to protect the operator from possible explosion of the primer and the detonator.

8. The complete fuze is given an inspection by an operator who gages the length of the threads, the depth of the detonator below the end of the fuze detonator holder, and examines the fuze in general for visible defects.

9. The loading of the primer and the detonator is covered under the article on Primers and Detonators. The packing of the fuze assembly is described in the article on Packing.



FUZE, P.D., M.46

FIG. 1

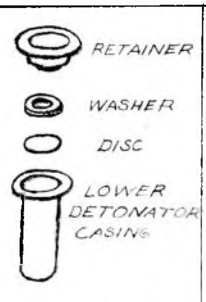


FIG. 2

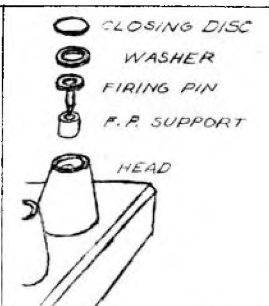


FIG. 3

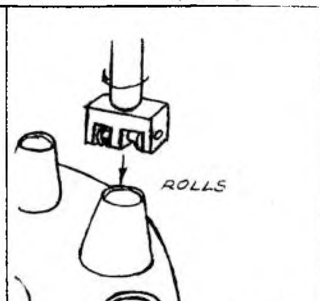


FIG. 4

FIG. 5

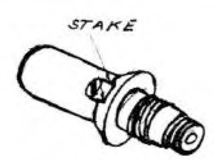


FIG. 6

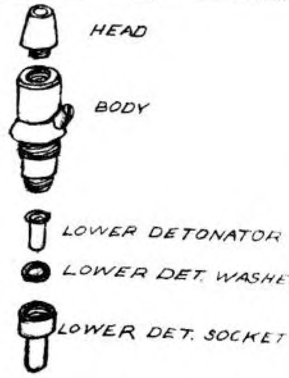
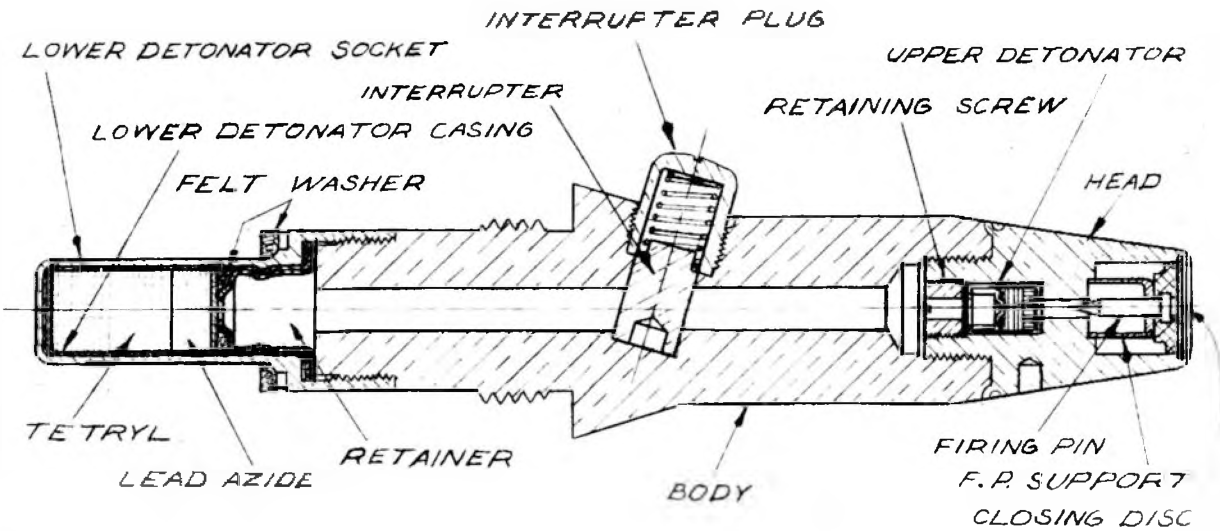


FIG. 7



FUZE, P.D., M.46

FIG. 1

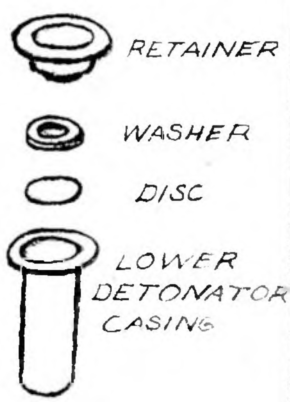


FIG. 2

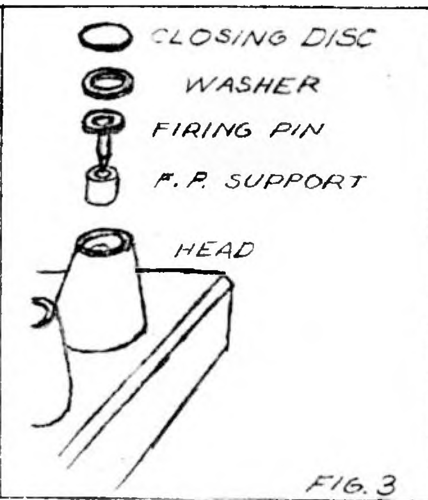


FIG. 3

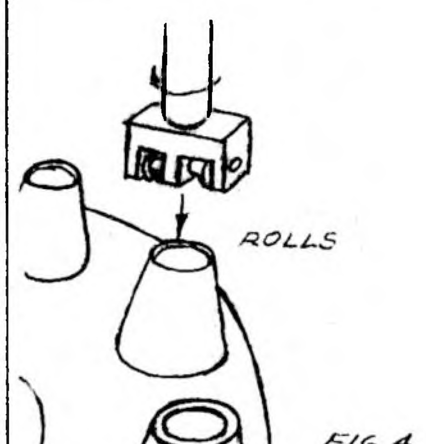


FIG. 4

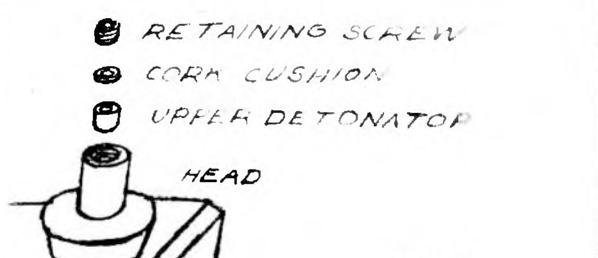


FIG. 5

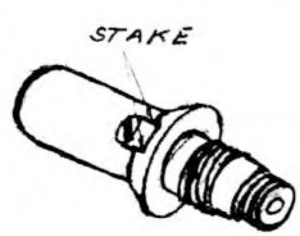


FIG. 6

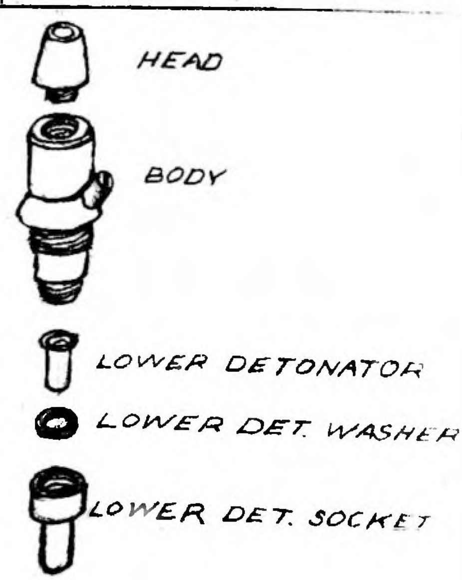


FIG. 7

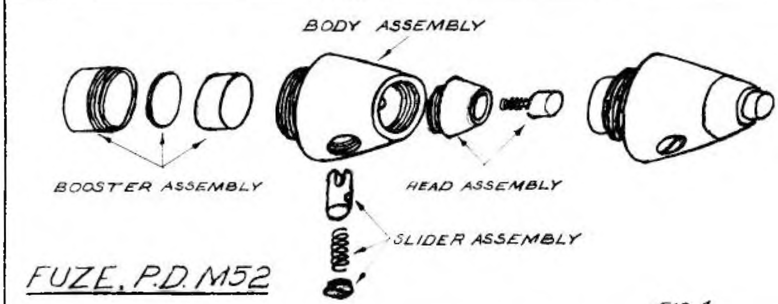


FIG. 1

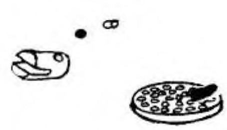


FIG. 2

FIG. 3

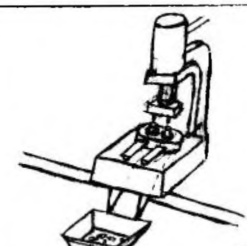


FIG. 4

FIG. 5

FIG. 6

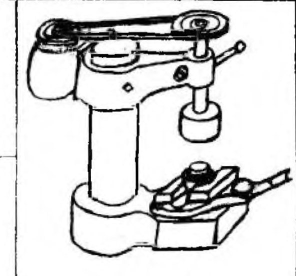


FIG. 7

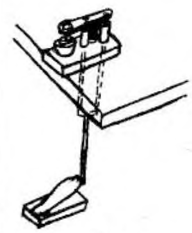
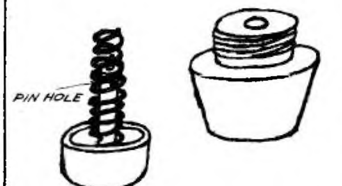


FIG. 8



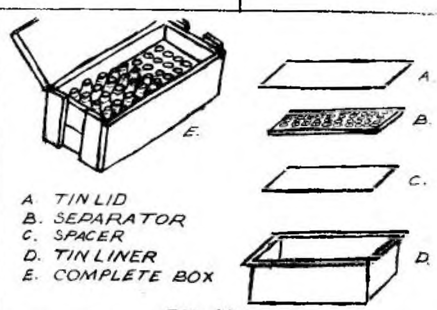


FIG. 10

FUZE. P.D. M52

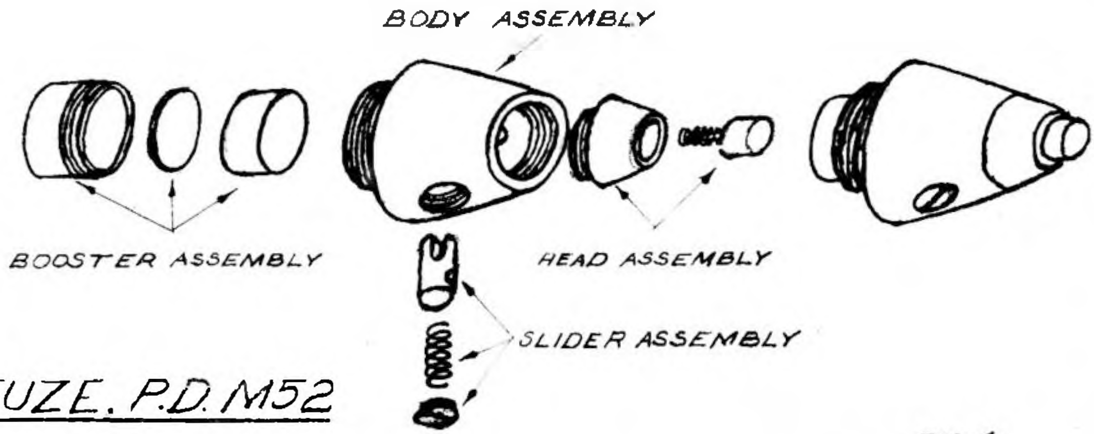


FIG. 1

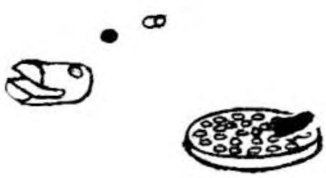


FIG. 2

FIG. 3

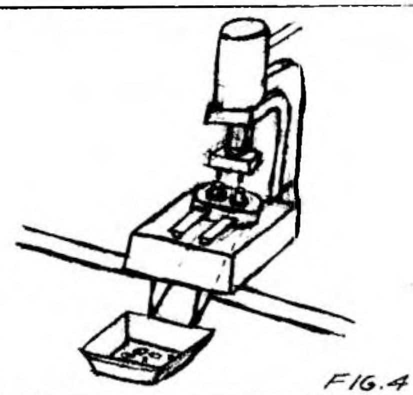


FIG. 4

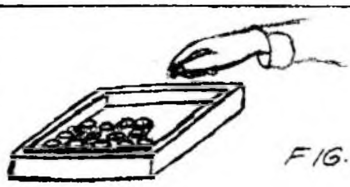


FIG. 5

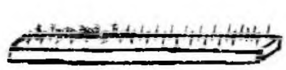


FIG. 6

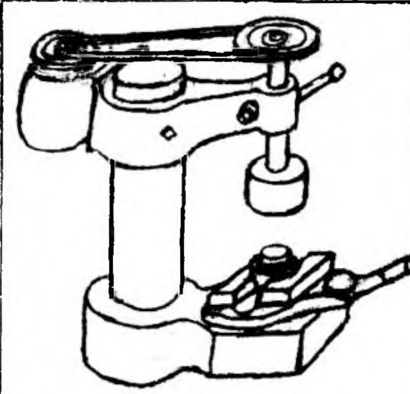


FIG. 7

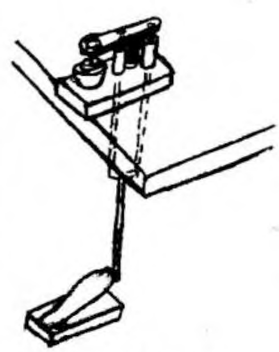
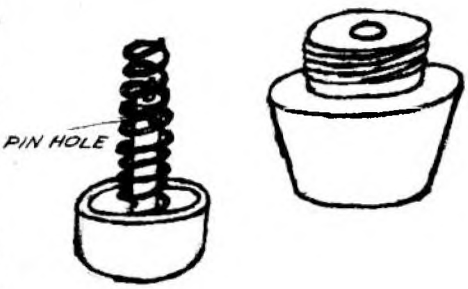


FIG. 8



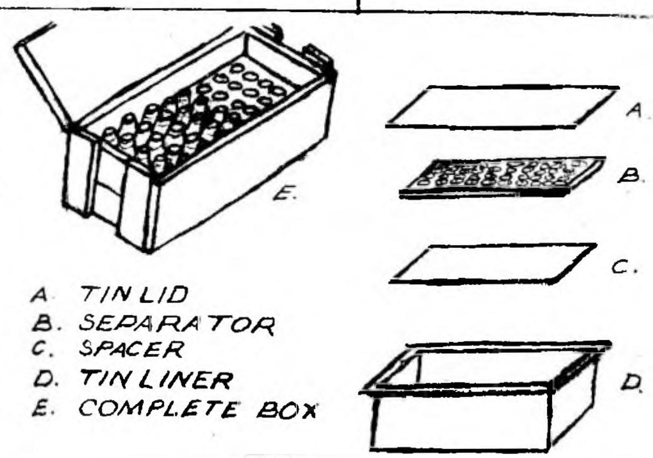


FIG. 10

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 14. PACKING, STORAGE AND SHIPMENT OF AMMUNITION.

A. Packing of Ammunition.

I. INTRODUCTION.

a. Definition and Explanation of the Subject. The packing of ammunition implies the placing and securing of ammunition and ammunition components in boxes, crates, metal drums or other types of containers for storage or transportation. The subject covers the various kinds of containers, as wooden boxes, wooden crates, metal crates, metal cartridge storage cases, fiber containers and metal containers used in handling and transportation of the ammunition; the methods of packing the ammunition and components in the various containers; the design, manufacture and use of these containers; and proper identification of the contents. In this discussion wooden boxes and crates will probably be referred to, and used as an example, oftener than other types, as they form by far the largest proportion of ammunition containers.

Practically all materials or articles of any sort, particularly small articles, are boxed or crated for shipment from the manufacturer to the storage point or to the person who ultimately uses the article. This is particularly necessary with ammunition, and especially with small parts or components, due to its nature, i.e. a hazardous material which must be protected for the safety of those handling it and to prevent damage.

b. Objects and Purposes of Packing.

1. To Insure Proper and Safe Transportation.- The primary object of packing of ammunition, then, is to provide a means whereby the complete rounds and components of ammunition are prepared to insure safe transportation to point where used, packed in a manner acceptable to the carrier and in form for convenience in handling, storage, transportation and issue to depots or the using Service. Ammunition must be packed safely and securely, due to its hazardous, and some times its somewhat delicate nature to insure as far as possible that it will not be injured in handling or transportation to such an extent that it will cause an explosion. Also it is imperative that the ammunition reach the depots or using Service in an undamaged condition in order that when used as received or when assembled with other components it will function properly, and there will be no question in the mind of the receiver but that

it will function properly. Any visible damage to the components which affect their functioning will cause doubt in the mind of the consignee as to the condition of the remainder of a shipment. The packing must also provide such protection that invisible damage will not occur.

The ammunition should be packed in such quantities and in such amounts that the containers, as far as possible, may be easily and conveniently handled and yet carry the maximum number to allow economy in construction and in the number of containers. In other words, for components that are to be stored or assembled before issue to the using Service, as large a quantity of the various types as can be properly handled, without exceeding maximum quantities that may with safety be packed in one container, should be packed together, rather than small amounts. With ammunition which is to be issued directly to the using Service, the nature of the container, material of which constructed, size, etc., will depend upon tactical requirements and other particular requirements as, convenience in handling, facilities for removing contents, the degrees of hazard involved, the particular type of protection desired, storage or transportation facilities, etc.

2. To Comply with I.C.C. and Other Regulations.- The secondary purpose of packing, or rather a factor influencing the design and method of packing, is to meet the different requirements and regulations for packing and shipping explosives contained in Ordnance Department Regulations, Technical Regulations, Army Regulations and, particularly, the I.C.C. Regulations for transportation of explosives and other dangerous articles. These last named regulations apply, to a large extent, to the Army and Navy, but primarily to commercial shippers of explosives. They will be covered more in detail later.

II. DESIGN.

a. General Policy and Trend in Design.

1. Past.- It has, apparently, been comparatively recently that a great deal of attention has been given to the proper design of packing by commercial concerns, and a large amount of research in the search for suitable and proper containers has been carried on.

The I.C.C. Regulations for shipping explosives, however, have existed for some time and it was required that they be followed. Then, too, it was necessary to pay some attention, more so than with other commodities, to the proper packing of ammunition. During this period the Ordnance Department designed packing which was generally considered satisfactory and was apparently designed with the idea of meeting the I.C.C. Regulations. Some of these old type containers are still in use for shipment of components of the earlier design and many containers in accordance with recent drawings, follow the general type of construction of the earlier designs.

2. Present.- The general trend followed in the design of boxes and crates apparently seemed to be towards the use of boxes made of standard 1 inch, or heavier, lumber. This trend still exists, although in a good many cases the I.C.C. Regulations would permit the use of thinner material and lighter construction, or containers of a different type. However, the tendency has been apparently, not only to meet the I.C.C. Regulations, but to "go them one better" and not to use material thinner than 1 inch standard lumber (25/32 inch thick when finished on both sides), although there are a few exceptions. This results in a good many cases in boxes and crates much stronger than required. However, consideration has been given to the Ordnance Department's desire to very definitely assure the safe transportation of the ammunition, and to the particular problems in each case to meet the requirements of packing.

Recently a study and investigation of more up to date methods of packing, used commercially, which will provide greater economy with lighter construction and reduction in storage space, have been carried out. In particular, boxes of wire-bound construction using a thin veneer lumber with reinforcing cleats, with strands of wire encircling the box, have been made up and tested in a number of cases with a view to substitution for the standard type of box or crate of heavier lumber. This type of construction will not only be more economical as regards cost, weight and storage space, but it is believed it would be more logical for use in an emergency. The results of the tests indicate that this type of box furnishes suitable protection for the items packed, and it has been adopted as standard in several instances.

Wirebound boxes will rpobably not stand as much reuse as the heavier wooden box, but their original cheaper cost will probably make them more economical and particularly at times when reuse of the box would not be warranted.

While corrugated or fiber board boxes are commercially replacing, to a great extent, wooden packing boxes, or crates, their use has not been undertaken or investigated to any great extent as a substitute for the wooden boxes in packing ammunition, and probably will not be, evidently because it has been felt that in the packing of explosives it is better to use the safer, stronger, wood box. There are, however, a few cases in which corrugated board or fiber board boxes are used in the packing of ammunition components. For example, certain pyrotechnics are packed in corrugated board containers, but these are in turn, however, in an outer container of wood. There are also two or three other exceptions. The wooden box, which includes the box of wirebound construction, is the better from the standpoint of long time storage, insurance against tampering, the number of handlings received, marking, and particularly where continued reuse is desired. With respect to this last point they may possibly be more economical in the end. Some investigation has been made on fiber drums for the packing of certain loose explosives as a substitute for metal containers and wooden boxes.

Some types of packing, as, for example, the packing of complete rounds in individual metal or fiber containers, are not required by the I.C.C. Regulations, but have been adopted for reasons peculiar to the particular ammunition or due to the desire to pack the ammunition in a certain way to meet certain conditions, as moistureproofness, or convenience in handling single units, or several units together, after being unpacked from the outer container in which several are shipped together. Such containers are designed without reference to the I.C.C. Regulations, but with reference to the Ordnance Department Regulations and the desires of the using Services to meet the particular purpose for which they are to be use.

b. Drawings and Drawing Policy.

For each container for packing ammunition there is prepared an assembly drawing, and where necessary additional detail drawings, and a packing and marking drawing. The present policy with regard to container drawings, principally with regard to the packing boxes, is that the assembly and detail drawings of a container will pertain only to the manufacture of that container, and that the packing and marking drawing will show the marking of the container and the necessary instructions for properly packing the ammunition and sealing the container. For example, a drawing of the packing box with metal liner for fuzes shows on the assembly drawing three views (plan and side and end elevations) of the assembled box, necessary notes regarding nailing etc.; the List of Parts required for the manufacture of the box and metal liner, List of Specifications, and other pertinent information. If this box has separators the construc tion of the separators will ordinarily be shown on a separate detail drawing, as will also the construction of the metal liner. All material used in the final packing, as for example, fillers, and instructions relative to packing, shall be omitted from the assembly drawing. The packing and marking drawing will have two representations of the box showing the marking required for proper identification of the contents, the shipping addresses, marking to comply with the I.C.C. Regulations and other required or informative marking. This drawing also carries packing instructions to cover the method of packing the contents, the final closure of the box and sealing to prevent tampering. A List of Parts and a List of Specifications covering materials used in the marking and sealing of the box are included. Where the packing of the contents is complicated and can not be clearly explained in the notes on packing instructions, a delineation of the box with part in section to indicate the contents in place may be added, to supplement and make clearer the packing instructions.

c. Regulations Governing Design of Container: Packing: Shipping.

1. I.C.C. Regulations.- The Interstate Commerce Commission under act of Congress has formulated a set of regulations, published in book form, covering the transportation by rail in freight, express and baggage services of explosives and other dnagerous articles. The Ordnance Department is primarily interested in the portion of these regulations dealing with the transportation of the explosives by freight, as practically all shipments are made in this manner. To aid in carrying out these regulations there has been set up by the American Railway Association, the Bureau of Explosives, which is maintained by the Association and is officially recognized by the Interstate Commerce Commission. This Bureau republishes the I.C.C. Regulations and publishes other regulations, furnishes inspectors, "who are stationed throughout the country to observe, investigate, and report upon shipping methods", and furnishes and publishes information relating to proper packing and shipping of explosives to aid the railroads and shippers. "The carriers utilize the services of the inspectors to enforce regulations and approved practices". Since Colonel B. W. Dunn was head of the Bureau, its republication of the I.C.C. Regulations - which leaves out certain summaries and adds only a list of railroads agreeing to the regulations, with exceptions - has been generally referred to as "Agent B. W. Dunn's Freight Tariff No. 2". It is now referred to as "Agent W. S. Topping's Freight Tariff No. 2".

The I.C.C. Regulations state that "Shipment of explosives offered by, or consigned to, the War and Navy Departments of the United States Government must be packed, including limitations of weight, in accordance with these regulations, or as required by their regulations". In general, in the design of the packing containers for ammunition the requirements for these containers are made at least as severe as the I.C.C. Specifications and in most cases more severe. It is required, however, that the marking on the container for proper classification of its contents for shipping purposes, be in exact agreement with the nomenclatures listed in the subject regulations.

These regulations classify explosives as "Dangerous Explosives, Class A", "Less Dangerous Explosives, Class B", and "Relatively Safe Explosives, Class C, and Non-Explosives Materials", depending upon the degree of hazard involved in the construction of the ammunition and attached to its handling and transportation. The explosives falling under each class are clearly defined and given a definite nomenclature to enable the proper classification by the shipper and by the carrier. Shipping clerks and agents connected with handling shipments for the carriers are trained in the specific nomenclature given under the different classifications and any material deviation from the wording of these designations would result in confusion, and in most cases, probably, in placing the ammunition in at least the classifications next above that under which it belongs, due to the desire of the person classifying to make sure that it would not be placed in a lower classification, or to actual misinterpretation of the erroneous nomenclature. This is the reason why it is required that shipments made by the Army show the proper nomenclature marking for proper classification. These regulations, in requiring packing in certain types of boxes or other containers, in accordance with a particular specification, do not generally require more substantial packing for explosives of the higher ratings.

2. Army Regulations and Technical Regulations.- General regulations governing the packing, marking and shipping of military supplies are set forth in Army Regulations 30-955. These regulations have a short section relating to the shipment of explosives, which requires compliance with the I.C.C. Regulations for packing and shipping of explosives and covers claims for damage. Regulations for the transportation by water of explosives are contained in Army Regulations 30-1270, which covers overseas shipments of materials by the Quartermaster Corps. Packing and methods of shipping of individual items of ammunition are usually covered in the particular Army Specification which covers this item, although such requirements for packing are usually stated in a general manner.

Methods of packing ammunition and components, and the marking of the containers, are given in Technical Regulations covering the different types of complete rounds of artillery ammunition, grenades, bombs, etc., though this matter is usually descriptive and instructive. However, Technical Regulations TR-1370A, "Miscellaneous Ammunition - Ammunition General", contains, as well, certain paragraphs on packing and marking which are mandatory.

3. Ordnance Department Regulations.- The Ordnance Safety Manual, Pamphlet No. 7224, under the Section headed "Packing, Marking and Shipping" refers to the various regulations (I.C.C., Army and other special regulations) for the packing of ammunition,

shipping and the marking of the containers for all types of shipment and prescribes compliance with the proper Federal Specifications and regulations, and where necessary, compliance with state and municipal laws and ordinances. This Section also details Safety Regulations for shipments. The Manual, under Sections for each particular item or component of ammunition, prescribes somewhat in detail the method used for packing the component, type of container used, the safety precautions necessary in packing, storage and shipment and marking of the containers. This little booklet contains much valuable information on all phases relating to safety. The Ordnance Office also issues Field Service bulletins which may cover details of packing or shipping instructions of a special nature or which supplement other regulations. Pamphlet No. 2036 - "Service Markings of Ammunition and Ammunition Containers" - has several plates showing the marking of ammunition boxes, but this pamphlet is principally of an informative nature. "The Standard Nomenclature Lists on the various items of ammunition give some information on the containers for the components, with, in some cases, plates showing the marking".

Of all the regulations, which govern packing and have a bearing on the design of containers, the I.C.C. Regulations are the most important, and in the design of new containers, they are followed, due consideration being given to the other factors involved.

d. Testing.

1. Connection with Design.- Whenever a new box or crate or some other type of ammunition container is designed, it may not be known whether the container will be strong enough to carry the contents satisfactorily to meet the Ordnance Department requirements, or the I.C.C. test requirements, although it may meet the construction requirements of the I.C.C. Specifications. Also, it may be desired to determine from time to time whether containers in accordance with old designs, which have not changed and which have not been previously tested, meet the requirements, or, in cases where such containers have actually failed in service, to determine as far as possible the nature of such failure with a view to correction. It may be desirable to determine the strength and satisfactoriness of an existing design before preparing a new design of similar type of construction. Further, it may be necessary or desirable to determine the satisfactoriness of other characteristics of the container.

2. Kinds of Tests.- Where and How Conducted.- In order to determine whether the container is satisfactory or not in every respect, to determine causes of failure, and to get a comparison of

its strength with other types of containers, it is necessary to conduct tests of it. Strength tests should be of such a nature that they give conditions simulating, as far as possible, actual transportation, handling, and storage conditions, and at the same time be of a sufficiently definite nature to afford comparisons of tests between containers of identical or similar types, or of different types. Tests to determine the satisfactoriness of other characteristics, as for example, moisture proofness, may be conducted so that conditions similar to actual service conditions - usually the worst - are met, or an accelerated test, giving conditions of greater severity than would be met in service, may be conducted.

Tests on ammunition containers, principally on boxes and crates, are conducted from time to time by the Packing Section and though the tests are usually mechanical tests of the strength of a container they sometimes include other tests, such as for moistureproofness, as in the case of fiber containers. Some of the tests are conducted at this Arsenal but usually those on the containers intended to simulate the hazards of handling and transportation are conducted by the Package Research Laboratory of Rockaway, New Jersey, which is a part of the 4-One Box Machine Corporation, Manufacturers of machinery for making a wirebound type of packing box. The tests conducted at the Arsenal are usually drop tests, static tests or packing tests for strength determination, and the other special tests on the various containers. Other tests, of an investigative nature to solve problems connected with packing are also conducted-for example, tests to determine effect on a box of variation of moisture content of the lumber, tests of possible substitutes for shellac varnish. Occasionally, containers loaded to weight, or filled with the proper material are shipped away by freight or truck, to be returned, to determine their ability to withstand actual transportation and handling incident thereto.

The Package Research Laboratory has two revolving drums which are now accepted as standard in the packing industry for tests on packing containers. A small hexagonal drum, 8 feet in diameter, is used for testing small boxes, and principally boxes of corrugated board or fiber board. The large drum, a 14 foot hexagonal revolving drum, is used exclusively for tests on containers for this Arsenal. This drum is similar to a drum of the same diameter developed by the Forest Products Laboratory for testing containers. The drum revolves at the rate of one revolution per minute, the box receiving approximately 6 falls within that time. Four baffles of two different types between sections of the drum, carry the box up some distance permitting it to fall on the side of an adjacent section, the height of fall depending upon the shape, size and weight of the container. The drops range from a drop of a few inches, and a slide along the floor of the adjacent section, to a drop of approximately six feet, clear across one section onto the second, depending upon the shape of the container and location of the center of gravity. The drops also range from a flat or broadside landing to a landing on one edge or a corner.

The general rule for shipments as stated by the director of the Package Research Laboratory in one of his test reports, is as follows: "A satisfactory container is one which, in a series of five or more tests in the 14 foot drum, fails at an average of not less than 15 drops with no container failing before the 10th drop". He stated that the believed that it was of no use to continue the test on boxes beyond 15 drops in accordance with this definition. However, in tests of containers by this Arsenal, the tests have been run to 30 drops before completion, due to the desirability of obtaining a container stronger than the ordinary. Boxes which stand this number of drops successfully, or can stand well beyond the 15 drops should, according to the definition, be able to withstand any hazards of transportation.

The design and construction of packing depends to a large extent on the nature of shipment and the intended use of the ammunition packed, and falls into the following classes:- Packing of complete rounds of all types or components in containers in which this ammunition will be finally issued to the Using Services; packing of components for inter-arsenal shipment or shipment to Field Depots for use in renovation work or assembly of new complete rounds; and packing of components for intra-arsenal movement or temporary storage pending the assembly into complete rounds.

<u>1</u>. Complete Rounds or Components for the Using Services.- Packed for issue:- Complete rounds are practically always packed in containers in which they will be finally issued to the using Services, even though they may be stored in War Reserve for a number of years. Such storage in the containers used for issue obviates the necessity of transfer from other types of containers at the time it is desired to issue War Reserve ammunition. The design of the containers depends upon the special requirements for issue, convenience in handling, transportation, etc., of the different services using the ammunition. For example, complete rounds of artillery ammunition of the medium caliber are packed individually in fiber containers to afford complete packing and moistureproofness to each round and to permit the handling of these complete rounds in single units. For pack howitzer complete rounds, the size of the box, and weight per box, must be such that they can be conveniently packed on, and easily carried by, the pack animals. Bombs are packed in a manner which permits of convenient handling in transportation, i.e.,

in metal crates or with shipping bands, depending upon the size of the bomb. Certain components of ammunition are shipped as such directly to the using Service for issue separate from the complete round. Examples of those are fuzes for complete rounds shipped without fuzes and components used in making up complete rounds of separate loading ammunition for the large caliber guns, in which projectiles, fuzes, propelling charges and primers are each packed separately. The packing for some of these may be of the same nature as that for components which are shipped from one Arsenal to another, as, for example, the packing for primers or fuzes.

2. Components for Other Arsenals or Depots.- Components packed for shipment to other Arsenals or Field Depots for assembly into complete rounds are usually packed in as economical a manner as possible, the containers being designed to carry the maximum number that may be handled conveniently and taking into consideration the hazard involved in the packing, i.e., limiting the quantity in each container to a certain amount dependent upon the nature and amount of the explosive in the component and its characteristics.

3. Intra-Arsenal Storage.- Complete rounds of ammunition or components assembled at an arsenal, which are to be stored there in War Reserve for shipment at some future time, are packed in the same manner as under the headings prescribed above, standard packing being used for this purpose. Where components are assembled or loaded at an arsenal for later use in assembling into complete rounds at the same arsenal, it is not necessary that these components be packed in the same containers which would be used for interplant shipment, unless the storage of the components is likely to be for some length of time and it is desired to pack them in a moisture-proof container, or there may be a possibility of shipping them out. The standard packing for shipment may then be used, or other improvised packing which will give the same results. Where moisture-proofness is not necessary any type of secure, improvised packing designed by that Arsenal for its own use, may be used.

At this Arsenal such improvised packing is often obtained by using old boxes which may have been intended for another component, or special packing may be designed for use in temporary storage of the ammunition. An example of such type of packing is that for temporary storage of the M20 Booster before assembly into the complete round. The standard packing for shipping this booster was formerly a metal lined box, with wooden separators inside, used for packing 50 boosters. (The present packing consists of individual cardboard cartons in an unlined box). For temporary storage here, fiber containers were purchased which held two boosters each. These containers have a screw cap and are waterproof by dipping in paraffin after the boosters are inserted in each. These containers are then packed in a hinged box for easy access, and the fiber containers as well as the boxes, may be reused a number of times. In this particula case this method of packing would undoubtedly serve as well for shipping purposes as the previous and present standard packing, though the metal lined box would probably be more convenient on the assembly line.

a. Types of Packing.

1. Boxes - Types.- Boxes for complete rounds of ammunition and components fall under three main types: end opening, chest type or hinged top, and screw top. End opening boxes are square or rectangular in cross section with the width of the sides varying, usually not being greater than 17 inches. The length is approximately 2-1/2 to 4 times that of the greater side. One of the ends is nailed in place, the other being removable, so that the contents may be drawn out longitudinally. This allows stacking in piles on the sides, and with the loose ends of less area than the cross sectional area of the box permits the boxes to be opened without being removed from the pile. With complete round boxes, the loose end is held in place by means of a carriage blot extending from one end to the other and a wing nut outside the loose end. Another type usually used for pyrotechnics has metal straps holding the loose end in place without the long carriage bolt, but with a wing nut holding the straps against the loose end. Metal strapping is almost always used to strengthen this type of box.

The chest type boxes are of all sizes and are used generally when easy access to the contents is desired and repeated use of the box is contemplated. The top is cleated for strengthening and provided with two hinges, and two hasps and swivels for securing the top. Boxes of the screw top type also are of all sizes and shapes, and differ somewhat in construction. Nails are practically never used for closing the tops of boxes, screws being used to permit reuse of the box and cover. The design of these boxes varies from boxes without cleats and with an under-cut groove on each end for hand holds, to boxes with four cleats on each end. One design of box which may be considered under this class is a box in which the top is secured by means of wing nuts screwed onto hooks fastened into the boards of the sides and ends, the wing nuts fitting into depressions in the top, in order not to project above the surface of the top. This type of box is more easily opened than with the ordinary screw top box and is used in some cases in place of hinged top boxes, in which quicker access to the contents is desired. Rope handles are used on end opening boxes for rounds of the larger caliber, in which the total weight of the box would be too great for handling without handles. They are also used on a few boxes of the other types, where the weight is excessive and they are desirable due to the handling the box will receive.

2. Crates, Metal and Wooden.- Crates are used for the packing and shipment of bombs and certain components which are of such a size and character that packing in a closed box, with its consequent protection from the atmosphere, is not necessary; and are used to add additional strength and give protection to metal containers in which are packed powder.

Crates are of two kinds, metal and wooden. The metal crates, of steel, are used entirely in the shipment of some of the smaller bombs, where rigidity and great strength are needed for proper protection of the contents, particularly the attached fins, against the hazards of transportation. They also make for convenience in handling the bombs. All other crates are wooden. Their construction varies from the lighter crates of 1 inch lumber, to the very strong crates for certain large caliber cartridge storage cases, made from 2" x 4" and 2" x 6" pieces. The designs also vary, depending upon the article or container protected. More detailed uses of crates will be given later.

3. Cartridge Storage Cases.- Cartridge storage cases are fiber or metal cylindrical containers used for packing propelling charges for separate loading ammunition. The fiber cartridge storage cases used in the past were for war time production, and were used with propelling charges for certain mobile artillery weapons where a container of great strength was not needed. These wartime containers consisted principally of a spiral or straight wound tube with crimped-on metal ends. A slip cover type of fiber container, similar to that used with complete rounds, has been developed, to replace the metal cases, for both peace time and wartime use in packing propelling charges for the 155 mm Gun and Howitzer and 240 mm Howitzer. The main advantages of the fiber cartridge storage case are: reduction in weight, reduction in cost, increased production, obviates necessity for salvage and reuse.

Of the metal cartridge storage cases the designs are many and varied, due to the difference in size and weight of the contents, different conditions involved and attempts made to improve various designs. The cartridge storage case must be airtight, as well as protect the contents against moisture, and must be able to retain this airtightness over a long period of time in order to properly protect the powder against deterioration. The case also protects the powder against possibility of ignition from heat or sparks. A rubber gasket is provided between the cover and body to procure a proper air seal, and the cover is provided with an air test hole, by means of which the case, when filled, and closed, may be tested to determine its airtightness. The method of closure usually consists of a spider arrangement on the cover which engages under a turned over flange on the open end of the body - or under lugs on slots cut in a rim band extending above the cover with a screw for exerting pressure through the spider on the cover, holding it tightly in place.

The case, in addition, must be of sufficient strength to carry a heavy load, to provide the necessary rigidity in order to prevent damage to the charge, and to provide, as far as is possible with the weight involved, a means of conveniently handling the charge. Some of the charges for the heavier guns, particularly the single section charges, are very large, weighing over 200 pounds, and require a very strong container to satisfactorily pack them. The steel case then is absolutely necessary. Some of the steel containers are crated to add strength and protect them against rough handling, because of the thin metal of the body. This is particularly true with certain types which have a wooden cover to protect projecting portions of the metal cover. This is an undesirable feature when the cases are not crated, as the wooden cover is larger in diameter than the body of the case and in addition to the possibility of being knocked off, causes trouble in stacking and shipping. In some recent designs a metal rim of larger diameter than the body is welded to it, and projects above all portions of the cover. This protects the closure and when an angle or rim at the bottom is provided, stacking and shipping are made easier. It has been recently decided to eliminate, as far as possible, the use of the wooden shipping cover in future shipment of charges. To effect this change, existing cartridge storage cases to be used for future shipment will be modified by having a rim band welded on to protect the cover, and any future manufacture of cases of this type will include this modification.

4. Fiber, Metal and other Miscellaneous Containers.- One type of container in common use for different purposes, principally for the packing of complete rounds, is known as a fiber container. The complete container usually consists of two tubes (the cover and body) each with one end closed with metal end, and each tube built up of layers of the same or several different paper board materials, secured with proper cementing materials. The thickness of the tubes vary considerably depending on the size, strength and amount of protection desired. The cover slides over a projection of one of the tubes of the body, hence this container is referred to as the "slip cover" type. The name "fiber container" has been taken from a trade name often applied to containers made of certain types of paper board products, though it is believed that the usual application is to boxes made from these materials.

The uses for this type of container are for the packing of complete rounds; propelling charges for separate loading mobile artillery weapons; hand grenades; assemblies of M20 boosters and fuzes; fuzes; etc.

Metal cans, of terne plate or tin plate, are used to a large extent packing individually, or in small quantities, small components of ammunition which it is desired to preserve against moisture. Metal liners for boxes, of terne plate or tin plate, are used in many cases in the packing of ammunition components, or in certain cases for small caliber complete rounds, where moistureproofness is desired. Packing of components in individual moistureproof containers is considered preferable to packing in metal lined boxes.

For packing primers or small fuzes, cartons made up from paper board products, which may be classed as fiber cartons, are used, a small number of the components being packed in each carton. These cartons are not only to provide protection for the component, but using the small quantity as a unit furnishes a means for convenient handling on the assembly line. Where moistureproofing of this type of container is desired. it is practically always done by immersing in hot paraffin, though some other moisture resistant material may at times have been used.

The containers discussed here under "Types of Packing", cover practically all the types of containers used for packing ammunition and ammunition components, but other means for use in packing, or for protection in shipping, ammunition and components, which would not be classed as containers, will be covered under the detailed packing for the ammunition and components in each case.

b. Detailed Packing.

1. Complete Rounds of Artillery Ammunition.- During the World War complete rounds of fixed or semi-fixed ammunition for the medium caliber guns were packed in fiber containers, rather thin walled, with metal ends, and tear strip soldered to the cover and crimped to the wall of the container; or in tin containers. A great deal of the 75 mm ammunition used during the War was packed in 9-round boxes of hinged cover type, and it is believed there are still many rounds left in War Reserve in this type of box. Upon renovation of rounds, in most cases, they are being repacked in the present type of slip cover fiber container and in the 4-round box or 3-round bundle. Packing for certain medium caliber rounds in the past, i.e., prior to, and during the World War, consisted principally of 4 and 6-round boxes, metal lined with screw tops (2.95" Mtn. Gun) and hinged tops (3" Seacoast and A.A. Guns, 4.7" Gun), in which the rounds, not in individual containers, were held in place by spacers; and unlined boxes (2.95") in which the rounds were packed in individual tin containers. Partitions were used even with these individual containers. The end opening box for four rounds made its appearance during the War. This type box was developed by a commer-

cial manufacturer of ammunition and used for the shipment of millions of rounds of ammunition to the British before our entry into the War.

The present policy of packing complete rounds of fixed and semi-fixed ammunition, except small arms ammunition, is as follows: Ammunition for the 37 mm guns is packed with 40 or 60 rounds in a single box of hinged top construction, with metal liner. Ammunition for the 2.24 inch Tank Gun is packed 12 rounds per box, in a screw top, metal lined box. This type of packing, for the 2.24 inch ammunition, has been in use since 1903.

For rounds above 2.24" packing is as follows: The 3-round packing bundle has been standardized for ammunition for the 75 mm Gun, M1897, the 75 mm Pack Howitzer, M1, and the 81 mm Mortar, M1; has been developed for 3" A.A. Gun, M1918 (Mobile) ammunition; and is being investigated for 105 mm Howitzer, M2, ammunition. The end opening packing box is used for ammunition for which the packing bundle has not been standardized. With each type of packing, each round is first packed in an individual fiber container.

The number of rounds packed in the end opening type of box depends upon the size of the round and weight of a full box. Rounds for the obsolete 75 mm Infantry Mortar were packed six in a box, those for the 105 mm Howitzer and 105 mm Anti-aircraft Gun are packed two ina box, rounds of 81 mm Mortar M43 and M44 (short) shell are packed eight per box. Rounds for other weapons are packed four per box. Rope handles are used on the heavier boxes to permit convenient handling by two men.

The adoption of the bundle method of packing complete rounds was the result of considerable investigation and test at certain posts. Tests were conducted by the 1st Cavalry Division Board with ammunition carts, in which some of the rounds in fiber containers were put up in bundles of six rounds, wrapped with hardware cloth with wooden or metal ends for the bundles, and with and without flat metal strapping around the containers. Tests at Aberdeen Proving Ground covering investigations of the limber for the 75 mm Pack Howitzer and of the ammunition trailer T8 included bundles consisting of three rounds in containers held together only by steel strapping.

As a result of these tests and investigation of other means of making up a bundle, there has been developed a special, cupped metal end for use in bundle packing. The bundle, then, consists of two of these ends connected by means of a carriage bolt and wing nut which hold in place three fiber containers with the complete rounds packed therein. The ends are of clover leaf design to permit nesting of bundles and as much utilization of space as possible. A flange around the edge protects the wing nut, and furnishes a hand hold. The drum tests conducted on this type of packing indicate it is satisfactory for packing complete rounds. Several rail shipments of 75 mm Field Gun ammunition, packed in bundles of this type, arrived in good condition. The designs of end plate and other accessories for 105 mm Howitzer ammunition have been developed, and these accessories satisfactorily withstood the revolving drum tests. Because of the weight of the complete rounds, the bundle for this weapon has been designed as a two-man load.

The use of packing bundles results in the exposure of the fiber containers to the elements and eliminates the protection afforded by the boxes, but test conducted at Fort Bragg on bundles in the open indicated that exposure of the fiber containers to the weather did no result in detriment to the containers themselves or the rounds which were packed therein.

The packing of complete rounds in bundles will, in most cases, result in a saving in shipping and storage space, a reduction in weight with consequent saving on freight charges, and a reduction in cost of packing material. In some cases, the three round bundle will be more convenient to handle than the four round box, the more handling will be necessary. Adoption of the bundle, in place of the present heavy box, where possible, indicates a desire to facilitate transportation in vehicles used by the artillery and handling by personnel, and to eliminate what is considered excess packing material.

The fiber container now used is of the slip cover type, in two parts, the cover and body, each with a metal end of terne or tin plate. The cover is made of one tube while the body is composed of three separate tubes glued one within another - an inner tube, intermediate tube and outer tube. The outer tube of the body is identical in construction with that of the cover tube and is built up of layers of different types of waterproof paper board materials, as asphalt impregnated Kraft paper and waterproof container board, several of which contain asphalt in their makeup, and it is the main moisture resistant and waterproofing part of the container. These tubes are made of a thickness sufficient to provide proper moistureproofing and to give, with the intermediate tube, proper strength to the container. The thickness is approximately the same on all sizes of containers.

The intermediate tube is usually of about the same thickness as the outer tube and provides additional strength to this tube as well as forming an extension over which the cover tube slides. The end of this tube also carries a ring which supports the complete round, in the case of fixed rounds, by means of the overhang of the cartridge case. With semi-fixed rounds the base of the cartridge case is usually raised slightly above the ring. The inside diameter of the intermediate tube is such that it allows only a slight clearance over the diameter of the cartridge case just in front of the base. With a tapered cartridge case the inside diameter of the container near the front end of the case is a great deal more than the outside diameter of the case. The container must furnish its own support along the length of the cartridge case. This intermediate tube is made up principally of layers of chipboard glued together.

An inner tube made up of several layers of chipboard and waterproof container board (which is two plies of chipboard with asphalt between) is glued inside the intermediate tube and extends from the metal end of the body tube to a point just in front of the rotating band of the projectile. This tube is of a little larger diameter inside than the bourrelet of the projectile and furnishes the support for the projectile to prevent its working loose from the cartridge case due to shaking around in the box, during transportation. This tube also strengthens the container and at the projectile end prevents mashing in of the tube, the projectile here furnishing some support. The thickness of this inner tube depends upon the amount of taper of the cartridge case, and in the case of the 105 m/m antiaircraft ammunition, particularly, it is about 9/10 inch.

In working up the design of the new type of slip cover container it was found that some means for supporting the projectile in the case of semi-fixed rounds to prevent longitudinal movement in the cartridge case would be necessary. For this purpose wood supports, of cylindrical shape with conical opening fitted to take the nose of the projectile or the fuze, were designed to be placed at the closed end of the body tube. In order to strengthen containers for fixed rounds, the wood support was used also in the containers for these rounds. These supports were at first designed to be removable so that the same container could be used for different rounds by insertion of a different support. This caused difficulties so the supports were glued and nailed within the inner tube, the nails passing through this and the intermediate tube. After the containers had been in use for some time it was decided to determine whether or not the wood supports were necessary to strengthen the containers. Tests were conducted and it was found that containers for fixed rounds, manufactured without the wood supports, gave sufficient strength. Accordingly, new drawings have been prepared covering fiber containers for fixed rounds in which the wood supports have been omitted. This has enabled, in some cases, a considerable shortening of the container.

With semi-fixed rounds, the projectile is supported, by its nose or fuze, on the wood block. The mouth of the cartridge case rests on the rear of the rotating band, and the container is so designed that when the cover is put on tightly and secured by the adhesive tape, the base of the case is still a short distance above the ring on the intermediate tube. This, then, prevents longitudinal movement of the projectile in the case.

When the M39A2 Fuze, or fuze of similar profile is used with 75 m/m Pack Howitzer and 105 m/m Howitzer ammunition, if packed in a container with a wood support with an opening turned to fit the fuze, there would undoubtedly be a wedging action and the fuze with projectile attached would wedge into the support and not come out with the cartridge case upon its removal from the container, but remain inside until force is exerted to remove it. To prevent this, a metal "gadget", called "packing stop", has been designed. This consists of two pieces of brass joined together by means of spring steel. The brass parts have projections which fit into the wrench slots on the fuze. A portion of the upper surfaces makes contact with the shoulder of the wood support. This prevents the projectile from wedging in the support, the brass pieces being of such shape that the inner tube of the container holds them in place. Since the two stops are joined on one side only, when they are brought past the inner tube they are actuated by the spring steel and forced out of the notches falling off of the projectile as it comes out of the container.

To place the round in the container is a rather difficult operation, requiring the use of twine and a certain amount of expertness in its performance. An objection to this method is that in the field when it is desired to replace unfired rounds in containers for further transportation and future use, the operation must be performed by troops who may not be skilled in the method, and the time may be limited. As the result of investigation and tests, a type of packing stop was developed which, it was believed, overcame the objections to the present type. This stop is automatically released from the projectile upon removal of the round from the container, and can be placed easily in position on the projectile when it is desired to return the round to the container.

The design of the automatic packing stop was considered unnecessarily complicated, and it was indicated by Field Service that a stop requiring manual removal would be satisfactory. A U-shaped stop of flat steel, heat treated, gave satisfactory results in drop tests, and following service test of caliber board orders of complete rounds, packed with stops of this design, it has been adopted as the standard for use with 75 m/m Pack Howitzer complete rounds.

Complete rounds of blank ammunition are packed individually in fiber containers which are of the same general design as the fiber containers for complete rounds, except that the body of the container is composed of only two tubes. These rounds are then packed in hinged top boxes carrying from ten to one hundred rounds, depending upon the caliber. This type of box permits reuse and easy access to the contents.

2. Other Complete Rounds.- Bombs, Grenades, Pyrotechnics.- Packing provided for the standard bombs is of two types. The 30-lb. fragmentation, and 100-lb. demolition bombs are packed with fins attached, in metal crates, two of the former and one of the latter to each crate. The components for the bombs - fuzes, swivel loops, safety clips, arming wire, primer detonators - are packed in an accessory tray in each crate, or otherwise secured in the crate.

The 300-lb., 600-lb., 1100-lb., and 2000-lb. cylindrical demolition bombs, now standard, are shipped without fins, and with shipping bands around the body for ease in handling, and to protect the suspension lugs. The fins for these bombs are packed one each in a wire-bound box, in which there is also packed an accessory box of the same type of construction, containing the other components for the bomb. Packing for the formerly standard bombs of the streamlined type is similar, except that the 2000-lb. bomb is shipped without suspension lugs, since these are assembled in the field; and the fins and accessories are shipped in crates of 1 inch lumber. A wire-bound box was adopted for the 300-lb. Mk. IMI bomb fin and accessories before investigation for use with the new types.

The packing just described for the standard bombs is for war time shipment. For peace time shipment, the fuzes are packed in bulk and are issued directly to the organizations in this manner. The fuzes of the type which use the Mk. IIB primer-detonator are shipped inert. Primer-detonators used in these fuzes are also shipped in bulk for assembly into the fuzes at the time the latter are placed in the bombs. Adapter-boosters are shipped assembled in the loaded bombs.

The M36 Practice Bombs (Miniature) are packed, empty, in wire-bound boxes, with the cartridges shipped in bulk. The M37 Practice Bomb bodies and parachute units are packed separately in wooden boxes.

The non-standard bombs, 17-lb., 25-lb., 40-lb., 50-lb. and certain 100-lb. and 300-lb., are packed in boxes or crates, ranging from five to one per package. The components are shipped in different ways, in a few cases certain ones are assembled to the bomb for shipment, but most are shipped in bulk.

Grenades were formerly packed in three ways: (1) With the grenade and fuzes or other components each in a separate compartment of the same box. (2) With the grenades and grenade fuzes each in separate boxes. (3) With the grenades shipped fuzed. The Mk. II fragmentation hand grenades, assembled with fuzes, - H.E. and practice - were packed 10 in a box, with metal liner. The present standard packing for the Mk. II practice and fragmentation hand grenades, and chemical hand grenades, consists of individual fiber containers for the fuzed grenades and unlined wooden boxes holding 25 grenades.

The fiber containers were developed to permit retaining the grenade as long as possible in such a manner that the firing mechanism is not exposed and is thereby kept protected against accidental operation, and at the same time to provide moistureproof protection to the grenade during this period. This will permit carrying the grenade in the belt, and consideration has been given to this feature. The grenade need only be taken from the container at the time it is to be used. This container is similar in consturction to complete round fiber containers and is water-proofed by sealing the joint with adhesive tape after packing.

Pyrotechnics are packed in various ways depending on the nature of the material, size, shape, etc. Small smoke charges are wrapped in a cylindrical waterproof bundle and several of those packed in an unlined box. Certain air and ground signals are packed in corrugated board cartons, waterproofed, several cartons are packed in corrugated board carton containers, then one of these in turn packed in a box, usually of the end opening type. Aircraft parachute flares, which are considerably larger than the signals, and vary in size, are packed one or two to the box. For the M8 and similar flares, the formerly standard box for the two flares was rather an elaborate affair, with padded spacers, for holding the flares in place, padded ends and a wedge on one side for tight packing.

The M8A1 Flare is now packed, without suspension bands, in an individual fiber container, similar to that for complete rounds. This type of packing for the flare is considered moisture proof and equivalent to hermetical sealing, and for this reason when flares are packed in this manner, the life is indicated as six years, whereas with the previous type of packing it was only three years. When the fiber container was first adopted, two flares were packed in the old two-flare box, with the elaborate spacers removed. The present practice is to pack the flares in single-flare wirebound boxes, without suspension bands. Where required, the suspension bands are shipped in wirebound boxes, twenty per box.

3. Components.

(a) Policy on Packing of Empty Components.

Although at one time drawings were prepared to cover the packing for certain empty components, as cartridge cases, projectiles, etc., the present policy is that packing for empty components of ammunition will not ordinarily be provided. For commercial procurement, any type of packing may be used which will be acceptable to the carrier and will insure safe transportation of the articles. This is in line with requirements for packing given in specifications relating to other types of material for the Government.

There are certain exceptions to this policy with regard to packing of empty metal components which apply to certain articles in general or in specific cases, for example, packing is prescribed for the peacetime shipment, in bulk, of certain inert bomb fuzes, (previously discussed) from the manufacturer to the organizations, In this case the type of packing is prescribed to insure the proper protection to the components, due to their nature and possibility of damaging the fins, and also because the fuzes are issued as shipped originally, and the packing must meet the requirements of the using Service.

In the particular case of adapters and boosters, or bomb adapter-boosters, the metal parts are usually made at Frankford Arsenal or taken from renovated rounds, and loaded at Picatinny Arsenal, (peacetime manufacture). In the case of those in which the metal parts are shipped here from Frankford, the same packing is used as is used after the parts are loaded for shipment elsewhere, as this avoids the necessity of having two kinds of packing for shipping the same item. Frankford Arsenal then makes the boxes or used boxes sent in by Field Depots where ammunition has been renovated and ships the empty components in these boxes.

Practically the same procedure is followed in the case of primers. At the present time Frankford Arsenal makes practically all primer bodies and primer percusssion elements. The empty bodies are shipped to Picatinny Arsenal for loading in the same cartons, or cans, and packing boxes which are later used for shipping the loaded components, the metal lined boxes being not sealed except that when the primers are to be used for assembly into complete rounds at this Arsenal, the bodies, in the cartons, are usually shipped in corrugated board boxes. The percussion elements were formerly assembled to the bodies for shipment, but are now shipped separately in paper tubes and corrugated board boxes.

Although the shipment described above for empty adapter booster and primer bodies are special cases for peacetime requirements, the same procedure may be followed in time of war in certain cases for shipment of empty components from a metal components plant to a loading plant.

Empty 3 inch A.A. projectiles have been shipped in corrugated fiber board containers, 6 projectiles to a container. Such packing, of course, furnishes very little support to the projectiles which need none, but supplies the proper protection to the rotating bands and furnishes a means of handling a number as a convenient unit. In the future, following a recent decision, all empty projectiles up to and including 105 mm will be shipped in solid fiber containers. This requirement will be provided for in the specification. Cartridge cases are often shipped in corrugated fiber boxes, to facilitate handling and protect the cases.

(b) Projectiles.- The methods of shipping projectiles are in boxes, in crates and unpacked with rope grommets. In the case of small or medium caliber projectiles, if the shell loading plant is not at the same location as the complete round assembly plant the loaded projectile will probably be shipped to the latter from the former in boxes with adapter closing plug inserted in the projectile to keep out dirt. However, this is not a condition desired as it is preferable to have the shell loading and complete round assembly plants at the same location. Considering only field shipment, the only case where loaded projectiles are boxed is with the 155 m/m Shrapnel, which are shipped fuzed and must be boxed for protection to the fuze, and due to lack of convenient means of handling these projectiles individually.

All other separate loading projectiles are shipped crated or with rope grommets, eye bolt lifting plugs being provided with point fuzed dummy projectiles, in addition to the grommets, to facilitate handling. The shipment of projectiles, depending upon the type, will be made, in general, in accordance with the following basic rules; point fuzed shell with fuzes or false ogives will be crated; point fuzed shell without ogives - rope grommets and eyebolt lifting plugs; base fuzed shell with fragile parts, as false ogives, steel caps, and windshields - crated; base fuzed shell without fragile parts - rope grommets; dummy projectiles - crated; cast iron projectiles - rope grommets.

The rope grommets used with projectiles are for the purpose of protecting the rotating band during shipment and storage to prevent scarring or serious deformation of the band which might affect the ballistics of the projectile. These grommets are of two types, one in which an eye or loop is spliced into each end of a short piece of rope, and the ends tied together by means of twine after placing the grommet around the rotating band; and another type in which the ends of a short piece of rope are spliced together to form a ring of the proper size. The former type is more easily applied or taken off as it can be easily tied and untied, but is apt to have one point, where the two ends do not come together, where the band is not properly protected. The latter type gives more uniform protection to the rotating band all around, but is harder to remove and replace on the projectile (an operation which is often necessary during the painting of the projectiles). Eye bolt lifting plugs are used with point fuzed projectiles which are shipped unfuzed to aid in handling and are of sufficient strength to take the weight of the projectile.

(c) Fuzes.- Fuzes are packed in individual metal or fiber containers or in metal lined boxes which are hermetically sealed for protection against moisture. Exceptions to this are: (a) Inert bomb fuzes, which are shipped in unlined boxes, no protection against moisture being needed due to the absence of explosives; (b) Grenade Fuzes, which in the past have been packed in unlined boxes, but for which packing consisting of fiber cartons similar to those used in the packing of primers has been designed for future use; (c) M38 minor caliber base detonating fuzes, which are packed in a fiber carton.

For 21-second fuzes, a metal-lined box has been adopted as standard in place of the former type of individual packing can. An investigation and contact with a commercial manufacturer have resulted in the development of an individual packing can of a commercial type for use in packing these fuzes, in cases where individual packing is desired. A number of cans were purchased for use on a production order and actual packing of fuzes in the cans indicates that cans of the design furnished should be satisfactory.

(d) Adapters and Boosters and Adapter-Boosters.- Ordinarily adapters and boosters, and adapter-boosters for bombs, of a type which consists of a metal adapter and a booster casing with tetryl loading, are packed in unlined boxes with separators for supporting the adapters and boosters. Liners are not considered necessary for this type of adapter and booster as the component itself is sufficiently waterproofed. For packing boosters of a different type in which there is a detonating element, in addition to an explosive charge - as for example, the M20 Booster,- metal lined boxes are used, as in the case with detonating fuzes. Since these components are shipped only from the loading plant to complete round assembly plant, they are packed in as large a quantity as can be conveniently handled, although some of the boxes of bomb adapter-boosters weigh over 300 pounds.

(e) Primers.- Primers for domestic shipment, i.e., in the continental limits of the United States, are packed in cartons made of paper board materials, as chipboard, strawboard, news board, etc. in quantities of ten or fifty, depending upon the size of the primer. These cartons are hermetically sealed by dipping in paraffin or by use of some other material; for example, cartons in the past have been waterproofed by painting over with shellac. These cartons are then packed in metal lined packing boxes for additional protection against moisture. The packing of primers in small quantities in the cartons provides an easy and convenient means of grouping them for packing and for use in the loading plant and on the assembly line. For certain primers, packing in tin containers in place of, or in addition to the carton is provided, for additional protection, or in some cases as indicated, for overseas shipment. The same quantities are packed in the tin containers as in the cartons. These are in turn inclosed in a box without metal liner.

The waterproofing of the individual cartons, although packed in a terne plate lined box, serves as an additional precaution in case a box may be left open for some time. The packing in the tin containers instead of cartons insures the moistureproofing of the primers in the small containers after the box is opened, as the metal containers furnish more positive protection from moisture than the paraffined carton. This permits moistureproofing of the primers in a damp climate until each small container is opened for actual use on the assembly line. The boxes are of the size for convenience in handling and economy of material without containing an undue amount of explosive. Primer-detonators for bombs are usually packed in tin containers, the Mk. IIB in the same container for bulk shipment which is used for complete round shipment in the bomb crate or fin crate.

4. (a) Smokeless Powder.- For shipment of loose smokeless powder for cannon, there are provided two metal lined boxes in which the lining is of zinc or copper, usually the former; one of 110-lb. capacity and the other 140-lb. capacity. The 140-lb. capacity box has been recently redesigned, by sloping the sections of the liner top toward the opening, to facilitate emptying the box. Small steel boxes, or more correctly drums, are used for the shipment of ballistic samples from one arsenal to another.

An all steel propellent powder box of the type used by the Navy Department has been in use for some time in the shipment and storage of powder within the Arsenal, and has recently been adopted for use for inter-plant shipment of propellent powder.

Propelling charges for separate loading ammunition from 155 mm and up are packed in cartridge storage cases for shipment, storage and issue to the using Service. Fiber cartridge storage cases are now standard for the 155 mm Gun and Howitzer charges and 240 mm Howitzer charges. Fiber cartridge storage cases are packed for shipment in 3-round bundles, in the same manner as complete rounds in fiber containers. For the other calibers, steel cartridge storage cases are provided. These have been covered more in detail previously. For packing in the cartridge storage cases, propelling charges are classed as single section, base and increment, or multi-section or aliquot parts. Depending upon the length of container used, size of the charge, etc., the charges are packed in the containers with from five charges to the case to as many as four cases for each charge. The aliquot part and multi-section charges are used with the heavier guns, where, due to the weight and for ease in loading the gun, it is necessary to divide the charges, although single section charges have been used with as high as 16 inch guns.

(b) Black Powder.- For the shipment of black powder, sheet steel cylindrical drums of 25-lb. capacity are provided. These drums have circumferential corrugations in order to strengthen the walls and have an opening on one end for filling and for removal of the powder. The standard type has an oval shaped opening in the center of the end and is fitted with bronze slides, in which the oval shaped cover of steel, with felt paper secured to the lower side, is slid into place and fastened. These containers are formed with a double lock seam running vertically, where the two edges of metal are joined, which is intended to be moistureproof. However due to the thinness of the metal and rough handling often received, seams loosen up in many cases and allow sifting out of the loose powder and entrance of moisture. To prevent this, a cloth bag is used for powders for the finer granulations, the bag being placed inside the drum, filled with powder and then tied before closing the drum. Regulations prescribe that black powder drums for overseas shipment shall be crated, two drums per crate being the usual method.

Black powder charges in bags, made up as practice charges for bombs or projectiles, are packed sometimes in metal lined smokeless powder boxes of 110-lb. capacity with proper markings to indicate the contents, and are sometimes packed in cartridge storage cases. They may also be shipped in the metal powder container. There may be left in storage some black powder (loose) in 50-lb. metal containers or in the 110-lb. smokeless powder boxes, but after using the powder in these containers, they should not be again used for this purpose.

5. Loose Explosives.- Loose TNT, Explosive "D", or tetryl are usually shipped in a standard packing container for these explosives which consists of a rectangular box of 5/8-inch lumber, corner locked and glued, and complying with I.C.C. Specification No. 14, or in a box of nailed construction, with heavy ends, complying with the same specification. Heretofore, the boxes were lined with strong paraffined paper, or other waterproofed paper, in such a manner that there were no joints at the bottom or sides. I.C.C. regulations now require a strong, sift-proof cloth or paper bag as a liner for these boxes. Some Explosive "D" now in storage, packed prior to the adoption of a standard container, is packed in wooden kegs of 100-lb. capacity, lined with a strong paper bag or in paper-lined boxes of 50-lb. capacity.

IV. MANUFACTURE.

a. Materials Used.- The materials required for ammunition containers and for use in packing are numerous and varied, and to use or prescribe them requires at least a general knowledge of their make-up and uses. The principal materials used in the construction of the containers themselves are: lumber for boxes and crates; plain lumber or plywood for separators inside the boxes; terne plate and tin plate for metal liners of boxes, individual terne plate or tin plate cans for packing components, fiber container ends, etc; steel for cartridge storage cases and other metal containers; zinc or copper for smokeless powder box liners; paper and paper board products as chipboard; kraft paper, waterproofed kraft and chipboards, for manufacture of fiber containers and cartons. Other materials used as portions of containers or inside the containers or for other purposes connected with packing, and materials used in marking boxes are: strawboard, chipboard, and other paper products used as fillers in packing boxes; paints, inks, and related materials used for marking, waterproofing or protective coatings; paraffin, used for waterproofing; rope for grommets for projectiles and packing box handles; rubber for cartridge storage case gaskets.

Although a few drawings may call for certain proprietary articles or methods, the Ordnance Office has adopted the policy to be applied to new drawings and revisions of old drawings, of omitting reference to a proprietary article or method. Where the possible use of a proprietary article is desirable, a note is added to the effect that "any suitable substitute approved by the Chief of Ordnance may be used".

b. Strategic Materials and Substitutes.- Certain materials used in the manufacture of ammunition and ammunition packing are classed as strategic materials. Where possible, substitutes are to be provided for these strategic materials which will be suitable for use in their place. If no substitute is entirely satisfactory, a material will be provided where possible for use in place of the strategic material if, during a period of emergency, the strategic material becomes unavailable. On the drawings the substitute may be called for as the standard with the strategic material as alternative, or vice versa, depending on whether the two are on about equal terms, or the strategic material much better. A study has been made, and some work has been done in the past, towards eliminating strategic materials in connection with packing, or determining suitable substitutes.

Materials used for packing of ammunition which are classed as strategic are: Antimony, tin, rubber, shellac, sisal, jute, and manila fiber. Tin is used in soldering and in tin plating on ferrous sheets. Principal uses for tin plating are box liners, fiber container ends and rings and metal cans. One of the substitutes proposed in the place of tin plate, and specified as the standard on drawings, is terne plate. Another substitute is shellacking or parkerizing of the black metal sheets, or use of some other protective coating which will prevent rusting. Tin as a component of solder, has not been entirely eliminated, though its proportion is reduced by using a solder of low tin content. Antimony, which is sometimes used in solders, can be eliminated by the use of solders not containing this material. Manila fiber, jute, hemp, and sisal are used in the manufacture of rope which is used as rope grommets or packing box handles. Rope handles on packing boxes may be eliminated by using cotton wobbing, metal handles, undercut grooves, or cleats, though the grooves and cleats are not in some cases suitable substitutes. An investigation was conducted on a fiber grommet for projectiles as a substitute for the rope grommet but this particular material investigated was not suitable for this purpose. Possible substitutes for this type of grommet are heavier cotton rope grommets, although this type grommet is not considered very satisfactory. Shellac varnish is used over the paper seals in the seal recesses of packing boxes, and as a protective coating on such items as data tags and labels. Following investigation to determine a suitable substitute for shellac varnish which included investigation of commercial varnishes of a non-strategic nature, phenol formaldehyde resin (bakelite) varnish has been adopted as standard, to replace the shellac varnish, with the latter as an alternative.

V. PACKING, SEALING AND MARKING.

a. Packing and Sealing Containers.- Under the latest system, the packing and marking drawing will give instructions covering the packing and sealing of the containers. Where the arrangement of the contents is not complicated detailed instructions are not given, the arrangement of the material being obvious. The contents are placed in the container in the prescribed manner, and in the case of boxes principally, the necessary fillers are added to insure tight packing of the contents. Where the packing is complicated, detailed instructions are given, and if necessary, a delineation of a portion of the contents in place to supplement the instructions is added, to insure proper placing of the contents.

Individual metal containers for components, metal cans and liners for a number of components, and other metal containers for materials, where such packing is intended to be moistureproof and airtight, are tested for airtightness after sealing the containers, by means of an air testing apparatus and gauge, using a small air test hole in the container. After the test, this hole is sealed with solder, or a plug. The usual pressure used in testing is 2 pounds per square inch. Fiber containers and fiber cartons can not be air tested, but methods are used for sealing them which are based on procedure established after experimentation.

Each container, after the contents are properly packed, is sealed in some manner which will indicate, before it is opened for issue or use of the contents, whether or not the container has been tampered with. The method of sealing depends upon the type and construction of the container. With screw top and hinged top boxes, paper seals are placed in large counterbores in the top and bottom of the box and covered over with shellac. A screw under the seal fastens the top or bottom boards, and it is access to this screw without indication which the seal prevents. Where metal strapping is used around boxes of these types, the paper seals are not necessary and will not in future be used.

Hinged top boxes are also sealed by means of car seals, one with each swivel and hasp, which principally serve the purpose of securing the hasps in place. These seals are used also with end opening boxes, for sealing the loose end, these boxes having strapping around the sides which serves the purpose of a seal there. Car seals are used also with cartridge storage cases and packing bundles.

b. Marking of Containers.- All outside containers, or items of ammunition shipped without packing (as the larger bombs shipped with shipping bands), must be properly marked by painting, stamping, or stenciling. This marking is for the purpose of furnishing certain essential information "to permit an intelligent handling, storage and issue of the round or component", and to do so must properly identify the contents. Such information includes the following name or nomenclature of the items or materials packed with proper descriptive information, quantity packed, lot number, month and year packed, gross weight of container and contents, cubical displacement, Ordnance Insignia (indicating Ordnance property), Ordnance Escutcheon and inspector's stamp (to indicate proper inspection), marking to comply with the I.C.C. Regulations for proper classification of the contents, and shipping addresses.

Boxes and crates are marked as follows: A complete description of the contents with lot number and date packed is given on one side. The other side is used for shipping addresses and other shipping data and the lot number is also included. The ends are marked with lot number, Ordnance Insignia, and as complete a description of the contents as space will permit. This should be as complete as possible, as boxes are generally stacked in stores with ends out. The marking on the top consists of lot number, Ordnance Escutcheon and inspector's stamp, and I.C.C. identification marking. This identification marking must be identical with one of the items in the lists of explosives given under each classification, but may be amplified - by adding after the proper I.C.C. Marking. Steel cartridge storage cases are marked in a similar manner.

c. Data Cards.- Data cards are prescribed for use with all items of ammunition containing explosives, except loose explosives in bulk, and are usually required by specifications for non-explosive materials procured for use with ammunition. One data card is placed in every box (two in metal lined boxes, one inside and one outside the liner) and one attached to every crate, or large item inclosed in a crate. Cards attached, which would be exposed to the weather, are inclosed in a waterproof envelope. The data card gives all necessary information for proper and complete identification of the item or component - lot number of the metal part or parts and lot numbers of the various components, manufacturer of each, date manufactured or loaded, name of loader, date assembled or loaded, etc., number in lot.

VI. CONCLUSION.

An endeavor has been made to cover the subject of the packing of ammunition and ammunition components in all phases, with the standard and accepted methods of packing more or less given in detail, to present a view of this broad subject as comprehensive as possible in the time allotted. Experimental packing has been given also where it helps to amplify the subject or to stress certain points. General methods of packing the ammunition and specific methods and types of packing are indicated and prescribed in several places - Ordnance Safety Manual, Standard Nomenclature Lists, different regulations - but to determine the exact nature and construction of the packing used for a specific item, it is best to refer to the latest drawings covering the packing of the item, and to the drawing covering marking of the container for the proper and exact marking.

REFERENCES

Lecture: "Past and Present Practice of Packing Complete Rounds of Artillery Ammunition",- S.P. Lewis.

Regulations for Transportation by Rail of Explosives and Other Dangerous Articles in Freight, Express and Baggage Services, Including Specification for Shipping Containers", I.C.C. Regulations, (or "Agent B.W. Dunn's Freight Tariff No. 2"; Bureau of Explosives Publication.)

Army Regulations 30-1270, "Transportation by Water of Explosives, Inflammables, and Chemical Warfare Materials".

Ordnance Safety Manual, Pamphlet 7224.

Complete Round Charts.

Technical Regulations TR 1370 A "Miscellaneous Ammunition-Ammunition, General".

"Service Markings of Ammunition and Ammunition Containers" Pamphlet #2036.

Sketch GA 1360 - "Packing Data for Bombs and Bomb Components - Complete Round or Component Shipment".

Sketch GA 1370 - "Standard Packing for Standard Service Rounds".

Standard Nomenclature Lists.

Training and Technical Regulations.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 14. PACKING, STORAGE AND SHIPMENT OF AMMUNITION.

B. Storage of Ammunition.

Regulations governing the storage of explosives and ammunition at Ordnance Depots are contained in the Ordnance Safety Manual No. 7224, 1931. However, paragraph 45 b, Section IX, "Storage" of the Manual, states that Manufacturing Arsenals, which have the older type of magazines and which cannot comply with the regulations set forth in the Manual, will comply with the spirit of the regulations and endeavor to obtain the maximum protection against fire and explosions, and to limit deterioration to the minimum, provided, however, that the Commanding Officer must make a specific written report of any mandatory requirements which he may consider impossible of application at his establishment. Further, he is authorized, in fact urged, to prescribe and enforce such additional safety regulations as may be needed to meet local conditions which are not covered by the general Safety Regulations.

The Quantity--Distance Tables contained in the Ordnance Safety Manual as well as the Storage Chart, which shows the explosives, ammunition, etc. which may be stored together, are unconditionally followed by Picatinny, although the "Types" of magazine prescribed for the storage of various commodities cannot be used as they do not exist.

Safety measures, which are considered especially vital in connection with the storage of explosives and ammunition, are as follows:

(1) Containers must not be opened or repaired in a magazine. This work must be done either in a building specifically set aside, or in the open at least one hundred (100) ft. from a magazine.

(2) Explosives and ammunition in open or damaged containers must not be stored in a magazine.

(3) Loaded material must be protected against extremely high temperatures, (over 85°F.) and as far as possible against sudden changes in temperatures. (The latter may damage air tight containers or may result in excessive condensation of moisture in the air.) If the temperature in a magazine exceeds 100°F. for

a period of more than twenty-four (24) hours, the magazine must be cooled by wetting the exterior of the building with water or by opening doors and ventilators after sunset and closing them in the morning. If this method fails the Commanding Officer must decide whether the stores are to be removed and if so report such case to the Chief of Ordnance.

(4) Containers must be free from dirt and grit before being placed in a magazine.

(5) Dry grass, leaves, and underbrush, capable of being ignited by sparks from locomotives, smoking, etc., must be cleared for a space of fifty (50) ft. around all magazines.

(6) Inflammable dunnage, crates, etc., will be eliminated or reduced to the minimum in magazines containing separate loading, unfixed shell and demolition bombs.

(7) As Black Powder is regarded as one of the worst known explosive hazards, the following rules should always be kept in mind.

   a. Never use tools or equipment made of metals which may cause sparks, in a Black Powder Magazine.

   b. Wear safety shoes or rubbers. (When handling loose Black Powder rubbers are prohibited, due to the probability of building up body charges of static.)

(8) High explosives in boxes must be handled with care and personnel should wear safety shoes although the use of same is not definitely required in regulations.

(9) Smokeless Powder should be closely observed for signs of deterioration, as it will ignite spontaneously after deterioration has progressed to any marked degree. The odor of ether or alcohol is a normal one, but the acrid odor of nitrous oxide fumes is a certain indication of advanced deterioration.

(10) Remove spilled grains of Smokeless Powders, especially of small calibers, as many small arms powders are nearly as sensitive to friction as Black Powder.

(11) Do not expose Smokeless Powder to direct rays of the sun for any long periods of time.

(12) Handle boxes of Smokeless Powder with care, as seams are easily ruptured in the inner container, thus allowing air and moisture to enter, which are conducive to impaired stability.

(13) Separate loading Shell will be closely observed for signs of exudate. Fuzed projectiles will be rolled slowly to prevent arming of the fuze.

(14) Demolition Bombs must be handled carefully. They are regarded as one of the most hazardous type of ammunition to store, because of the tendency to detonate en masse. Look for signs of exudate. Never ship Bombs with primer detonators in place.

(15) Primers, Detonators, Fuzes, etc. must be handled with extreme care, even when properly packed.

(16) Pyrotechnics should be handled with extreme care. Boxes must not be dropped or thrown.

Explosives and ammunition when packed and stored in accordance with War Department Regulations are grouped, so far as the hazards due to fire or explosion, into the following general classes.

Class 1--Small arms ammunition and sodium nitrate. These are principally fire hazards and no limits are placed on the storage of material of this nature.

Class 2--Smokeless powder and pyrotechnics. These materials may become unsafe under extreme conditions of moisture and high temperature. They burn with intense heat but do not usually form missiles or generate pressures which cause serious structural damage to adjacent magazines.

Class 3--Point-detonating fuzes, minor caliber base-detonating fuzes, powder train and mechanical time fuzes packed separately in boxes. The amount of explosives in articles of this class varies from 30 to 250 grains. These fuzes usually explode progressively, not more than a box or two at a time. Pressures which would cause serious structural damage to adjacent magazines are not usually generated, and missiles are small and of light weight, usually falling within 100 yards.

Class 4--Fixed high-explosive shell, 3-inch trench-mortar ammunition, fragmentation bombs, grenades, and shrapnel of all calibers, fuzed or unfuzed, packed in boxes. Articles in this class usually explode progressively, only a few boxes at a time, many explosions of individual rounds being of a very low order. Pressures which would cause serious structural damage to adjacent magazines are not usually generated and most missiles would fall within 200 yards.

Class 5-- Separate-loading or unfixed loaded shells of all calibers, loaded with explosive D, fuzed, or unfuzed. These shells usually explode one at a time, and in practically all cases with low order. As only one shell should be involved in an explosion, the missiles are limited both as to number and range and most missiles will fall within 400 yards.

Class 6-- Major and medium caliber base-detonating fuzes, bomb fuzes; and adapters and boosters for high explosive shell, for chemical shell, and for bombs, packed separately in boxes. The amount of explosives in articles of this class does not exceed one-half pound. They usually explode progressively, by piles. The numbers involved in any explosion is limited by making the piles small and separating them by prescribed distances determined by actual detonation tests. Structural damage caused by the pressures generated is usually limited to adjacent magazines and the missiles are light and usually fall within 200 yards.

Class 7-- Separate-loading and unfixed loaded shell of all calibers, except those loaded with explosive D. Shell in this class usually explode progressively by piles. The number involved in any one explosion is limited by making the piles small and separating them by prescribed distances which have been determined by actual detonation tests. Structural damage caused by the pressures generated is usually limited to adjacent buildings. Most missiles will fall within 500 yards.

Class 8-- Primers, detonators, primer-detonators for bombs, grenade fuzes, and blasting caps, packed in metal containers and wooden boxes. The amount of explosives in articles of this class varies from 30 to 110 grains. All in a magazine may explode at one time, but as the total amount of explosives involved is limited and the explosives are not strongly confined, structural damage is usually limted to adjacent magazines. This class of ammunition forms light missiles which have a very limted range.

Class 9-- <u>Bulk explosives such as black powder, T.N.T., tetryl, and explosive D.</u> The black powder usually explodes, and T.N.T., tetryl, and explosive D usually burn but may explode. Since these explosives are similar to commercial explosives, structural damage should not occur at the distances specified in the American Table of Distances for similar quantities of commercial explosives. Missile hazards are minimized by using a type of magazine construction which breaks up into small fragments in case of explosion.

Class 10-- <u>Demolition bombs.</u> All in a magazine may explode. If this happens, structural damage caused by the pressures generated should not occur at the distances specified in the American Table of Distances for similar quantities of commercial bulk explosives, and most missiles will also fall within these distances.

It is customary at Field Service Depots to assign certain magazines to certain classes of material, i.e., the Magazine Areas are divided into Smokeless Powder Sections, High Explosives Sections, Ammunition Sections, etc. This system is followed not only because of the fact that the various "Types" of Magazines are grouped in the Magazine Area, but because of the practical advantage of having all of one class stored in the same section for safety and supervisory purposes. However, no such arrangement is possible at Picatinny Arsenal as our manufacturing schedules are not uniform with respect to the various types of ammunition manufactured and assembled. This frequently results in an enormous demand for space for one type of ammunition one year and for another type the following, making it necessary to use all available magazines for housing whatever ammunition is being produced.

It will be noted when an inspection tour of the Magazine Area is made that large numerals are attached to the magazines. This is a local arrangement for indicating the degree of hazard represented by the contents of each of the buildings in case of fire or explosion in the building itself, or in adjacent territory. The significance of each of the numbers is as follows:

<u>No. 4 indicates</u> - Bombs, demolition and flashlight;

Black powder in cans or charges;
Dynamite; Explosive "D"; Fulminate of Mercury; Lead Azide; Nitroglycerine; Picric Acid; T.N.T. Blocks; T.N.T. boxed; Tetryl; Flashlight Powder.

(Every effort will be made to prevent fire from reaching this class of material. If this can not be done, the fire fighting forces will withdraw to a distance of at least 800 feet and protect themselves against explosion, by seeking such cover as is available.)

<u>No. 3 indicates</u> - Smokeless Powder in Boxes and in Bulk.
Separate Loading Propelling Charges.

(If a fire is discovered in a building in which smokeless powder is stored, there is little chance of saving the building. Personnel should take shelter against heat wave and protect surrounding property.)

<u>No. 2 indicates</u> - Bombs, Fragmentation; Boosters; Fixed Ammunition, H.E.; Fixed Ammunition, Shrapnel; Grenades, H.E.; Shrapnel, Separate Loading; Shell, H.E. Separate Loading; Shell, H.E. Trench Mortar.

(Every reasonable effort will be made to control the fire and the building should not be abandoned until it is evident that the fire can not be controlled. If fire gets beyond control, personnel should seek cover to protect themselves from flying fragments.)

<u>No. 1 indicates</u> - Acetone; Turpentine; Oil; Gasoline; Paints; Benzol; Ether; Alcohol; Acids; Compressed Gases, etc.; Ammonium Nitrate; Caps, detonating, blasting, and percussion; D.N.T.; Fuzes, time detonating, and grenade; Primers and Primer Detonators; Pyrotechnics; Smokeless Powder in course of manufacture, except in dry houses and blenders; Small quantities of loaded components; Surveillance Magazines.

(Every effort will be made to put the fire out. If the fire can not be contolled the building should be abandoned and efforts of the fire fighting forces should be made to protect surrounding buildings. If fire gets beyond control personnel should seek such cover as is available to protect themselves from light missiles. When fire occurs in building containing inflammable liquids or compressed gases, the possibility of explosion must be considered.)

The Ordnance Safety Manual describes in detail the method of piling which shall be followed for each type of ammunition and each kind of explosives. However, with the exception of separate loading shell which are piled with a view to eliminating sympathetic detonation, the general scheme is to pile material in double rows with stencilled ends facing aisles of approximately twenty-six (26) inches in width, in order that inspection, inventory and handling may be facilitated.

Aside from the physical angle of handling and protecting explosives and ammunition, the surveillance of the chemical changes, which are inherent in all explosives in varying degrees, is of major importance. By the term "Surveillance" is meant, observation, inspection, investigation, and test, (ballistic, chemical, or physical) of explosives and ammunition in storage. The purpose of surveillance is to determine whether deterioration is in progress, and if so the state and nature of such deterioration and the consequent degree of serviceability in order that reliance will not be placed upon munitions which are no longer safe or effective. Also to eliminate the danger of disaster through spontaneous ignition or explosion of materials which have become dangerously unstable.

The surveillance work in the Field is carried on by a Surveillance Inspector who is closely allied with, if not actually under the supervision of the Chief of the Storage activities. However, at Picatinny, due to the presence of a most modern equipped Laboratory and qualified technical personnel, the surveillance activities are conducted by the Technical Group rather than by the Stores Department, the only exception being the yearly N/10 Normal Methyl Violet Paper test on Smokeless Powder, which is conducted by the latter with the understanding that any questionable conditions are to be reported to the Technical Group for consideration and decision. This test consists of inserting a strip of Methyl Violet Paper approximately 5 1/2 inches long in each box of powder of a web size up to and including the 12 in. mortar, provided the powder is more than five (5) years old, for the purpose of determining the stability of the powder.

RESERVE OFFICERS'

LOADING PLANT COURSE

SUBJECT: 14. PACKING, STORAGE AND SHIPMENT OF AMMUNITION.

C. Shipment of Ammunition.

In order to minimize the dangers to life and property incident to the transportation of explosives and other dangerous articles, by carriers engaged in interstate or foreign commerce by rail, the transportation of such articles within the limits of the jurisdiction of the United States is regulated by Federal Law. Therefore when presented for shipment to a common carrier they must be packed and described to comply with Interstate Commerce Commission Regulations, provided, that shipments of explosives offered by the War and Navy Departments of the United States Government may be packed, including limitations of weights, as required by their own regulations. However, any proposed departure from the requirements of the Interstate Commerce Commission Regulations must be submitted to the Chief of Ordnance for a decision, i.e., where the Ordnance Department is involved.

The services of the Bureau of Explosives are utilized by the Interstate Commerce Commission in the execution of its regulations. This Bureau was organized by the American Railway Association in 1906. Nearly all common carriers are members of the Association, and comply with the rules and regulations issued by the Bureau of Explosives. Inspectors of the Bureau of Explosives are stationed throughout the country to observe, investigate, and report violations to the Interstate Commerce Commission, which prosecutes if conditions warrant. In this connection it is well to dwell on the fact that heavy penalties are provided for the shipper who knowingly solicits the transportation of any explosives or other dangerous articles without complying with the requirements of the Interstate Commerce Commission as well as for the carrier that knowingly accepts and transports same. When the death or bodily injury of any person results from the violation of the regulations the person or persons who shall have so knowingly violated or caused to be violated such regulation shall be fined not more than $10,000 or imprisoned not more than 10 years, or both.

The Interstate Commerce Commission Regulations governing the transportation of explosives and other dangerous articles describe in detail how shipments must be loaded, braced, placarded, certified, etc., and Bureau of Explosives Pamphlet No. 6 contains data, photographs, etc. on the shipment.

It is impossible to go into the specific details connected with each item of ammunition or explosives shipped from Picatinny, but an example will be given of the requirements in connection with making a shipment of 3 inch A.A. Ammunition.

Such ammunition is classed by the regulations as "Ammunition for Cannon with Explosive Projectiles," and each outside package must be marked accordingly. A "Certified car" is required for shipment. Certified cars must be inspected inside and outside, and must conform to the following specifications:

a - Closed cars of not less than 80,000 pounds capacity, with steel underframes and friction draft gear, must be used when available.

b - Cars must be equipped with air brakes in condition for service.

c - Cars must have no loose boards or cracks in the roof, sides, or ends, through which sparks may enter, or unprotected decayed spots liable to hold sparks and start a fire.

d - The doors must shut so closely that no sparks can get in at the joints, and, when necessary, they must be stripped. The stripping for doors should be on the inside and be fastened to the door frames where it will form a shoulder against which the closed doors repressed by means of wedges or cleats in door shoes or keepers. The openings under the doors should be similarly closed. The hasp fastenings must be examined with doors closed and fastened, and the doors must be cleated when necessary to prevent doors shifting. When the car is opened for any cause, wedges or cleats must be replaced before car containing explosives is permitted to proceed.

e - The journal boxes and trucks must be carefully examined and put in such condition as to reduce to a minimum the danger of hot boxes or other failure necessitating the setting out of the car before reaching destination. The lids or covers of journal boxes must be in place.

f - The car must be carefully swept out before it is loaded. For less-than-carload shipments the space in which the packages are to be loaded must be carefully swept.

Holes in the floor or lining must be repaired and special care taken to have no projecting nails or bolts or exposed pieces of metal which may work loose or produce holes in packages of explosives during transit. Protruding nails in the floor or lining which have worked loose must be drawn, and if necessary for the purpose of fastening the floor or lining, new nails must be driven through other parts thereof.

g - When packages of explosives are to be loaded over exposed draft bolts or kingbolts, the bolts must have short pieces of solid, sound wood with beveled ends (2-inch plank) spiked to the floor over them (or empty packages of the same character may be used for this purpose) to prevent possibility of their wearing into the packages of explosives.

h - The roof of the car must be carefully inspected from the outside for decayed spots or broken boards, especially under or near the running board, and such spots must be covered or repaired to prevent their holding fire from sparks. A car with a roof generally decayed, even if tight, must not be used.

The carrier must have a certified car examined by a competent employer to see that it is properly prepared, before permitting same to be loaded and must have a "Car Certificate" signed in triplicate, by a representative of the carrier and of the shipper, after same is loaded and properly braced. The original certificate must be filed by the carrier at the forwarding station and the other two (2) must be attached to the outside of car doors, or to the sides of the car, one (1) on each side, the lower edge of the certificate not less than 4-1/2 ft. above the floor level.

In addition to the certificate mentioned above, Explosive Placards, as prescribed in Interstate Commercial Commission Regulations, must be attached to both sides and both ends of the car, (these placards and certificates must be removed from cars by the party unloading same) and Bill of Lading covering the shipment must bear the following notation, "This is to certify that the above articles are properly described by name and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission." Care must be exercised to insure that no commodities not authorized to be loaded or stored with Ammunition for Cannon with Explosive Projectiles, as indicated by Loading and Storage Chart shown in the Interstate Commerce Commission Regulations, are placed in the same car. In the particular case illustrated there are no specifications in existence for the type of box to be used, nor any container weight limit. However, in the majority of cases a container, conforming to a certain specification, as outlined in the regulations, must be used, and the weight limit prescribed must be adhered to.

The shipping requirements for any commodity can be ascertained with little effort by referring to the index in the Interstate Commerce Commission Regulations, and if an item is encountered which is not listed in the regulations, contact must be made with the Bureau of Explosives for a decision as to packing and shipping regulations.

In view of the fact that all stations are called upon frequently to ship samples of explosives and ammunition for chemical analysis and other investigational purposes, it is deemed advisable to briefly cover the requirements in connection with express shipments. It is to be understood that most explosives and ammunition are classes as "Forbidden explosives" so far as shipments by express is concerned. However, exception is made (not including nitroglycerin) in the case of properly packed samples for laboratory examination. It must be understood, however, that "Laboratory examination" does not include ordinary use or demonstration. 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; each sample must not consist of more than one-half pound of explosive, and the interior package must be placed in sawdust or similar cushioning material, at least 2 inches thick, in a wooden box, complying with Interstate Commerce Commission Specification No. 14. 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 specification 14, with at least 2 inches of cushioning material separating the boxes. Not more than 100 blasting caps may be shipped in one outside package for laboratory examination and they must be packed and cushioned as just described. Not more than 20 half-pound samples of explosives for laboratory examination may be placed in one outside box or transported at one time and the net weight of the explosive contents must be plainly marked by the shipper on the outside of each box offered for transportation. In this connection it is advised that when components of ammunition are being shipped, the net weight of the explosive content is the guiding factor with respect to the half-pound limit.