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INTRODUCTORY HANDBOOK
FOR
SMALL ARMS AMMUNITION

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U.S. ARMY
FRANKFORD ARSENAL
JULY 1967

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CONTENTS

PAGE

SECTION I - INTRODUCTION

- 1. Purpose 1

SECTION II - TERMINOLOGY

- 2. Cartridge 3
- 3. Caliber or Millimeter 3
- 4. Type 3
- 5. Model 3
- 6. Cartridge Case 3
- 7. Primer 5
- 8. Propellant 5
- 9. Bullet 6
- 10. Cartridge Identification 6

SECTION III - MANUFACTURE

- 11. General 7
- 12. Case and Bullet Jacket Cup 7
- 13. Cartridge Case 8
- 14. Case Operations 9
- 15. Primed Case 16
- 16. Cartridge Operations 17
- 17. Bullet 20
- 18. Bullet Jacket Operations 21
- 19. Bullet Operations 22
- 20. Slug, Point Filler, and Base Filler
Operations 23
- 21. Primer Operations 24
- 22. Cores for Armor Piercing Cartridges 27
- 23. Closure Cups and Closure Discs for
Tracer Cartridges 28
- 24. Incendiary and Tracer Manufacture 28
- 25. Incendiary and Tracer Charging 28
- 26. Packaging 29



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CONTENTS

PAGE

SECTION IV - THE CONTROL OF QUALITY

27. General	31
28. Definition	31
29. Inspection	34
30. Control Tests	35
31. Work Tests	36
32. Statistical Quality Control	36

SECTION V - QUALITY ASSURANCE

33. General	39
34. Function	39
35. Nonconforming Material	41

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This handbook provides A brief description of the manufacturing of small arms ammunition. ←			

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INTRODUCTORY HANDBOOK

SECTION I

INTRODUCTION

1. PURPOSE

a. This handbook is intended to provide a general narrative description of the processes and problems involved in the manufacture of small arms ammunition. Additional detailed technical data can be found in the Descriptions of Manufacture, Machinery Handbook, Adjustor's Handbooks, Technical Data Packages, Operations Control Procedures, and Quality Control Inspection Plans.

b. The preceding paragraph mentions that the small arms ammunition process involves "problems". At the outset it should be emphasized that the production of a small arms cartridge is not as simple as might be indicated by a casual study of components and drawings, or a visit to a production line. A lipstick container is not unlike a cartridge case in form. It is blanked, cupped, drawn and trimmed by the same general process and equipment. However, the lipstick tube serves only as a container while the cartridge case is a component of a very powerful "engine".

c. In the firing of a 7.62mm cartridge, the charge of propellant weighing slightly more than 1/10 ounce develops 4880 horsepower in the 14/10,000 second that elapses between the firing of the primer and the emergence of the bullet from the muzzle of the weapon. This is the energy required to propel a bullet weighing approximately 1/3 oz. at a speed 2 1/2 times that of sound. The bullet is capable of traveling up to 2 1/2 miles. The energy at work is so tremendous and the masses and time intervals are so minute that the effect of physical and dimensional variables in the components and assembly of the cartridge is exceedingly complex.

SECTION I

INTRODUCTION

d. Since the beginning of the production of metallic center-fire military rifle cartridges circa 1870, the process has constituted an industrial art. Science has been of great assistance in lessening the importance of personal "know-how" but that element remains essential.

INTRODUCTORY HANDBOOK

SECTION II

TERMINOLOGY

2. CARTRIDGE

This term is used to designate a complete assembly consisting of all the cartridge components necessary to fire the weapon once; that is, the bullet, case, propellant, and primer. Terminology is illustrated in Figure 1.

3. CALIBER OR MILLIMETER

In small arms ammunition, the size of the cartridge is described by the use of "caliber (cal.)" or "millimeter (mm)". Caliber represents the approximate diameter of the bullet as the decimal fraction of an inch. Millimeter represents the approximate diameter of the bullet as expressed in the metric system.

4. TYPE

The "type" of cartridge or bullet is descriptive of its principal military characteristic.

5. MODEL

The "model" designation refers to a specific design. The following are examples of standard nomenclature:

<u>Item</u>	<u>MM or Caliber</u>	<u>Type</u>	<u>Model</u>
Cartridge	7.62mm, NATO	Ball	M80
Cartridge	5.56mm	Ball	M193
Cartridge	Caliber .30	Ball	M2

6. CARTRIDGE CASE

The cartridge case holds the primer, propellant

SECTION II

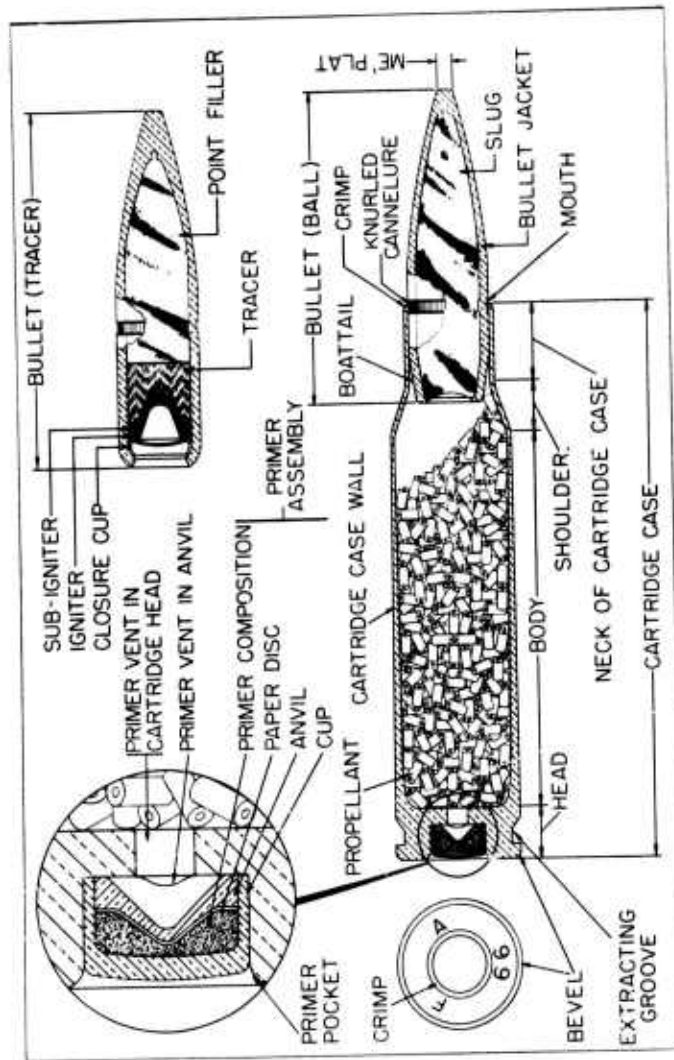


Figure 1
A Sectioned Cartridge and Terminology of Components

SECTION II

INTRODUCTORY HANDBOOK

and bullet in a fixed unit. It is usually made of brass although steel has been used as a substitute material. When a cartridge is fired in the chamber of a weapon, the case expands tightly against the wall of the chamber and thus prevents the hot gases from escaping rearward, damaging the weapon and possibly injuring the gunner. After expanding (obturating) at firing the case must then shrink away from the chamber walls to permit easy extraction.

7. PRIMER

The primer is an assembly consisting of a brass cup, a pellet of primer composition, a paper disc and a brass anvil. The primer composition detonates under the impact of the firing pin. The resulting flame is forced through the vent in the bottom of the primer pocket and ignites the propellant in the case.

8. PROPELLANT

The propellant charge of a cartridge consists of a quantity of smokeless propellant, either a single base (nitrocellulose) type or a double base (nitrocellulose-nitroglycerin) type. The geometry of small arms ammunition propellants is generally confined to spherical, cylindrical or flake configuration. The propellant charge weight is measured in "grains" (avoirdupois) and is controlled to produce the required bullet velocity within the prescribed pressure limits. The propellant is manufactured by commercial or government owned contractor operated facilities. Small arms propellants are relatively stable, usually of uniform quality and reasonably safe to store and handle. The current propellant types as manufactured to the technical data requirements, present no serious production problem to the ammunition manufacturer.

SECTION II

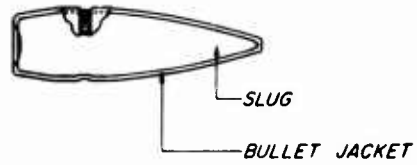
TERMINOLOGY

9. BULLET

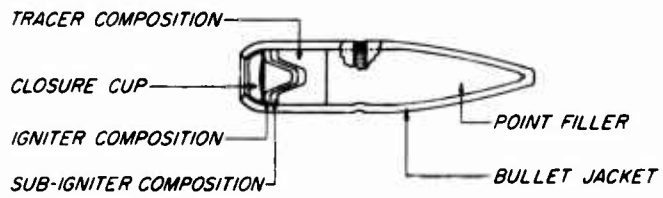
The term "bullet" is applied only to small arms ammunition projectiles. The various types of bullets are illustrated in Figures 2, 3 and 4.

10. CARTRIDGE IDENTIFICATION

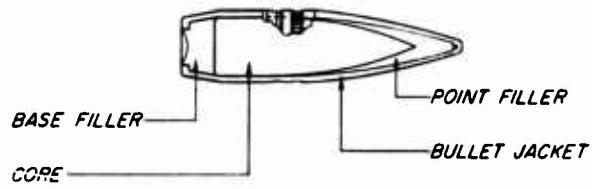
Figures 5, 6, 7, 8, 9, 10 and 11 illustrate the various types of 7.62mm, 5.56mm, caliber .30, caliber .30 carbine, caliber .45 and caliber .50 cartridges. The painted tips on certain bullets are for purposes of identification.



BULLET, 7.62 MM, NATO, BALL, M80



BULLET, 7.62 MM, NATO, TRACER, M62



BULLET, 7.62 MM, NATO, AP, M51

EXAMPLES OF BULLETS, 7.62 MM (SECTIONED)

Figure 2

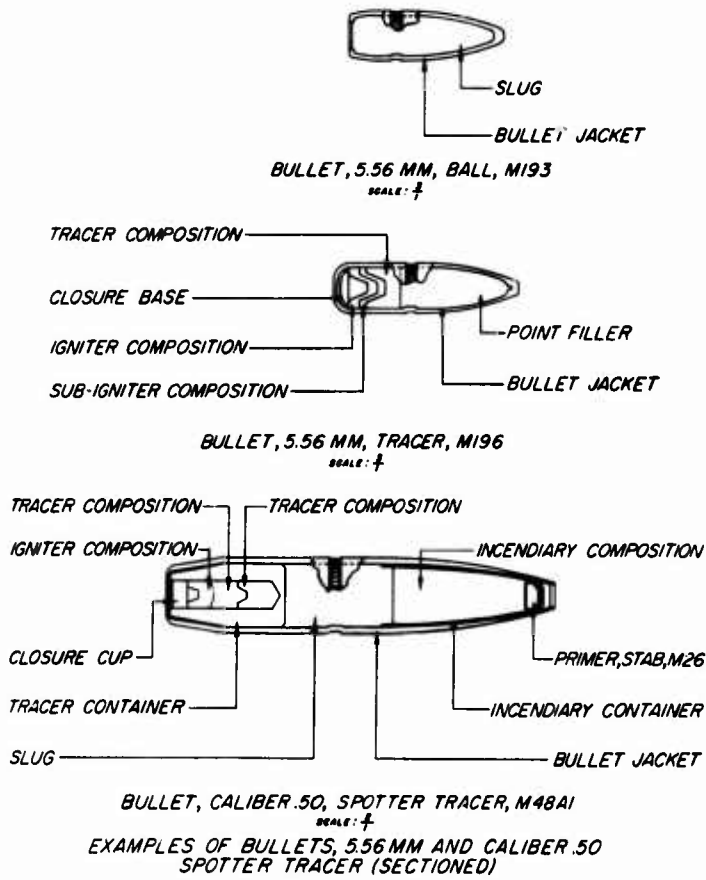
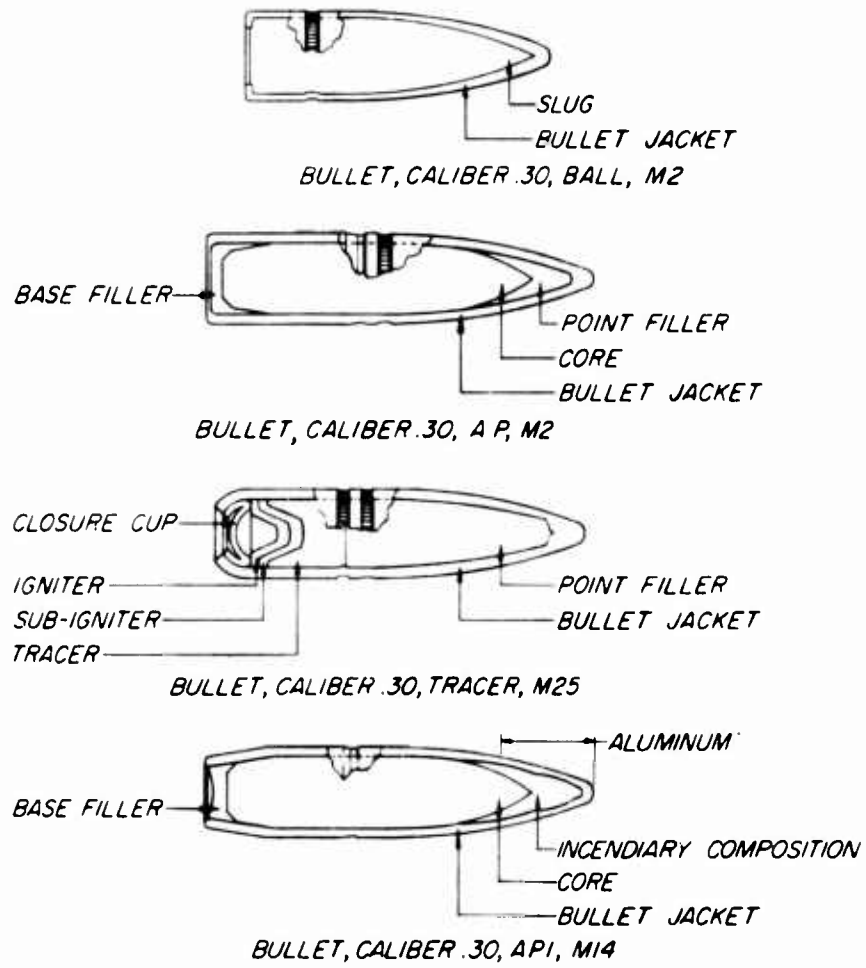


Figure 3



EXAMPLES OF BULLETS, CALIBER .30 (SECTIONED)

Figure 4



BALL, M59 AND M80



HIGH PRESSURE TEST (HPT), M60



ARMOUR PIERCING (AP), M61



TRACER, M62



DUMMY, M63

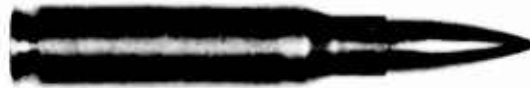


RIFLE GRENADE, M64

Figure 5 - Examples of Cartridges, 7.62mm



BLANK, M82



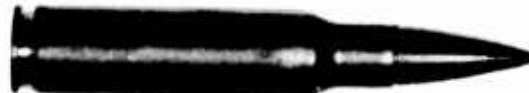
MATCH, M118



BALL, FRANGIBLE, M160



DUMMY, INERT LOADED, M172

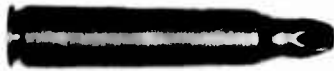


DUPLEX, M198

Figure 6 - Examples of Cartridges, 7.62mm



BALL, M193



RIFLE GRENADE, XM195



TRACER, M196



HIGH PRESSURE TEST (HPT) M197



DUMMY M199



BLANK, XM1200

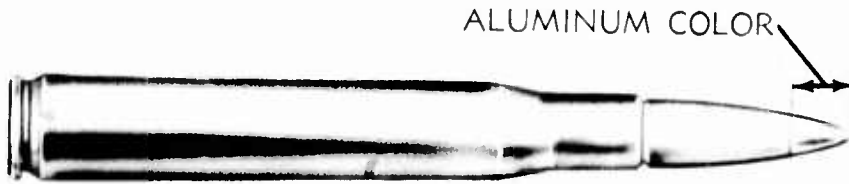


DUMMY, INERT LOADED, M232

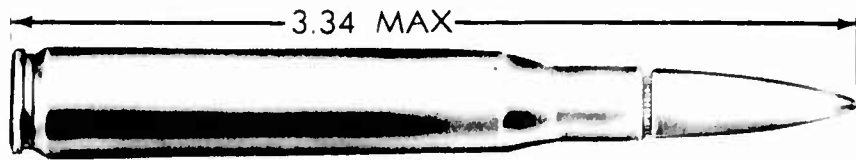
Figure 7 - Examples of Cartridges, 5.56mm



ARMOR-PIERCING, M2



ARMOR-PIERCING-INCENDIARY, M14



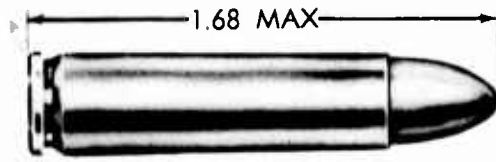
BALL, M2



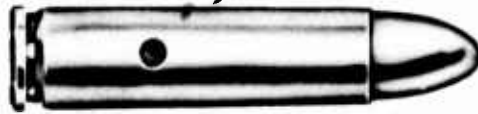
TRACER, M25

ORD D91

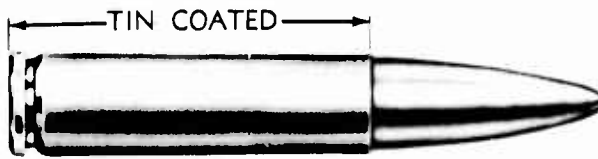
Figure 8 - Examples of Cartridges, Caliber .30



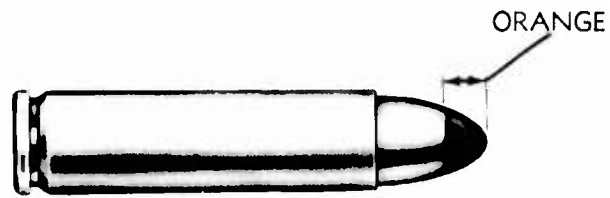
BALL, M1



DUMMY: M13



TEST, HIGH-PRESSURE, M18



TRACER, M27

ORD D89

Figure 9 - Examples of Cartridges,
Caliber .30 Carbine

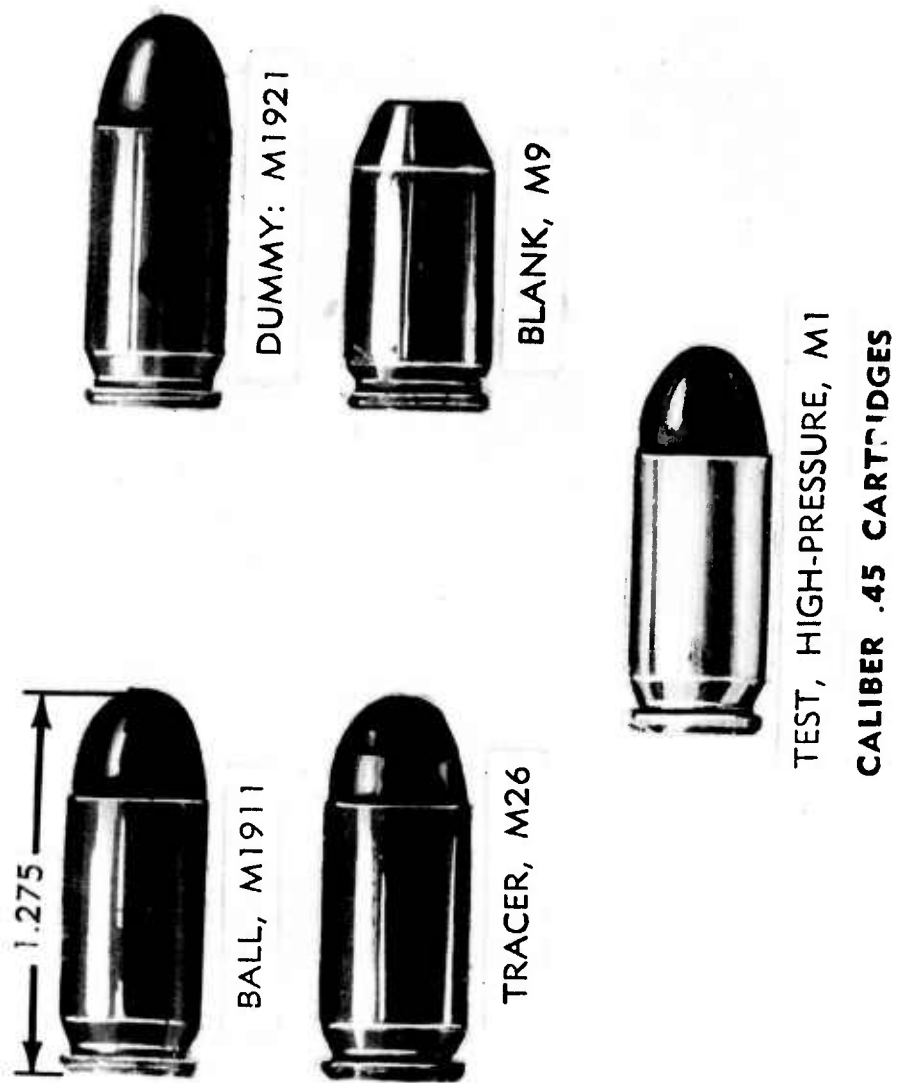


Figure 10 - Examples of Cartridges, Caliber .45

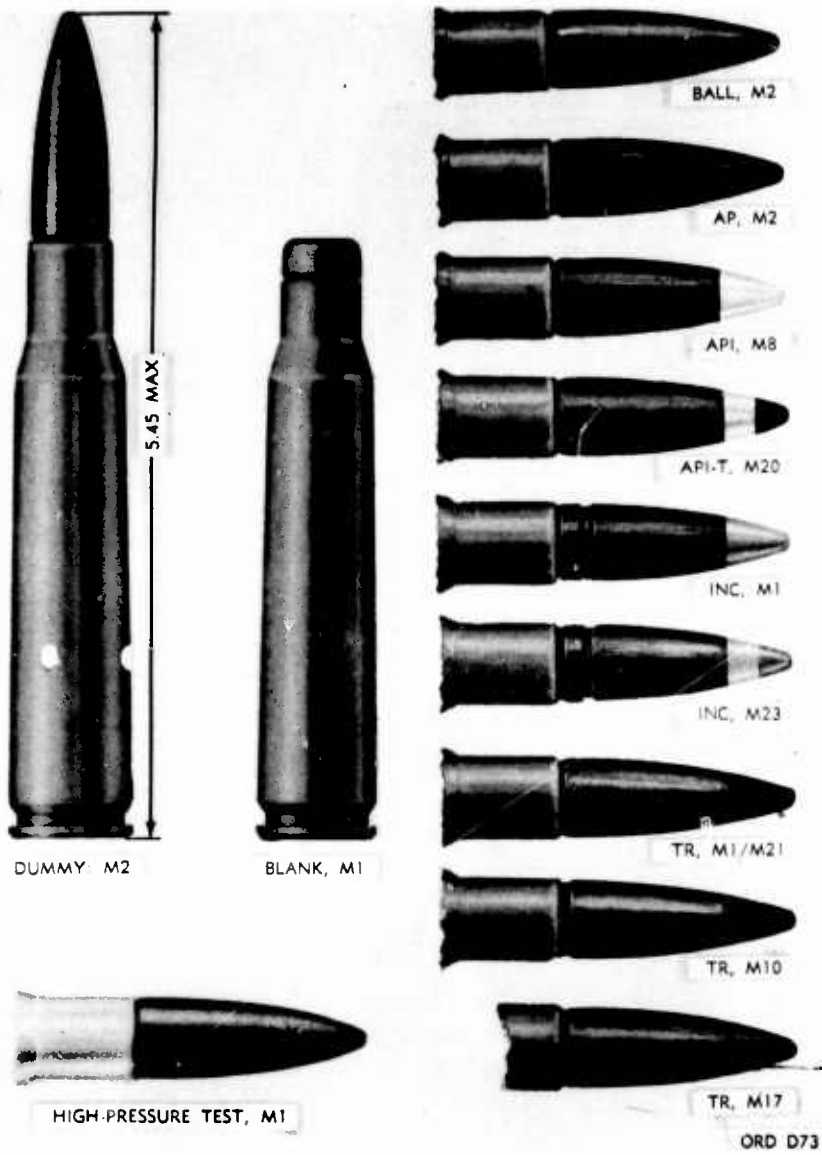


Figure 11 - Examples of Cartridges, Caliber .50

INTRODUCTORY HANDBOOK

SECTION III

MANUFACTURE

11. GENERAL

a. The manufacturing process as described in paragraphs 12 through 21 is based on the manufacture of Cartridge, 7.62mm, NATO, Ball, M80. A similar process is used for the manufacture of other cartridges with variations as necessary to accommodate the type and caliber of cartridge being manufactured. This description omits the inspection, control and test operations except for those few instances where a 100% inspection operation is performed. The general description of inspection, test and control operation is presented in Section IV.

b. Figure 12 is a flow chart of the process for the manufacture of Cartridge, 7.62mm, NATO, Ball, M80.

12. CASE AND BULLET JACKET CUP

a. The conventional draw process for fabricating cartridge cases and bullet jackets starts with a disc which is blanked from strip and formed into a cup. The blank and cup operation is accomplished in one operation on a double action vertical crank press. Cups are usually purchased from cup manufacturers.

b. Following the Blank and Cup Operation, the cups are processed through a Wash Operation and then through an Anneal, Pickle, Rinse, Rinse, Neutralize and Rinse Operation. The anneal operation imparts the required workability to the cup and the pickle through rinse operations remove oxide, scale and dirt.

c. It is imperative that case cups and bullet

**FLOW CHART
FOR
CARTRIDGE, 7.62 MM, NATO, BALL, M80**

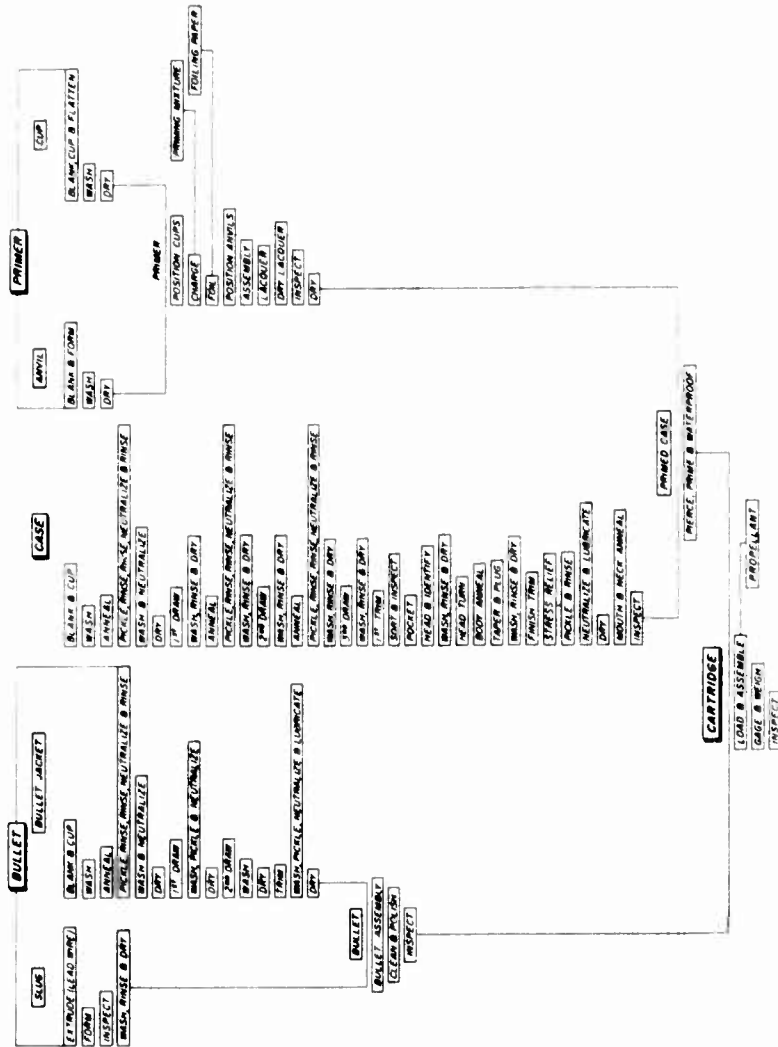


Figure 12

SECTION III

MANUFACTURE

jacket cups conform to the dimensional and physical requirements of the drawings and cup specifications; however, during times of emergency it may be necessary to accept substandard cups and make compensations in the process to overcome the deficiencies in the cup.

d. Wall thickness variations are particularly critical in bullet jacket operations where excessive wall thickness variations will have a direct effect upon the accuracy of the bullet.

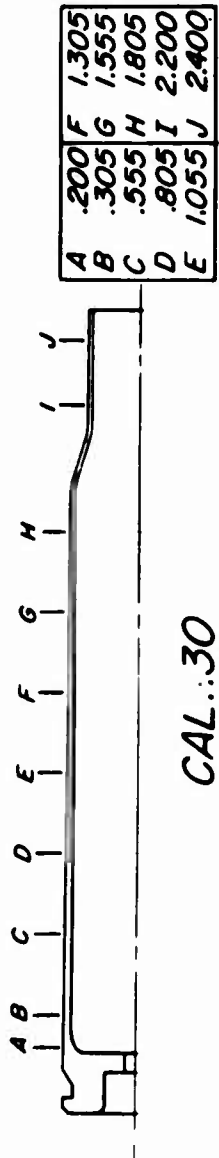
e. Cups from various manufacturers must be segregated from each other to decrease the possibility of variations from batch to batch of cups.

13. CARTRIDGE CASE

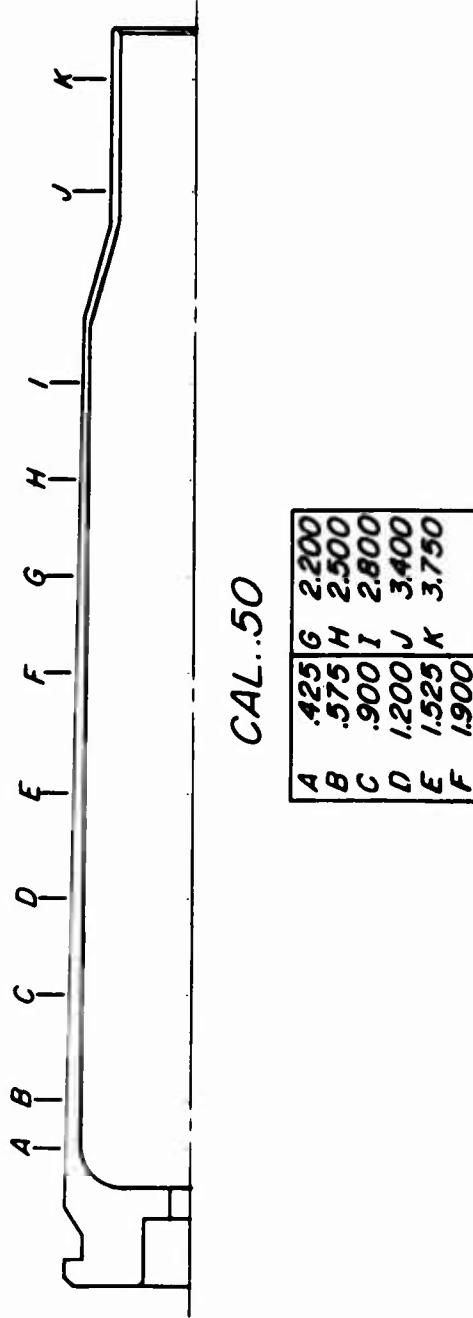
a. A cartridge case not only must be formed to the dimensions shown on the drawing, it must have the necessary metallurgical properties "built in" during the process. The mouth of the case must be hard enough to retain the bullet and soft enough that it will not "season crack" under the tension of the bullet fit and mouth crimp. The head of the case must be hard enough to contain the primer detonation and resist without deformation the high pressures generated by the propellant. Figures 13 and 14 show the location points at which readings are taken to check the hardness of the various families of cartridge cases.

b. The several operations in the case process shown on the flow chart (Figure 12) are relatively simple. However, the tooling, adjustments and process controls are complex and require skilled "know-how" and vigilant attention.

DISTANCE FROM OUTSIDE HEAD



CAL.:30



CAL.:50

Figure 13 - Hardness Location Points
(Caliber .45, .30 Carbine, 7.62mm)

DISTANCE FROM OUTSIDE HEAD

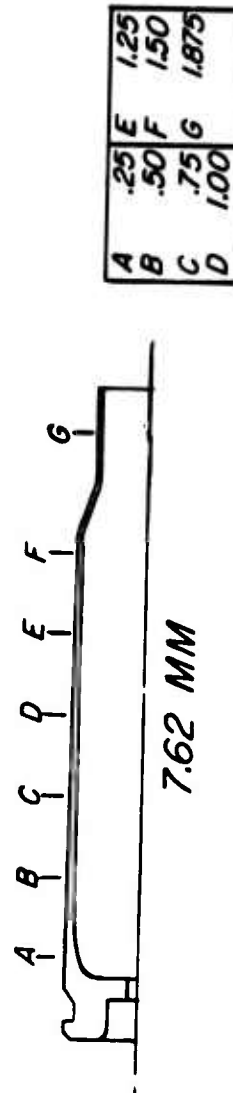
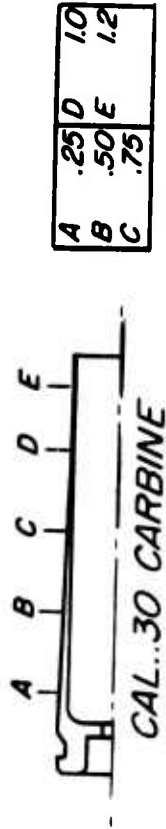
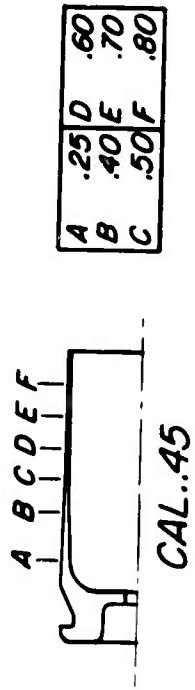


Figure 14 - Hardness Location Points
(Caliber .30 and .50)

INTRODUCTORY HANDBOOK

14. CASE OPERATIONS

a. Wash and Neutralize

This operation is required to ascertain that the cups are clean prior to the draw operation. The cups may be in storage either at the manufacturer's plant or at the ammunition plant for some period of time before being processed through the draw operations.

b. Dry

The cups are dried prior to the First Draw Operation.

c. Draw

(1) Cartridge cases for the 7.62mm family are fabricated in three successive draws with a Wash, Rinse and Dry Operation; an Anneal, Pickle, Rinse, Rinse, Neutralize and Rinse Operation; and another Wash, Rinse and Dry Operation between draws.

(2) The draws differ principally in the tooling, e.g., the punch and die combination and die block assembly. The presses operate at speeds between 85 and 120 strokes per minute. Each press draws two to four components on each stroke.

(3) Tooling, adjustment of tooling, and proper lubrication of punches, dies and draw pieces are of critical importance to the operation.

(4) A single action vertical crank press is used at each operation.

SECTION III

MANUFACTURE

d. Anneal, Pickle, Rinse, Rinse, Neutralize and Rinse

(1) The anneal may be accomplished in an oil, gas fired or electric continuous furnace. The anneal process restores the draw piece to approximately the same degree of hardness that prevailed before the "work hardening" caused by the preceding draw operation.

(2) The annealing operation is critical and must be closely controlled with reference to time and temperature. Underannealed components may be salvaged by further annealing, but overannealed components must be scrapped.

(3) The pickle solution removes oxidation caused by the anneal operation.

(4) The two rinse operations remove the pickle solution.

(5) The neutralizing solution removes any remaining pickle solution.

(6) A four section conical drum with a rinsing attachment is utilized in conjunction with the annealing furnace for this operation.

e. 1st Trim

(1) Before trimming, the final draw piece must be thoroughly washed, rinsed and dried. The spindle of the trim machine will not operate properly unless the pieces are clean and free of lubrication.

(2) The Trim Operation is conducted on a hopper fed, single spindle horizontal bench type machine. While the case component is positioned on

SECTION III

INTRODUCTORY HANDBOOK

the rotating spindle, a free, circular cutter presses into the case and causes a radial separation of the excess uneven material from the open end of the work piece. Both portions are then forced off the spindle; the trimmed draw piece falling upon a conveyor and an air jet directing the lighter scrap material into a scrap chute. As a consequence of this operation, all pieces become a uniform length which aids in the automatic feeding of components in subsequent operations.

f. Sort and Inspect

After the Trim Operation all pieces are visually inspected on a conveyor. Any scrap and all untrimmed or defective pieces are removed.

g. Pocket

(1) In this operation, a deep indent, which the subsequent heading operation will form into a finished pocket, is swaged in the head of the case. Alignment and adjustment of punch, die and ejecting stem are critical.

(2) The operation is conducted on a hopper fed, horizontal crank and toggle press. The work piece is held in the die and restricted from movement as the punch swages the head.

h. Head and Identify

(1) This operation is performed on the same type of press as used at the preceding operation; however, the punch and die are different. The head of the case and the primer pocket are given their final form with the exception of the head turn operation. The punch in addition to performing the heading operation also stamps the identification or manufacturing plant's symbol and year

SECTION III

MANUFACTURE

of manufacture on the head face.

(2) The head as now formed must not be subsequently annealed. The cold working which the head has received during this and previous operations must have produced the required hardness.

i. Wash, Rinse and Dry

Since the cases have been lubricated in the hopper at the Pocket Operation, it is necessary to remove the lubricant prior to the Head Turn Operation; therefore, a Wash, Rinse and Dry Operation is performed. Any trace of lubricant or dirt will prevent the collet from holding the case at the Head Turn Operation.

j. Head Turn

(1) At this operation burrs or excess metal are removed from the head face, the head diameter is turned and the extractor groove is cut to size.

(2) Adjustment of the form cutting tools is critical if excessive dimensional and visual defects are to be avoided.

(3) The operation is performed on a hopper fed, horizontal single spindle machine; i.e., a lathe design.

k. Body Anneal

(1) The case, having been work hardened in the final draw operation, must be annealed on the sidewalls or body to permit the tapering of the case, and forming of the shoulder and neck in the next operation. The Body Anneal Operation is performed on a hopper fed induction or gas heating

INTRODUCTORY HANDBOOK

machine. With the induction machine, the cases are rotated axially through the machine on a conveyor worm as an alternating current in the inductor establishes an alternating magnetic flux that creates heat to body anneal the cases. With the gas annealer, the case is rotated axially through a series of open gas flames. With both systems, the head of the case is submerged in water to prevent the anneal from extending down into the head.

(2) Care must be exercised in handling the cases after this operation since the cases are in a softened condition and are easily dented.

1. Taper and Plug

(1) At this operation the case is tapered, the shoulder and neck are formed, and the inside neck diameter is sized.

(2) The operation is performed on a hopper fed double action vertical crank press.

m. Wash, Rinse and Dry

The cases are thoroughly washed, rinsed and dried to remove the lubrication applied at the Taper and Plug Operation.

n. Final Trim

(1) At this operation, the cases are trimmed to final length. Since this affects overall length of the assembled cartridge, the operation must be controlled to close limits.

(2) A hopper fed single spindle vertical machine is used at this operation.

SECTION III

MANUFACTURE

o. Stress Relief

(1) Because stresses have been induced at prior operations due to cold working, a stress relief operation must be performed. The operation is performed by subjecting the cases to a temperature of approximately 475°F for a predetermined period of time. Close control of time and temperature is of utmost importance since cases that are subjected to excessive periods of stress relief or to too high temperature are damaged beyond salvage.

(2) This operation is performed in a stationary electric recirculating air furnace.

p. Pickle and Rinse

Following Stress Relief the cases are subjected to a Pickle and Rinse Operation. The pickle solution removes oxidation caused by the stress relief and the rinse operation removes the pickle solution.

q. Neutralize and Lubricate

At this operation a soap solution is used to neutralize any traces of acid that remain from the pickle solution at the preceding operation. A residual film of soap remaining on the sidewall of the primer pocket facilitates insertion of the primer at the Pierce, Prime and Waterproof Operation. The cases are processed through a Dry Operation after this operation.

r. Mouth and Neck Anneal

(1) The cases are mouth and neck annealed at this operation to soften the mouth and neck sufficiently to ease bullet insertion and crimping. Otherwise the stresses caused by bullet insertion

SECTION III

INTRODUCTORY HANDBOOK

would result in "season cracks" of the mouth and neck.

(2) The operation is accomplished on a hopper fed horizontal straight line twin screw conveyor open gas flame machine. The cases are rotated axially through the series of open gas flames.

(3) The adjustment of the gas jets is critical and must be maintained to insure the required physical metallurgical properties.

s. Inspect

(1) Prior to the Pierce, Prime and Waterproof Operation a 100% visual inspection is performed on the cases.

(2) The operation is performed on a hopper fed horizontal straight line twin screw conveyor machine. The pieces are conveyed and rotated past two mirrors which aid the operator to observe the inside of the case and the head of the case. Bar attachments detect for cases which exceed minimum or maximum length limits. A bushing located in the feed tube prevents the passage of a case with a large head diameter.

t. Completed Component

(1) At this point in the process, the cartridge case is complete as a component and ready for partial assembly by piercing the primer vent, inserting and seating the primer, and applying the waterproofing compounds.

(2) In the interest of continuity, this narrative will proceed with a description of the assembly operations and thereafter discuss the manufacture of bullets and primers.

SECTION III

MANUFACTURE

15. PRIMED CASE

a. Pierce, Prime and Waterproof

(1) This is a semihazardous operation in which explosive safety precautions must be observed. Primers in close contact with each other may, by the explosion of one primer, cause mass detonation. The severity of the explosion will depend largely upon the number of primers involved and the degree of their confinement.

(2) The operation is performed on a hopper fed multistation straight line vertical crank and rocker press or dial type vertical crank and lever press.

(3) In addition to detect stations for no case, foreign matter, no vent, inverted or no primer, and inverted or missing anvil, the following operations are performed:

- (a) Deburr the primer pocket.
- (b) Vent (a hole is punched in the pocket in the head of the case).
- (c) Insert and seat the primer.
- (d) Crimp the metal around the primer joint.
- (e) Primer and mouth waterproofing.

(4) After the mouth waterproofing has dried, the primed case is ready for the loading operation.

INTRODUCTORY HANDBOOK

16. CARTRIDGE OPERATIONS

a. Loading

(1) The loading operation consists of putting a measured charge of propellant in the cartridge case, inserting the bullet in the mouth and neck to the proper depth, and crimping the case mouth into the bullet cannelure.

(2) The propellant charge must be one which will produce the required velocity and develop a pressure that is within the established limit.

(3) In the 7.62mm cartridge, a deviation of one grain of propellant from the established charge will affect velocity to the extent of approximately 60 feet per second (fps) and pressure to the extent of approximately 1,000 pounds per square inch (psi). Obviously, the weight of the propellant charge from cartridge to cartridge must be very uniform. Careful verification and control testing of the loading process is necessary.

(4) In the processes used in the United States, the charge is loaded by volumetric measurement although determined by weight. The propellants are sufficiently uniform in density to permit this. The propellant charge in 7.62mm cartridges, once established, can usually be held within a tolerance of plus or minus 0.3 grains under mass production, volumetric loading.

(5) The loading operation is conducted on a hopper fed multistation automatic vertical straight line cam machine. The following operations are performed:

(a) No case detect and spread mouth.

SECTION III

MANUFACTURE

- (b) Load (Insert propellant).
- (c) Detect for high, low or no charge.
- (d) Bullet insert and detect for no bullet.
- (e) Seat bullet.
- (f) Case eject for high, low or no propellant charge or no bullet.
- (g) Crimp.

NOTE: This same type of machine can be used with a lacquering attachment to point identify bullets requiring such identification.

(6) Another method of loading is known as "plate loading". This unit consists of several presses, machines and plates. Plate loading accomplishes the same operation as the straight line machine; however, it requires more pieces of equipment. The production rate for plate loading far exceeds the straight line machine.

(7) Propellant weight and bullet pull (force required to extract the bullet from the mouth of the case) are the characteristics directly established in the loading process. The former and to some extent the latter characteristics may affect velocity and pressure. However, velocity and pressure are also affected by variables in the components such as primer brisance, case volume, bullet diameter, propellant moisture, etc.

b. Gage and Weigh

- (1) A 100% gage and weigh operation is

SECTION III

INTRODUCTORY HANDBOOK

performed after the Load and Assemble Operation.

(2) The following gaging inspections are performed:

- (a) Profile and alignment.
- (b) Length, head to shoulder.
- (c) Length, total.
- (d) Diameter, extractor groove.
- (e) Depth, primer.
- (f) Diameter, head.
- (g) Thickness, head.

(3) As the cartridge reaches the end of the gaging transfer bar, it drops into a sensitive weighing pan which weighs the cartridge and rejects underweight cartridges.

(4) Cartridges are automatically rejected at the gaging operations if they are not within limits. Rejected cartridges are processed through another machine. If rejected again they are hand gaged. If such rejects are found to be acceptable they are included with acceptable cartridges. Defective cartridges are segregated for verification of causes and scrapped.

(5) This operation is performed on a manual or hopper fed seven station automatic lever action machine with a weighing attachment.

c. Inspect

A 100% visual inspection is performed on

SECTION III

MANUFACTURE

the cartridges after the Gage and Weigh Operation. The cartridges which have been divided into lots are then submitted to the Government Quality Assurance Representative in Charge (QARIC) to ascertain that they comply with the requirements of the Technical Data Package. Upon acceptance the cartridges are returned to the manufacturer for packaging. After packaging the wirebound boxes are submitted to the QARIC for inspection of packaging.

17. BULLET

a. A bullet for a Ball, M80 cartridge is an assembly of a pointed bullet jacket and a lead slug. Other types of bullets are composed of a combination of a bullet jacket with various components such as core, point filler, base filler, closure cup, tracer composition, incendiary composition, igniter composition, and/or sub-igniter composition. For example, a Tracer, M62 bullet is composed of a pointed bullet jacket, a point filler, a closure cup, tracer composition, igniter composition and sub-igniter composition.

b. The required accuracy as well as the special performance characteristics must be "built in" the components and assembly. Compliance with drawings and an established production manual will not alone guarantee performance in firing tests. Bullet manufacture calls for highest skills and specialized "know-how". For example, matching of tools is not limited to matching a punch to a die but in matching a series of tools throughout the various stages of manufacture, particularly the bullet assembly operation.

SECTION III

INTRODUCTORY HANDBOOK

18. BULLET JACKET OPERATIONS

a. Bullet Jacket Draw

(1) Bullet jackets for the 7.62mm family of bullets are formed in one or two draws depending upon the type of material that is used (gilding metal clad steel or gilding metal). The draw operations are similar to the case draw operations. The major differences in the operations are the size of the tools and the smaller capacity (tonnage) of the press. A vertical crank press is used at this operation.

(2) Prior to the First Draw Operation the bullet jacket cups are subjected to a Wash and Neutralize Operation and a Dry Operation. These operations are necessary to ascertain that the cups are clean and dry. The cups may be in storage at the manufacturer's plant or at the ammunition plant for some period of time before being processed through the draw operations.

b. Wash, Pickle and Neutralize

(1) A Wash, Pickle and Neutralize Operation is performed after the First Draw Operation. The wash operation removes foreign matter; the pickle solution removes oxidation and the neutralize solution removes the pickle solution.

(2) A Dry Operation follows the preceding operation.

c. Wash and Dry

When a two draw process is used, separate wash and dry units perform these operations prior to the Trim Operation.

SECTION III

MANUFACTURE

d. Trim

(1) The bullet jacket is trimmed on a hopper fed horizontal single spindle (lathe) machine.

(2) The trim length of the bullet jacket is controlled to meet requirements expressed in weight (grains).

e. Completed Component

(1) At this point in the process the bullet jacket is complete as a component and ready for assembly into a bullet.

(2) In the interest of continuity, this narrative will proceed with a description of bullet assembly and thereafter discuss the manufacture of the lead slug.

19. BULLET OPERATIONS

a. Bullet Assembly

(1) A multistation straight line vertical crank press is used at this operation to perform the bullet assembly operation on the Ball, M80 bullet. The jackets are fed by a pin wheel hopper and the lead slugs by means of a profile hopper.

(2) The bullet jacket is fed to the press in the form of a trimmed, cylindrical, closed end tube and the slug is fed as a cylindrical piece that is pointed on one end.

(3) This press can be set up as a single or duplex press. When the duplex setup is utilized, two pieces are completed with each stroke. The following operations are performed when either

SECTION III

INTRODUCTORY HANDBOOK

method is used:

- et. (a) Insert and inspect bullet jacket.
- (b) 1st point.
- (c) 2nd point.
- (d) Insert, inspect and seat slug.
- (e) 1st boattail, cone and base.
- (f) Finish boattail.
- (g) Size.
- (h) Cannelure and resize - A distinct attachment to the bullet assembly press.

(4) The set up of the bullet assembly press is very complex since the adjustment of each station is interdependent.

b. Clean and Polish

Following bullet assembly the bullets are cleaned and polished in a horizontal rotary barrel containing ground corncobs.

20. SLUG, POINT FILLER, AND BASE FILLER OPERATIONS

a. The lead slug for the Ball, M80 bullet and the point fillers and base fillers for other types of bullets are manufactured by a similar process. Only the tools are different.

b. Extrude

A hydraulic vertical press is used at this

SECTION III

MANUFACTURE

operation to extrude lead cylinders having required lead antimony composition into wire of a predetermined dimension.

c. Form

A horizontal crank press is used to cut predetermined lengths of wire and feed these segments into a die and swage them to the required shape and weight.

d. Inspect

The components are 100% visually inspected on a conveyor belt after the Form Operation. The pieces are inspected for short piece, deep nick or scratch, embedded foreign matter or bent piece.

e. Wash, Rinse and Dry

(1) A scoop type reversible rotary cylinder two section machine is used to Wash, Rinse and Dry the components. A helix propels the pieces through the machine.

(2) An alkaline solution removes foreign matter from the pieces and rinse water removes the alkaline solution. A drying compartment dries the pieces.

21. PRIMER OPERATIONS

a. Composition

(1) The formulation and preparation of primer composition is a batch process described on the drawing for the particular primer composition and in the Operations Control Manuals or Standard Operating Procedures used by the various ammunition producers.

SECTION III

INTRODUCTORY HANDBOOK

b. Cups and Anvils

(1) Cups are blanked and cupped by a stamping process on high speed double action vertical crank presses while anvils are blanked and formed by a stamping process on high speed single action vertical crank presses. The tolerance on the outside diameter of the anvil is 1/1,000 of an inch. Considering that these components are made in a high speed stamping operation with crank speeds of approximately 350 spm, this tolerance may seem to be amazingly close. However, given strip material of proper thickness and hardness and proper tools, the physical operation is not difficult. Tool adjustments to assure production of acceptable components is critical.

(2) After a wash-water polish-dry operation, the primer cups and anvils are ready for assembly.

(3) Dimensional variations in the cup and anvil may affect the function of the assembled primer. Blunt anvil points, thick or high crowned cups may cause misfires. The whole primer manufacturing process is critical, requiring skilled, careful personnel. Some modern plants successfully and consistently produce one hundred million or more primers for varied calibers and types of ammunition per month.

c. Charge and Assembly

(1) Primers are charged in one of two ways, either with wet or dry priming composition.

(2) Wet priming is accomplished by the manual compression of wet primer composition into volumetrically controlled holes of a stainless steel charging plate. Dry charging is accomplished

SECTION III

MANUFACTURE

in a somewhat similar fashion except remote mechanical means are used to charge the dry primer composition into the charging plate holes.

(3) The increments (pellets) of volumetrically measured primer composition are then transferred from the charging plate to primer cups previously oriented in a transfer plate.

(4) The plate of charged primer cups is then placed on a multiple punch press where treated paper foil is cut and inserted in the charged primer cups followed by consolidation of the foiled primer composition. It is noteworthy to mention; however, that some producers of some primers do not employ paper foil.

(5) Shaker plates filled with anvils and foiled charged cups respectively, are placed together under a power operated vertical action toggle press which presses the anvils to the desired depth into the cups.

(6) A drop of either lacquer or liquid shellac is placed on top of the anvil of each wet primer immediately after assembly. Dry charged primers have a drop of either lacquer or shellac placed directly into the cup prior to charging or on top of the pellet prior to assembly.

d. 100% Visual Inspection

(1) After assembly, the primers are given a 100% visual inspection. Since the cost of a primer is so small and the function so vital, it is a recognized practice in conducting the 100% visual inspection to remove and scrap any primer that appears defective.

SECTION III

INTRODUCTORY HANDBOOK

e. Drying and Storage

(1) Primers may be dried by various methods -- in a vacuum oven, by exposure to infrared light, in a heated air dryer or controlled dry-house.

(2) Primers are stored in a temperature-humidity controlled area conforming to local safety regulations.

f. Invert

(1) When primers are released from storage to cartridge production, it is necessary that they be inverted; i.e., arranged anvil side up in a small flat tray for feeding into the magazine of the primer insert machine.

(2) This operation may be accomplished by a special inverting machine or by manual means.

(3) The operator of the inverting machine or the manual operator conducts an additional visual inspection of the anvil side of the primer and scraps any primer that appears defective.

g. Safety

Immaculate housekeeping, personnel and quantity limits, and handling procedures must be respectfully and strictly followed. Some of the large plants have accomplished the production of billions of primers without serious accidents.

22. CORES FOR ARMOR PIERCING CARTRIDGES

Armor piercing (AP) cores are manufactured on an automatic screw machine. Experience has shown that a core conforming to drawing dimensions and

SECTION III

MANUFACTURE

having a correct hardness will, if properly assembled in a bullet, possess the required armor piercing characteristics.

23. CLOSURE CUPS AND CLOSURE DISCS FOR TRACER CARTRIDGES

The cup or disc is used to seal the base of the tracer bullet and protect the composition from moisture. The thin cup ruptures when the cartridge is fired.

24. INCENDIARY AND TRACER MANUFACTURE

The manufacture of incendiary and tracer compositions is described in the drawing for the particular composition and in the Operations Control Manuals or Standard Operating Procedures used by the various ammunition producers.

25. INCENDIARY AND TRACER CHARGING

a. These are semihazardous operations requiring vigilant observance of safety regulations.

b. The charging of these compositions is similar in principle. The bullet jacket is seated in a die. The pyrotechnic powder is automatically placed in the jacket and compressed or consolidated by mechanical means. Depending on the type of bullet and the pyrotechnic composition, the charging is accomplished on several types of multistation machines and in one or two operations.

c. Charges of incendiary and tracer compositions are established by weight, but the charging operation is accomplished volumetrically. Variations in the volume available in the bullet as well as variation in the density of the compositions require careful control and adjustment. Further, in-

SECTION III

INTRODUCTORY HANDBOOK

secondary and trace performance are directly affected by the compression, which must be uniform and carefully adjusted.

d. The performance is also affected by: the length of time the compression punch dwells on the compressed charge; the relationship of the punch diameter to the bullet jacket inside diameter; the configuration of the working end of the compression punch; the interrelationship of the charging die dimensions, tolerances, and configuration to those of the bullet jacket; the bullet jacket material; the dimensions, tolerances, and configuration of the coning punches, basing dies, and sizing dies used for the final bullet assembly operation; the distributions of particle sizes in the basic chemicals used to blend the pyrotechnic compositions; the humidity and temperature when the composition was blended; the humidity and temperature when the composition was charged and compressed.

26. PACKAGING

a. The same degree of control must be maintained over the packaging process as is maintained over the cartridge manufacturing process.

b. Small caliber ammunition must be packaged in such a manner:

(1) That it will be properly identified.

(2) That it will be functionally serviceable when it arrives at its destination. The ammunition must be packed to withstand conditions normally encountered in shipping, in storage, and in the field. Waterproof ammunition boxes and suitable wirebound boxes are used to provide this protection.

SECTION III

MANUFACTURE

c. Many items of automated or semiautomated equipment exist for the cartoning, clipping and linking of cartridges, bandoleer packing, and the marking of ammunition and wirebound boxes; however, a considerable amount of hand labor is also required.

INTRODUCTORY HANDBOOK

SECTION IV

THE CONTROL OF QUALITY

27. GENERAL

The adage "Quality must be built into a product, it cannot be inspected into it" is particularly applicable to the manufacture of small arms ammunition. Ammunition must be manufactured dimensionally and functionally conforming the first time to avoid excessive scrap and rework costs. Small arms ammunition production is inherently high speed and a defective machine condition can be responsible for producing thousands of scrap components within an hour. Furthermore, completed lots of ammunition must not contain any "critical" type defects, almost no "major" and very few "minor" types. The incidence of as few as one (1) critical defect in a million rounds can affect the safety of personnel using the malfunctioning cartridge, and jeopardize the success of his individual mission. For these reasons there is a continuous striving for highest ammunition quality. This quality is controlled and assured through application of a modern management tool, Quality Control.

28. DEFINITION

a. Quality Control has been defined as "an effective system for coordinating the quality maintenance and quality improvement efforts of the various groups of an organization to enable production at the most economical levels which allow for full customer satisfaction".

b. The word quality in "quality control" does not have the popular meaning of "best" in any absolute sense. Rather, it is the ability of the product to conform to its specifications and control is simply the business of assuring that conformance. Effective small arms ammunition control is accom-

SECTION IV

THE CONTROL OF QUALITY

plished through the following procedures:

(1) Interpreting Requirements - Preparing such documents as "Quality Assurance Provisions" for inspection of incoming material, "Quality Control Instructions" and "Detail Inspection Plans" for process inspection guidance.

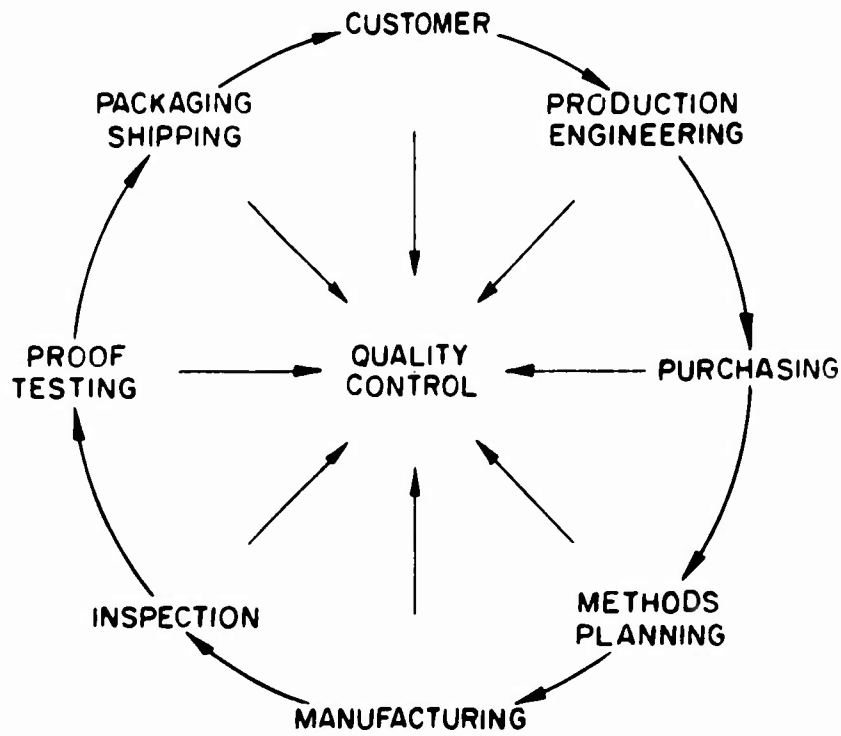
(2) Appraising Conformance - Comparing the conformance of the manufactured product to standards. Process inspection and proof testing actions are vital in accomplishing the appraisal. Statistical methods are employed to measure quality and determine action.

(3) Acting When Necessary - Taking corrective action when appropriate, e.g., when standards are not attained, trends toward defective conditions are discovered, "assignable causes" (variation beyond the stable predicted pattern) and erratic, unstable conditions are exhibited.

(4) Recommending Improvements - Analyzing quality data and submitting proposals for modification of processes to achieve more efficient operation and to resolve quality difficulties.

c. From the administrative point of view, quality control enters into all phases of the small arms ammunition production process. It starts with the customer's specification and moves into production engineering, materials purchasing, methods planning, manufacturing, inspection, proof testing, packaging, shipping and back to the customer, whose needs must be satisfied with quality small arms ammunition. Figure 15 illustrates this "Quality Control Cycle".

INTRODUCTORY HANDBOOK



QUALITY CONTROL CYCLE

Figure 15

SECTION IV

THE CONTROL OF QUALITY

29. INSPECTION

a. Operator Inspection - The machine operator is the first line of defense against the occurrence of defective work. He continuously inspects the production obtained from the machine. The adjustor and line foreman also check the work under their charge at random intervals.

b. Process Inspection - Process inspection is vital to the effective functioning of the small arms ammunition quality control system. As the major arm of the system, it serves in data collection, material identification and all inspection activities. The process inspection element appraises conformance by performing the following:

(1) First Piece Inspection - This inspection is performed on production from all small arms ammunition component and assembly machines when an operation is initially set up and after every major tool change.

(2) Machine Inspection - The process inspector visits every machine in his area a scheduled number of times per shift. He inspects a small sample. If it is satisfactory, all production since his last visit is considered acceptable and is added to the day's production. If the sample contains a defective(s), corrective action is taken immediately.

(3) 100% Inspection - Process inspection performs certain 100% visual and dimensional inspections to insure that no critical defects will be processed and shipped to the field in small arms ammunition lots.

(4) Lot Sampling Inspection - The visual and dimensional quality of lots is assessed by

SECTION IV

INTRODUCTORY HANDBOOK

using sampling procedures. Sampling is performed to verify that good manufacturing practice and the machine and 100% inspections have, in fact, combined to produce small arms ammunition of acceptable quality.

30. CONTROL TESTS

a. The primary goal is to manufacture ammunition that functions properly and exhibits acceptable ballistic characteristics. Therefore, during the manufacturing cycle, in addition to dimensional and visual inspections, proof testing is conducted to assure conformance to functional and ballistic requirements. Small samples, identified to a particular machine, machine group, or lot of material, are taken at specified intervals, identified, processed into finished cartridges and fired. The results of these tests are utilized to verify processes, make necessary process adjustments or confirm the effectiveness of new material. The tests are called daily production control tests and they include:

(1) Accuracy tests from bullet assembly machine production.

(2) Velocity, chamber pressure, and port pressure tests from loading machine production. Bullet pull tests and propellant charge weight checks are performed at this stage, also.

(3) Primer sensitivity tests.

(4) Tracer bullet performance tests from tracer bullet charging and basing operations.

(5) Function and casualty tests representing daily case line production. This includes the evaluation of metallurgical characteristics

SECTION IV

THE CONTROL OF QUALITY

such as case hardness and grain size.

31. WORK TESTS

Work tests are conducted under controlled conditions to determine the performance of new or improved tools, equipment or material.

32. STATISTICAL QUALITY CONTROL

a. Statistics are used in the overall small arms ammunition quality control program whenever it may be useful. But statistics are only one phase in the program; they are not the program itself.

b. Statistical methods have been employed with great success in inspecting small arms ammunition materials, parts and cartridges to test their conformance to appropriate quality levels, and in controlling the production process itself. They have made possible the diagnosis and correction of many production problems, brought improvements in quality and reduced scrap and rework.

c. Statistical methods have had a profound effect upon the entire area of small arms ammunition quality control. The following four statistical tools may be used separately or in combination to achieve quality goals:

(1) The Frequency Distribution - The frequency distribution is a tabulation or tally of the number of times a given quality characteristic occurs within the sample of product being checked. As a picture of the quality of the sample, it may be used to show:

(a) The average value of the characteristic

INTRODUCTORY HANDBOOK

(b) The spread of the characteristic

(c) The comparison of the characteristic results with specification requirements (capability study)

(2) **The Control Chart** - The control chart is a chronological (hour by hour, day by day) graphical comparison of a quality characteristic with special limits. It allows the user to maintain statistical control over a process. The concept of the control chart briefly is: Measured quality of manufactured product is always subject to a certain amount of variation as a result of chance. Some stable "system of chance causes" is inherent in any particular scheme of production and inspection. Variation within this stable pattern is inevitable. The reason for variation outside this stable pattern may be discovered and corrected. The power of the control chart technique lies in its ability to separate the assignable causes of quality variation which should receive corrective engineering attention. Moreover, by identifying certain variations as inevitable chance variations, the control chart tells when to leave a process alone.

(3) **Sampling Techniques** - Sampling techniques are utilized to judge the quality of an entire lot by examining only a small portion of it. Admittedly, there is always a chance that a sample will fail to truly describe its lot by indicating acceptable quality when poor quality is present or vice versa. However, the errors involved in sampling are predictable and well worth the risks in view of the advantages over 100% inspection. Sampling is more efficient than 100% inspection (industrial studies show 400% inspection is necessary to achieve 98% efficiency); it is more economical and provides potential process control information

SECTION IV

THE CONTROL OF QUALITY

more readily than end-of-the-line 100% sorting.

(4) Special Methods - Some of the special methods are: analysis of variance, analysis of means, "t" test, "F" test, "chi-square", regression and correlation techniques and designed experiments. They are utilized to solve such problems as:

(a) Determination of ballistic (accuracy, velocity, pressure) capabilities of ammunition lots.

(b) Comparison of ammunition lots or special groups, for ballistic differences.

(c) Establishment of daily production control group acceptance criteria.

(d) Establishment of daily production control group combination criteria to determine composition of ammunition lots.

(e) Comparisons among processes or machines to determine best performers.

INTRODUCTORY HANDBOOK

SECTION V

QUALITY ASSURANCE

33. GENERAL

a. The manufacturers of military small arms ammunition, whether a government arsenal, a government-owned contractor-operated plant, or a private commercial plant, are required to submit the ammunition to the Government Quality Assurance Representative In Charge (QARIC) for acceptance.

b. The manufacturer is also required to provide the QARIC access to all parts of his production facility.

34. FUNCTION

a. The function of the QARIC in a small arms ammunition plant and the purpose of his presence are as follows:

(1) Process Observation

(a) The manufacturer when he signs the contract will have agreed to make the ammunition by an approved process and in accordance with applicable drawings and specifications. The reason for the government's interest in the process is the fact that acceptance examination and testing are performed on a relatively small sample of each ammunition lot. Since the effective application of such sampling inspection assumes homogeneity of the cartridges within the lot, it is most important that the ammunition be produced by an effective, established, uniform, proven process.

(b) The QARIC, in observing the process, will not interfere with production or conduct any process inspection as such. If he detects any irregularity or deviation, he will bring the

SECTION V

QUALITY ASSURANCE

matter to the attention of the manufacturer and will request that corrective action be effected. Continued occurrence of cited deficiencies will be cause for discontinuance of government acceptance.

(2) Official Acceptance

(a) Current cartridge specifications contain a statement to the effect that the manufacturer is responsible for the performance of all inspections prescribed therein. However, the government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that ammunition conforms to prescribed requirements. The amount and nature of product verification to be performed by the QARIC are delineated in the "Quality Assurance Letter of Instructions" generated by the Army Materiel Command Quality Assurance Representative (Key Inspector). The QARIC formally and officially accepts or rejects ammunition, based upon objective evidence that the ammunition either complies or does not comply with the specification. The actions required to obtain such evidence are outlined in the above mentioned "Quality Assurance Letter of Instructions", and normally include both government product inspection and evaluation of the manufacturer's inspection records.

(3) Assistance

The QARIC has the function of assisting the manufacturer whenever possible, particularly in presenting engineering problems through proper channels to the responsible technical agency.

(4) Protection

The presence and activity of the QARIC in a manufacturer's plant operates as a sub-

INTRODUCTORY HANDBOOK

stantial protection to both the government and manufacturer. Monitoring of the manufacturer's inspection system by the QARIC enables detection and correction of deficiencies on a timely basis, thereby preventing the manufacture of sizeable quantities of unacceptable ammunition. Product verification by the QARIC provides additional assurance that the ammunition being submitted by the manufacturer to the government is of acceptable quality.

35. NONCONFORMING MATERIAL

The QARIC will not have authority to waive the specification requirements. However, procedures for the submission and processing of "Requests for Waiver" for consideration for approval to accept nonconforming material are provided in the "Quality Assurance Letter of Instructions" or in established regulations.