FIELD ARTILLERY MATERIEL

BY

1ST LIEUT. JAMES P. KELLY F. A.

The Project Gutenberg eBook of Field artillery materiel

This eBook is for the use of anyone anywhere in the United States and most other parts of the world at no cost and with almost no restrictions whatsoever. You may copy it, give it away or re-use it under the terms of the Project Gutenberg License included with this eBook or online at www.gutenberg.org. If you are not located in the United States, you will have to check the laws of the country where you are located before using this eBook.

Title: Field artillery materiel

Compiler: James P. Kelly

Release date: October 25, 2023 [eBook #71954]

Language: English

Original publication: Columbia, MO: University Coop Store, 1920

Other information and formats: www.gutenberg.org/ebooks/71954

Credits: Bob Taylor, Brian Coe and the Online Distributed Proofreading Team at https://www.pgdp.net (This file was produced from images generously made available by the Library of Congress)

*** START OF THE PROJECT GUTENBERG EBOOK
FIELD ARTILLERY MATERIEL ***

FIELD ARTILLER MATERIEL

NOTES ON THE DEVELOPMENT,
USE AND CARE OF MODERN FIELD ARTI
EQUIPMENT, INCLUDING THE

3" Field Gun, American, French and
British 75s, the 4.7" Gun, 155-mm
Howitzer, GPF, Fire Control Instrumen
Signal Equipment and small
arms used by the Field Artillery—autom
pistol, automatic rifle and
the Browning machine gun.

Compiled by

JAMES P. KELLY
1ST LIEUT. FIELD ARTILLERY
U. S. ARMY

COPYRIGHT
BY
THE UNIVERSITY CO-OPERATIVE ST
UNIVERSITY OF MISSOURI
COLUMBIA, MO.

1920

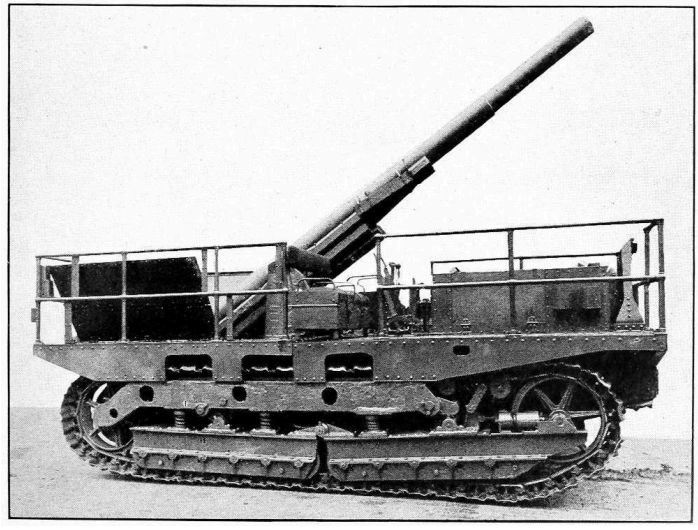
DEDICATION

To those efficient officers and inspiring gentlemen who interested the “youngsters” of the Yale batteries in the service of their country, and, in a time of peace, prepared them for the duties which they later performed in a time of war, this book is gratefully and respectfully dedicated.

ARTILLERY OF THE FUTURE.



SELF-PROPELLING CATERPILLAR MARK VII 75-MM. GUN. MODEL 1916.



SELF-PROPELLING CATERPILLAR MARK II 155-MM. FILLOUX GUN.

INTRODUCTION.

The compiler of this volume believes that the Field Artillery student should possess a broad, general knowledge of the history and development of ordnance, with some idea of the elements of gun construction; that he should be acquainted with the organization, ideals and practicalities of modern field artillery armament; that he should know the ammunition and the guns in our Field Artillery service with their care and maintenance.

It is also believed that in the R. O. T. C. units of Field Artillery the student should make the complete 3” equipment the basis of his knowledge of materiel. He should become thoroughly and familiarly acquainted with this weapon, and, to a lesser extent, with the other light pieces which are in present use. The reason for this being that our experience in the World War has shown that a thorough knowledge of one class of materiel permits a ready adaptation to any other type. He should also know the manner of functioning of the 4.7” and 155-mm rifles, with a somewhat more intensive knowledge of the 155-mm howitzer—and with a sound knowledge of the capabilities and limitations of all.

To complete his instruction in materiel he should know the use and care of Fire Control equipment, Signal equipment, and the small arms used in the field artillery, pistol, automatic rifle and machine gun.

The lack of a single volume covering the above has

been the cause of the compilation of this book. The compiler hopes the R. O. T. C. student will find in it a text which will be interesting, instructive and comprehensive. To the lieutenants in charge of Department “A” and to those who aspire to that responsibility it is hoped that this work will prove a valued addition to their professional libraries.

The subjects covered herein have been taken wholly or in part from the various official handbooks, from “Ordnance and Gunnery, U. S. M. A.,” “Naval Gunnery, U. S. N. A.,” “America’s Munitions,” “Gun Making in the U. S. A.,” “Ordnance and Gunnery for Field Artillery Officers,” “Artillery Firing,” “The Field Artillery Journal,” Ordnance Doc. 2033, from lecture notes taken at the School of Fire, Brigade Training Pamphlets, and various other sources.

The compiler is indebted to Lt. Col. Lloyd E. Jones, F. A. and Major H. C. Jackson, F. A. for the valuable advice and the helpful assistance they rendered in this compilation.

CONTENTS.

Chapters		Page
I.	Definitions.	11
II.	History and Development of Materiel.	16

Biblical references —Use by Romans in Punic wars— Greeks; Chinese use of pyrotechmy; French field artillery in the time of Charles VIII; Gustavus Adolphus and artillery in the 17th century; Louis XIV; Gribeauval's work in 1765; Shrapnel, 1808; Smooth bores to rifles, middle of 19th century; French "75;" Period 1897 to date.

III. Elements of Gun Design and Construction. 27

Guns—wire wrapped and built-up; twist; breechblocks; carriages; traversing mechanisms; elevating mechanisms; recoil systems. Air and spring recuperators; shields; sights; wheels; trails.

IV. Modern Armament. 46

Discussions of types of artillery and their organization; missions and guns suitable to accomplish different missions; ideal and practical types for divisional corps and army artillery.

V. Three-inch Field Gun. 62

Weights and dimensions.

Description of gun, carriage, caisson and limbers; functioning of principal parts.
Mounting and dismounting.
VI. 75-mm Model 1897 (“French 75”). 84
Weights and dimensions.
Description and functioning of principal parts.
Care, preservation, dismounting.
VII. 75-mm Model 1916 (“American 75”). 105
Weights and dimensions.
Description and functioning of principal parts.
Care, preservation, dismounting, mounting.
VIII. 75-mm Model 1917 (“British 75”). 147
Weights and dimensions.

Description and functioning of principal parts.
IX. 4.7” Rifle Model 1906. 154
Weights and dimensions.
Description and functioning of principal parts.
X. 155-mm Rifle (Filloux Gun) (GPF). 160
Weights and dimensions.
Description and functioning of principal parts.
XI. 155-mm Howitzer Model 1918. 167
Weights and dimensions.
Description and functioning of principal parts.
Notes on dismounting and mounting —cleaning.
XII. Explosives, Ammunition and Fuzes. 199

Explosives—classes, fillers, H. E., nitrogen compounds.
Ammunition—classes, discussion of fixed, semi-fixed and separate ammunition, primers, charges, construction of different types of shell, care.
Fuzes—principle of operation, arming, classification, precautions, tables of fuzes giving description, use, etc.
Ammunition marking.
XIII. Care and Preservation of Materiel. 236

	Oils and cleaning materials; tools and accessories; care and cleaning of different parts of carriages, emptying, cleaning and filling cylinders, cleaning bore, breech, springs, etc.; general instructions for care of cloth, leather and metal equipment. Cleaning schedules.	
XIV.	Fire Control Equipment.	258

Sights—line, front and rear, panoramic; model 1915 and 1917 with their use, care and verification. Range Quadrant, care, use and adjustment. B. C. Telescope, model 1915 and Aiming Circle model 1916, with their use, care and adjustment. Range Finder, 1 meter base, use, care and adjustment. Field Glasses. Fuse Setters.

XV. Signal Equipment. 285

Telephones and Monocord Switchboards —description, use, adjustments, trouble shooting and care.

Projectors—
description,
use,
adjustment,
service code
for lamps and
buzzer,
conventional
signals.
Pyrotechnical
signaling,
classification of
rockets, use,
code.
Panels—liaison
with airplanes,
signals,
description of
panels, panel
code.
Flags—
classification,
use of
semaphore and
wig-wag.

Radio—Description of equipment, SCR-54 and SCR-54-A Sets, methods of operation, use of vacuum detectors, precautions, sources of trouble, maintenance, reception of airplane signals.

XVI. Small Arms. 315

Pistol, machine gun and automatic rifle—description, use and care.

XVII. Motors 328

Reconnaissance car, Dodge, Harley-Davidson motorcycles. 5-ton tractors, ammunition trucks, cargo trucks. How to drive, sources of trouble, maintenance.

Appendices. 349

A.Gunner's Examinations —preparations, Cannoneers' "Don'ts," training gun crews.
B. Tabular comparison of light guns used in World War. 370
C. Table of Equivalents. 371
Index.

LIST OF ILLUSTRATIONS

Title	*Page*
Artillery of the Future	Frontispiece
Diagram Hydro-Springs and Hydro-Pneumatic Recoil Systems	41
3-inch Field Gun Breech Mechanism	Facing 63
Carriage Model 1902, Plan View	Facing 65
Elevating Gear	67
Traversing Gear	Facing 66
Recoil Controlling Mechanism	Facing 69
Caisson Limber, Model 1916	73
Caisson, Model 1902	Facing 74
75-mm Field Gun, Model 1897 (French)	85
Breech Mechanism	86
Firing Mechanism	88
Gun Carriage, Longitudinal Section	90
Gun Carriage, Rear View	91
Gun Carriage, Left Side	92
Gun Carriage, Right Side	93
Gun Carriage, Plan View	94
Wheel Brake Mechanism (Abatage)	96
Range Elevating Mechanism	98

75-mm Field Gun, Model 1916 (American) 107
Breech Mechanism 108
Breech Mechanism 109
Gun Carriage, Left Side 112
Gun Carriage, Right Side 113
Gun Carriage, Rear View 116
Gun Carriage, Plan View 117
Gun Carriage, Longitudinal and Transversal Sections 119
Recoil Mechanism 122
Valve Turning Gear 125
Angle of Site Mechanism 128
Elevating Mechanism 130
Traversing Mechanism 132
75-mm Field Gun, Model 1917 (British) 148
Breech Mechanism 149
Recoil Mechanism 151
Gun Carriage, Plan View 152
4.7-inch Gun, Model 1906, Longitudinal Section 155
Gun Carriage, Left, Plan and Rear Views 158
155-mm Gun, Model 1918, (GPF) (Filloux) 161
Longitudinal Section in Battery 163
Carriage and Limber, Traveling Position Facing 165

155-mm Howitzer, Model 1918 169
Carriage and Limber Facing 166
Carriage Unlimbered Facing 167
Breech Mechanism 171
Breech Mechanism 172
Firing Mechanism 174
Longitudinal Section 180
Carriage, Left Side 183
Elevating Mechanism 184
Traversing Rollers 186
Traversing Mechanism 188
Air and Liquid Pumps 190
Howitzer Carriage, Plan View 191
Quadrant Sights, Model 1918 193
DeBange Obturator 205
Mark II-A Primer 207
155 Steel Shell Mark IV 210
155 Shrapnel Mark I 212
4.7-inch Gun Ammunition 213
3-inch Gun Ammunition Facing 214
Detonating Fuze, Mark III 225
Detonating Fuze, Mark V 226
45 Second Combination Fuze, Mark 1 230
21 Second Combination Fuze, Model 1907 M 231
75-mm Gun Ammunition 234

Rear Sight, 3-inch Field Gun	259
Panoramic Sight, Model of 1917	261
Panoramic Sight, Model of 1915	264
Range Quadrant, 3-inch Field Gun	266
Battery Commander's Telescope, Model 1915	271
Aiming Circle	275
Diagram of Range Finder Principle	279
Range Finder, Rear View	Facing 280
Range Finder Tripod	Facing 281
Three-Steps in Range Finding	Facing 282
Fuze Setters	Facing 284
Camp Telephone	Facing 286
Diagram Telephone Circuit	287
Diagram Radio Circuit	307
The Automatic Pistol, Cal. 45, Model 1911	Facing 316
Receiver, Barrel and Slide	Facing 317
Component Parts	Facing 318
Component Parts Assembled	Facing 319
Ammunition Truck	Facing 334

CHAPTER I
DEFINITIONS.

In the study of any subject which is rather technical in nature, it is absolutely essential that the reader be familiar with the meaning of the words and phrases which must be used in the matter to be discussed. If the subject matter is to be understood there must be a common phraseology. The reader is therefore strongly urged to perfect his knowledge of the following short vocabulary before passing on to the matter which follows.

Ammunition. A general term applied to all forms of powders, shells, cartridges, primers, etc.

(a) *Fixed Ammunition.* When the powder charge is enclosed in a metallic container which is fixed to the projectile, it is called "**Fixed Ammunition**."

(b) *Semi-Fixed Ammunition.* When the charge and metallic container are a fixed unit but are not fastened to the projectile, it is called "**Semi-Fixed Ammunition**."

(c) *Separate Ammunition.* When the powder charge is contained in bags separate from the projectile and containing not a fixed but a varying charge, it is called

"**Separate Ammunition**."

Artillery. All firearms not carried by hand, excepting machine guns. It is divided into two general classifications: (1) artillery of position, and (2) mobile artillery.

(1) Artillery of Position is that which is permanently mounted in fortifications.

(2) Mobile Artillery consists of two classes: first, artillery designed to accompany an army in the field; second, railway artillery which requires tracks for its transportation.

Ballistics. The science of hurling projectiles or of the motion of projectiles in their flight.

Bore. The hole which extends from the muzzle to the breech. The passageway for the projectile. That part of the tube which is bored out.

Breech. The rear end of the gun, tube, or barrel.

Caisson. A two-wheeled vehicle which supports an ammunition chest. The wheeled equipment of a gun section consists of one gun with its limber and one caisson with its limber. For a caisson section it consists of two caissons with their limbers.

Caliber (**Calibre**). The diameter between the

highest points in the bore.

Carriage, gun. Usually understood to mean all the piece except the tube with its appurtenances and the limber.

Cartridge case. A hollow cylinder shaped to fit the bore. A container for the propelling charge.

Charge.

(a) *Propelling.* A quantity of powder used in the bore to generate the gases which propel the projectile from the gun.

(b) *Bursting.* A quantity of powder used in shrapnel to strip off the head of the projectile and to force out the balls.

(c) *Explosive.* The matter used in a shell to detonate it at the end of its flight.

Cradle. In general, that part of the carriage which houses the recoil and counter-recoil mechanisms.

Elevating Mechanism. The device used to elevate the gun through a vertical arc in order to give the gun an elevation corresponding to the desired range at which the piece is to be fired.

Fire Control Equipment. Those instruments used to compute firing data, observe and correct the fire, such as B. C. Telescopes, Aiming Circles, Range Finders, etc.

Firing Mechanism. A device located in the

breechblock for exploding the primer and thus causing the ignition of the powder charge.

Fuze. That part of the round which is fastened to the point or to the base of the projectile and causes the latter to be detonated or exploded near the time or the place desired.

Fuze Setter. A device used to set time fuzes in such a manner that shrapnel or shell will burst at or near the desired height in air.

Gun. A metallic tube from which projectiles are hurled by gases generated from the ignited powder. In general, all fire arms; but in Field Artillery terms, comparatively long-barreled weapons using relatively high muzzle velocity in contra-distinction to the howitzers and mortars.

Howitzer. A weapon which differs from a gun in that for the same caliber it uses a shorter tube, lower muzzle velocity and generally a more curved trajectory. From two to seven varying strengths of propelling charges may be used in the howitzer. This gives it selective angles of fall, and allows the howitzer to reach targets that are hidden from the flat trajectories of guns.

Initial Velocity. The speed with which the projectile first moves.

Limber. A two-wheeled carriage which is

sometimes used to carry an ammunition chest and always used to support the weight of the trail of the piece or caisson. It adds the other two wheels to make a four-wheeled vehicle.

Materiel. A term used in the Field Artillery in contra-distinction to Personnel.

Mortar. A weapon using for the same caliber, a barrel much shorter than the corresponding howitzer. Used at short ranges with extreme steep angles of fall to reach highly defiladed targets.

Muzzle. The front end of the bore.

Muzzle Velocity. Speed or velocity of the projectile measured as it leaves the muzzle.

Ogive. The rounded shoulder of the projectile.

Ordnance. Arms, ammunition, and their accessories.

Piece. A fire arm, small or large.

Primer. Device used to insure ignition of the propelling charge.

Projectile. The effect-producing part of the round. The bullet-like form which is thrown toward the target.

Quadrant, gunners. A device for measuring angles of elevation.

Recoil Mechanism. That part of the piece which checks the recoil—or kick—that always occurs when a piece is fired. It generally includes the counter-recoil

mechanism which restores the tube “into battery” after it has fired.

Rifle. A gun. A weapon with a comparatively long barrel and high muzzle velocity. Rifles under 6 inches seldom use over two different charges. Term used in contrast to Howitzer or Mortar.

Rifling. The lands and grooves in the bore of the piece which imparts to the projectile during its passage through the bore, the rotary motion that increases accuracy and range.

Round. Consists of the primer, cartridge case or powder bags, projectile and fuze. For light Field Artillery the round weighs about 18 lbs and the projectile about 15.

Shell. A projectile which secures its effect by the force of its detonation, the bursting of its walls, and the fragmentation and velocity of the fragments. Also used as a gas carrier.

Shrapnel. A projectile which secures its effect by the expulsion in the air of lead balls with shot-gun like effect.

Trail. That part of the piece which extends from the axle to the rear and transmits the force of recoil to the ground through the trail spade. Usually supports the elevating and traversing mechanisms.

Traversing Mechanism. A device used to give the piece direction by moving it through a horizontal arc.

CHAPTER II
HISTORY AND DEVELOPMENT OF MATERIEL.

In taking up the study of materiel, the Field Artillery student should know something of the history and development of ordnance and the reasons for the various changes which have taken place from time to time.

The sole use of a gun is to throw a projectile. The earliest projectile was a stone thrown by the hand and arm of man—either in an attack upon an enemy or upon a beast that was being hunted for food. Both of these uses of thrown projectiles persist to this day, and, during all time, from prehistoric days until the present, every man who has had a missile to throw has steadily sought for a longer range and a heavier projectile.

In ancient times the man who could throw the heaviest stone the longest distance was the most powerfully armed. During the Biblical battle between David and Goliath, the arm of David was strengthened and lengthened by a leather sling of a very simple construction. Much practice had given the youthful shepherd muscular strength and direction, and his stronger arm and straighter aim gave him power to overcome his more heavily armed adversary.

Projectile-throwing machines were developed after the fashion of a crossbow mounted upon a small

wooden carriage which usually was a hollowed trough open on top and upon which a stone was laid. The thong of the crossbow was drawn by a powerful screw operated by man power, and the crossbow arrangement when released would throw a stone weighing many pounds quite a distance over the walls of a besieged city or from such wall into the camps or ranks of the besiegers. This again was an attempt by mechanical means to develop and strengthen and lengthen the stroke of the arm and the weight of the projectile. The Bible states that King Usia (809-757 B. C.) placed types of artillery on the walls of Jerusalem. The Romans used it in the Punic Wars. The Alexandrian technicians established scientific rules for the construction of early weapons. Athenaeus reports catapults having a range of 656 meters and that the gigantic siege tower at Rhodes successfully resisted stone projectiles weighing 176 pounds.

References to explosives are to be found in works as old as Moses. Archimedes is said by Plutarch to have “cast huge stones from his machines with a great noise;” Caligua is said by Dion Cassius to have had machines which “imitated thunder and lightning and emitted stones;” and Marcus Graecus in the eighth century gives a receipt of one pound of sulphur, two of willow charcoal and six of saltpetre, for the discharge of what we should call a rocket.

The use of Greek fire was understood as early as the sixth century, but powder was earliest used in China, perhaps a thousand years before Christ, and was introduced to European notice by the Saracens.

From the discovery of gunpowder by the English monk Bacon in 1248, sixty-five years elapsed before a Franciscan monk produced the first gun in

Germany, about 1313. The first guns were of a small breech-loading type, supported in front by crossed sticks and anchored by a spike at the breech. Later these guns were fastened to cradles, the latter being mounted on sleighs, and finally, in 1376, the Venetians produced the first wheel mounts, which had become common by 1453, when the Turks took Constantinople.

The ancient carriages were remarkable because of the fact that in general design they embodied the same principals which are included in the field carriages of to-day. One example from the fifteenth century shows a breech-loading gun mounted in a cradle supported by trunnions on the forward extension of the trail over the axle. The cradle was elevated by a pin-and-arc arrangement, supported on the trail. The axle supported by wheels passes through the trail to the rear of and below the cradle trunnion support and in front of the point of attachment of the elevating arc.

Field guns fell into disuse about 1525 with the introduction of musketry, and remained so until 1631, when Gustavus Adolphus gave artillery its true position on the battlefield.

Swedish artillery reigned supreme in the early part of the seventeenth century. Gustavus introduced marked changes by making the guns and the carriages lighter and handier, and by adapting their movements to those of the other arms and to the requirements of the battlefield. In this, as in all his military efforts, his motto was mobility and rapidity of fire.

In 1624 Gustavus had all his old types of guns recast into newer models and the following year he himself contrived a gun which three men and one

horse could maneuvre to good effect. It was an iron three and four pounder with a cartridge weighing less than a pound and consisting of a charge held in a thin wooden case wired to a ball. This was the first artillery cartridge, the original fixed ammunition. The gun was afterwards used in other European armies and known as the “piece Suedoise.” Not only had it the advantage of lesser weight but its cartridge was always ready to fire and it could be fired eight times to the six times of the infantry musket of that day.

In the wars against the Poles, Gustavus employed with profit the so-called leather cannon, a fact which shows how lacking the times were in artillery power. These guns were invented in the early 1620s by a Colonel Wurmbrandt, and consisted of a thin copper tube reinforced by iron bands and rings, then bound with rope set in cement, the whole covered with sole leather. The tube was made to screw in and out because it grew heated by from eight to twelve charges and had to be cooled. The gun carriage was made of two planks of oak. The gun without the carriage weighed about ninety pounds and was fired with a light charge. They were used during 1628-29 and then gave way for four pounder cast-iron guns which remained in common usage in Europe until artillery was reorganized by Frederick.

Gustavus’ batteries excited universal admiration. Grape and canister were generally employed in the field guns and round shot only in the siege guns. Artillery was used massed or in groups and also with regiments of foot soldiers. Gustavus was probably the first to demonstrate the real capabilities of artillery.

Mortars throwing bombs were first used at the siege of Lamotte in 1634. Hand grenades, shells, fire-

balls, etc., came into more general use as the German chemists made their new discoveries. Artillery practice grew to be something of a science; experts took it up and the troops were better instructed. Regimental artillery, that is, artillery with the infantry, was attended by grenadiers detailed for the work. There were special companies for serving the reserve guns.

The period following the Thirty Years' War—the middle of the seventeenth century—gave no great improvement to the art of war but there were many marked advances in the matter of details of construction. During the era of Gustavus it was Sweden that led in making war more modern; during the era of Louis XIV it was France.

Artillery ceased to be a guild of cannoneers as it long had been and became an inherent part of the army. More intelligence was devoted to it and more money spent on this arm of the service; it grew in strength and importance, and was markedly improved. But while the artillery service ceased to be a mere trade, it did not put on the dignity of a separate arm, nor was the artillery of any great utility in the field until well along in the eighteenth century. Guns, however, in imitation of the Swedes, were lightened, particularly so in France; powder was gradually compounded on better recipes; gun-metal was improved; paper and linen cartridges were introduced; gun carriages were provided with an aiming wedge; and many new styles of guns and mortars, and ammunition for them were invented.

Science lent its aid to practical men, and not only exhausted chemical ingenuity in preparing powder and metal, but mathematical formulas were made for the artilleryman, and value of ricochet firing was

discovered. Louis XIV founded several artillery schools, and initiated the construction of many arsenals. Fontainebleau, the French artillery school which trained many Americans during the World War had its beginning in this period. Finally, the artillery was organized on a battery and a regimental basis, and careful rules were made for the tactics of the guns. These were served by dismounted men and generally hauled by contract horses.

Although sensibly improved, the artillery was far from being skillfully managed and was slow firing; it usually stood in small bodies all along the line of battle. It was heavy and hard to handle and haul, principally because the same guns were used for both siege and field work, and was far from being, even relatively to the other arms, the weapon which it is to-day.

In 1765 General Gribeauval of France introduced artillery improvements, especially in the carriages, and formed a distinct artillery service for the field which was lighter than the old service and was drawn by teams which were harnessed double as they are to-day.

Howitzers were introduced in France in 1749. The weapons were given an early sort of perfection by the Dutch. The term “howitzer” comes from the German “haubitz.” In 1808 the first shrapnel appeared at Vimera. It was invented by an English colonel by the name of Shrapnel. At the time it was known as case shot. The type employed by Napoleon, had a fuze that could be used at two different ranges. The French still have this type in their armament.

Field artillery now began to appear in the form which it was to retain with but a few changes, until

the era of the modern field carriage. The cradle disappeared, muzzle-loading guns cast with trunnions taking its place, and a stepped wedge resting on the trail superseded the pin and arc. With the exception of the gun, most parts of these carriages were of wood and were to remain so until 1870, when metal carriages came into general use. Muzzle loading guns had supplanted breech-loaders because of the poor obturation and the many accidents resulting from use of the latter type. Although numerous experiments were made, breech-loading guns did not come into vogue again until 1850, when the experiments of Major Cavalli (1845), the Walnendorff gun (1846) and the Armstrong gun (1854), produced satisfactory types.

Up to 1860 practically all guns were smooth bore. Even during the Civil War the smooth bore was generally used, although the rifled gun began to make an appearance and was used in small numbers by both sides at the battle of Gettysburg. Some breech loaders began to appear at the same time. Improvement in the ballistic properties of the gun necessitated a corresponding improvement in the sighting facilities. In 1880 rifled breech loading and built-up steel cannon came into general use. Rifled guns shoot accurately and as a result, improved methods in direct laying were devised.

The period between from 1880 to the present, has brought about changes in gun construction which, possibly, have been equaled in importance to artillery only by the present change which is taking place in the means of artillery transportation and self-propelling mounts. In this period in rapid succession came the modern breechblock and with it the rapid firing gun. This brought about the change

to the present system of breaking the force of recoil of the gun and restoring it to its firing position without disturbing the position of the carriage. This added to the possibilities of rapid and more accurate fire. Then came the invention and use in the field artillery of smokeless powder. Previous to this time the great amount of smoke produced by the black powder when the piece was fired retarded the rapidity of fire because it enveloped the materiel in a thick cloud of smoke which obscured the target and made it impossible to fire again until the smoke had blown away. It made concealed positions for the artillery almost impossible. The advent of smokeless powder made firing more rapid and made possible the selection of concealed positions. This in turn made indirect fire feasible and necessitated the development of better sights. Indirect fire increased the rapidity of fire and gave to the commanders of firing units a greater control over their fire. With the use of recoil mechanisms and shields for the guns, the cannoneers were permitted to serve the piece continuously—a condition which was impossible with the recoiling carriage. The shields made it almost impossible to put the gun out of action unless some vital part of the mechanism was destroyed.

The first of the modern carriages which were produced in the early nineties should be classified as semi-rapid carriages, as the recoil brakes were so abrupt that the carriage was not stable and jumped considerably, gaining for the type the sobriquet of “grass-hopper guns.”

In 1897 the immortal French “75” was born, the pioneer of all modern quick-firing field guns, which still maintains its superiority in many respects over later designs.

In 1902 our own 3-inch field gun was produced and still finds favor among many of our field artillery officers, even over the French “75.”

The Deport carriage brought to this country from Italy, in 1912, introduced to us the split trail, high angle of fire, wide traversing type of field gun carriage. This carriage was extensively tested by the Ordnance Department; by the Field Artillery Board at Fort Riley, Kansas; and by the School of Fire for Field Artillery, at Fort Sill, Oklahoma. The Field Artillery Board unqualifiedly approved of the Deport carriage and recommended that it be adopted. The School of Fire for Field Artillery also approved of this type.

In 1916 the United States produced a 75-mm field gun which featured a split trail with an elevation of 57 degrees which permits its use as an anti-aircraft weapon and a variable length of recoil which prevents the breech from hitting the ground at the extreme elevations. It has a traverse of 800 mils in comparison to the 106 of the French 75 and the 142 and 140 of the British 75 and American three-inch field gun.

The outbreak of the late war saw all modern armies largely equipped with guns resembling the French “75” in a long-run recoil mechanism, weight of projectile and weight of carriage, etc. The fact that the largest number of horses which could best be handled to maneuver the light guns—about 6—could not pull over a long period a gun or caisson with its limber if the weight was more than about 4500 pounds, resulted in the practical standardization of light guns in all armies. So in 1914 we see that time and development had given light gun perfection and mastery of artillery technique to the French while the Germans, probably, possessed the most efficient

artillery program. The German types of weapons were more varied and perhaps better suited to the varying artillery needs in rendering that assistance to the infantry for which the artillery exists.

In our service during the World War, French 75s and the 155-mm Howitzer were used as divisional artillery. Two regiments of the light guns and one regiment of 155-Howitzers were assigned to each infantry division. As the war progressed guns and howitzers ranging from the 4.7" rifle, up to, and including 14 and even 16-inch naval guns on railroad mounts, were used as Corps and Army artillery.

Thus artillery development has gone steadily forward. Every military power has striven with the aid of its best engineers, designers and manufacturers to get a stronger gun, either with or without a heavier projectile, but in every case striving for greater power. As a special development and a not too important one, due to its lack of effectiveness in comparison to its cost, we find the now famous long range gun of the Germans, successfully delivered a projectile approximately 9 inches in diameter into Paris punctually every twenty minutes from a point about 75 miles distant. The Germans used three of these guns in shelling Paris. Their life was probably limited to about 75 rounds due to the excessive demands made upon the materiel.

The American Field Artillery Service now has before it four types of field gun carriages, namely our 3" model of 1902; the French 75 M-1897; the British 18 pounder, M-1905 converted to a 75-mm (known as the model of 1917); and our 75-mm model, 1916. There is being produced (1919-20) an improved model of 1916 75-mm carriage on which the St.

Chamond pneumatic recuperator, adopted jointly by the American and French governments, will be substituted for the spring recuperators; and the French 75-mm gun will be substituted for our shorter calibered type. From these types one must be selected. An intelligent selection involves a consideration of what may be expected in the future in order that it may best fit in with the new types yet to be evolved.

For horsed artillery—and horse artillery will be with us for some years to come—the limiting features of draft and man power will still pertain.

For tractor-drawn mobile artillery, the limiting feature is the tractive power of the tractor with relation to the weight of the gun and carriage, the unit being physically limited in weight by the supporting-power of the pontoon bridge which is about 10,000 pounds per vehicle.

For Caterpillar Artillery.—By that is meant guns mounted on caterpillar tractors—the limiting features are power and weight, coupled with the weight limitations of the pontoon bridge. To circumvent the question of weight, the load may be divided by mounting the motor by an electric generator on one caterpillar and the gun with an electric motor, on the other, a transmission cable connecting the two vehicles.

In conclusion it might be said that one of the greatest changes which has ever taken place in the development of field artillery is now underway in the form of motorization. Prior to 1917 horse traction had been the sole means of transporting mobile field artillery. The limit of the capabilities of horse traction placed a weight limit upon gun construction and to some extent upon artillery tactics. The

increase in the ratio of field artillery to infantry, the corresponding demand for artillery types of horses and the decrease in the availability of the latter as the war continued, combined with the great improvements which were constantly being wrought in mechanical transportation as the war lengthened, opened the way for artillery motorization.

The French began by placing their 75s on trucks for rapid changes of position. All the armies saw the possible advantages to be gained from the use of trucks with artillery but none planned—nor have any since put into practice—the extensive use of trucks, caterpillar tractors and motor transportation for personnel, which the United States planned on her entrance into the war. It was planned to equip about one-third of the A. E. F. artillery regiments with complete motor equipment. This plan did not entirely materialize but after the armistice the 3rd Field Artillery Brigade of the 3rd Division was completely motorized and its practice marches in Germany were most successful and full of promise for the future. To date the motorization of all our mobile Field Artillery, with the exception of about fifty per cent of the light field guns, has been authorized.

Motor traction gives a better performance than animal. While the latter, especially with the light field guns, possesses great mobility, it is not a sustained nor a persistent mobility; it is more easily exhausted and requires longer to recuperate. These are points of vital importance from a military viewpoint.

In 1920 a self-propelling caterpillar mounted with a 75-mm gun, model 1916, was tested with a view to ascertaining the ability of the motor to function in

water, i. e. fording streams, etc. The caterpillar successfully moved through ice water which completely submerged the carburetor.

Passenger cars for the transportation of personnel, four wheel drive trucks with caterpillar tractors for the transportation of the materiel, and the development of self-propelling mounts for the 75 and 155 rifles are the latest and the most important developments in field artillery materiel.

CHAPTER III
ELEMENTS OF GUN CONSTRUCTION AND DESIGN

"A gun is a machine by which the force of expanding gas is utilized for the purpose of propelling a projectile in a definite direction." It is essentially a metal tube closed at one end, of sufficient strength to resist the pressure of the gases caused by the combustion of the powder charge in the confined space at the closed end of the tube behind the projectile. The rapid combustion of the powder, which produces a high temperature, gives rise to a pressure uniformly exerted in all directions within the confined space. The energy exerted is used in forcing the projectile from the tube.

TUBES

Due to the effort of the large amount of superheated gas generated, which tends to expand in all directions, tremendous rending stresses are set up in the tube. Formerly these stresses were met by a sheer mass of metal, but, as the size of the projectiles increased and the necessary pressure to give them muzzle velocity increased, the size of the guns increased beyond the practical limits of mobility. This was at first offset by forgings of refined alloyed steels, but even these failed to keep pace with the increasing pressure desired. The new condition was met by the introduction of the "built-up" and the "wire-wrapped" guns. The modern built-up gun is

made by assembling one or more superimposed cylinders around a central tube. The superimposed cylinders, whose inside dimensions are slightly smaller than the outside dimensions of those on which they are to be assembled, are expanded by heat sufficiently to allow them to be assembled over the tube. The subsequent contraction on cooling causes each of them to exert a uniform pressure on the cylinder immediately underneath. This method of assembling is called “shrinkage.” This gives a compression to the inner tube and a slight tension to the outer one. The compression is so much additional strength to the tube because it must first be overcome before the powder gases can exert a tension on the inner tube fibers. The exact amount of the compression and tension for all parts of a gun at rest or resisting an explosion is a matter of mathematical calculation. The built-up construction has been used in practically all our present day types of field artillery.

THE WIRE-WRAPPED GUN.

Wire-wrapped guns consist of:

(a) An inner steel tube which forms a support on which the wire is wrapped and in which the rifling grooves are cut.

(b) Layers of wire wrapped upon the tube to increase its resistance by the application of an exterior pressure as well as to add to the strength of the structure by their own resistance to extension under fire.

(c) One or more layers consisting of a steel jacket and hoops placed over the wire with or without shrinkage. The jacket generally furnishes

longitudinal strength to the guns, and the breech block is screwed into the jacket, or into a breech bushing, which is screwed into the jacket.

The principal advantages of this type of gun over the built-up is economy of manufacture and greater facilities for inspection of materiel in the layers over the tube. The wire wrapping has itself a large reserve of strength due to the high elastic limits that may be given it. Two methods are used to wrap the wire: (a) at constant tension (b) at varying tension so that when the gun is fired with the prescribed pressure, all layers of wire shall be subjected to the same tangential stress. The latter method is theoretically better, but because of the ease of manufacture, together with the large factor of safety possible, the wire is usually wrapped at a constant pressure.

THE BUILT-UP GUN.

All army guns except small howitzers or mortars are of the built-up or wire-wrapped type. Built up guns of less than 5” caliber, or howitzers up to 8” caliber consist of an inner tube and a jacket shrunk onto this tube. The jacket covers the breech end of the gun and extends forward to the center of gravity. Built-up guns of larger caliber have one more layer of hoops in addition to the jacket, one layer of hoops usually extending to the muzzle.

The bore of the tube forms the powder chamber, the seat for the projectile and the rifled bore. Rifling consists of a number of helical grooves cut in the surface of the bore. The soft metal of the rotating band of the projectile is forced into these grooves causing the projectile to take up a rotary motion as it passes through the bore. This is necessary in order to

keep the projectile stable in its flight.

TWIST.

By twist of rifling is meant the inclination of one of the grooves to the element of the bore at any point. Rifling is of two kinds: (a) Uniform twist, or that in which the twist is constant throughout the bore, (b) Increasing twist or that in which the twist increases from the breech towards the muzzle.

The twist of rifling is usually expressed in the number of calibers length of bore in which it makes one complete turn. The twist actually required at the muzzle to maintain the stability of the projectile varies with the kind of projectile and the muzzle velocity. If a uniform twist be used, the driving force on the rotating band will be at a maximum when the pressure in the guns is at a maximum—or near the origin of rifling (seat of the projectile). The increasing twist serves to reduce the maximum driving force on the band thus lessening the danger of stripping the band. This is its principal advantage over the uniform twist, though it also reduces slightly the maximum pressure in the gun. The principal disadvantage of the increasing twist is the continued change in form of the grooves pressed in the rotating band, as the projectile passes through the bore. This results in increased friction and a higher value for the passive resistance than with a uniform twist. (Note: greater ranges obtained by cutting grooves in projectile, principal used on the long range gun by the Germans.) If the twist increases from zero at the breech uniformly to the muzzle, the rate of change in the tangent to the groove is constant. A twist in this form offers less resistance than the uniform twist to the initial

rotation of the projectile. To still further diminish this resistance a twist that is at first less rapid than the uniformly increasing twist and later more rapid has been generally adopted for rifled guns.

Formerly in our service the twist was uniform; one turn in 25 calibres for guns and one turn in 20 calibres for howitzers. All the latest model army guns, however, have an increasing twist of one turn in 50 calibres at the breech to one turn in 25 calibres at a point from 2 to 4 calibres from the muzzle. In howitzers and mortars the twist is sometimes one turn in 40 calibres at the breech to one turn in 20 calibres at a point several calibres from the muzzle. Some mortars are rifled with a uniform twist and some guns have a rifling which begins with a zero twist. (The 1905 3” gun, 0 to 1 in 25.)

OUTER CYLINDERS.

Outside of the tube is the jacket. It extends to the rear of the tube a sufficient distance to allow of seating the breech block. In this manner the longitudinal stress due to the pressure of the powder gases on the face of the breech block is transmitted to the jacket thus relieving the metal of the tube from this stress. In all built-up guns there is some method devised for locking the tube to the jacket so as to prevent relative movement of these parts.

Considering the gun alone the greatest range is obtained at an angle of about 43 degrees from that gun which fires the heaviest projectile with the greatest velocity. The caliber being limited to from 2.95 inch to 3.3 inch, the projectile is limited in weight to from 12 to 18 pounds. The weight of the gun is limited to between 700 and 1000 pounds and

in length to between 27 and 36 calibers. The longer the gun, the greater the weight and velocity from the same charge of powder. A pressure of 33,000 pounds per square inch with a corresponding velocity of 1700 f. s. has been found to be as high a pressure and velocity as are desirable for a reasonable length of life for a field gun, the average life of which is 10,000 accurate rounds.

Under the French school of artillery, which dominates our service at present, our bore is 75-mm, the weight of our shell 12 pounds, our shrapnel 16 pounds, the velocity for the one about 1,750 f. s. and for the other about 1,680 f. s.

BREECHBLOCKS.

The breechblock appears in four distinct types. Our own service has for years used the swinging interrupted screw breechblock which in the 1905 model is the equal of any of that type in existence. The swinging block has serious disadvantages for high angle fire in that it requires an excessive amount of room to operate and is difficult to load at high elevations.

The Italians have introduced a new breechblock in one of their recent guns, consisting of a half cylinder with superimposed spherical face on its cylindrical surface rotating vertically about a horizontal axis perpendicular to the axis of the bore. The gun is loaded through a groove in the breechblock when the latter is in its horizontal position. The block, which is semi-automatic, is very satisfactory. It is adapted to high angle fire.

The French in their “75” have used the rotating eccentric screw type, which is rapid in movement

and lends itself fairly well to high angle fire. It is completely enclosed and of rugged construction.

The Germans have used the sliding wedge type of block, moving in a horizontal direction, which does not lend itself to high angle fire.

The United States in its recent field carriage adopted the sliding wedge type in a vertical plane on account of its manifest superiority in fire at high angles. This block is rather difficult to manufacture and the type has a tendency to stick. The automatic closing necessitates a strong closing spring which fatigues the block operator, No. 1 in the gun squad. It is interesting to note that in a prospective new design for the 1916 gun carriage the American Ordnance Department adopted the French breechblock; and the St. Chamond Company, designing for the American Expeditionary Forces, adopted the American drop block.

Requirements for a breech mechanism:

The following may be said to be the principal requirements for a successful breech mechanism.

1. *Safety.* To be safe: (a) the gas must be restrained from escaping to the rear; this sealing or obturation must be automatic, greater pressure insuring better obturation. (b) The breech of the gun must not be weakened by the fitting of the breech mechanism. (c) The parts must have ample strength to prevent any portion from being blown to the rear. (d) The danger of premature discharge must be minimized. (e) The breechblock must be securely locked to prevent opening on firing.

2. *Ease and Rapidity of Working.* Otherwise, rapid and continuous fire cannot be maintained. Hence this would include facility in loading and certainty of

extraction for rapid fire guns.

3. *Not Easily Put Out of Order.* In other words it must be able to meet service conditions and hard usage. Parts should have a reserve strength.

4. *Ease of Repair.* Parts most exposed to wear should be so designed as to permit being replaced. This will also include accessibility to parts, so that breakage of a part will not disable the mechanism for a long time.

5. *Interchangeability.* Not only should individual parts be made interchangeable by accurate workmanship, but the whole mechanism should be capable of being mounted on similar guns. This is to meet service conditions.

GUN CARRIAGES.

A modern gun carriage is expected to stand steady on firing, so that in the first place it requires no running up, and in the second place it maintains the direction of the gun so that only a slight correction in elevation and direction is required after each round. The carriage is maintained in position by the spade, which sinks into the ground, and by the friction of the wheels upon the ground. If the force of the recoiling gun were communicated directly to the anchored carriage the effect would be to make it jump violently, which would not only disturb the lay, but would prevent the cannoneers from maintaining their position. The hydraulic recoil brake is therefore interposed between gun and carriage. If the guns were rigidly attached to the carriage the latter would be forced back a short distance at each round, and the whole of the recoil energy would have to be absorbed in that short motion. Instead of this the gun

alone is allowed to recoil several feet and although the recoil energy is in this case greater than it would be if gun and carriage recoiled together yet it is so gradually communicated to the carriage that instead of a violent jerk we have a steady, uniform pull, the only effect of which is to slightly compress the earth behind the spade. In a well designed carriage the amount of this pull is always less than that required to lift the wheels off the ground by rotating the carriage about the spade.

The only motion of the carriage which takes place is that due to the elastic bending and rebound of its parts under the cross strains set up on discharge. These strains are inevitable since the direction of recoil cannot be always exactly in the line of the resistance of the earth behind the spade. This movement of the axis is known as jump and must be determined by experiment for the individual piece in its particular mounting.

The principal parts of the typical gun carriage are the cradle, a device for mounting the cradle—called in the different models rocker, pintle yoke, and top carriage, the trail, the wheels and axle. The gun slides in recoil on the upper surface of the cradle and the cradle contains the recoil controlling parts.

In the design of the carriage the constructional difficulty lies not so much in preventing the carriage from recoiling but in preventing the wheels from rising off the ground on the shock of discharge. The force of the recoil of the gun, acting in the line of motion of the center of gravity of the recoiling parts, tends to turn the carriage over backwards about the point of the trail or center of the spade. This force is resisted by the weight of the gun and carriage, which tends to keep the wheels on the ground. The leverage

with which the overturning force acts is due to the distance of its line of action above the center of the spade; the leverage with which the overturning force acts is that due to the horizontal distance of the center of gravity of the gun and carriage from the center of the spade.

It follows that the steadiness of the carriage for a given muzzle energy may be promoted by four factors.

(a) Increasing the weight of the gun and recoiling parts. This reduces the recoil energy.

(b) Increasing the length of recoil allowed. This reduces the overturning pull.

(c) Keeping this gun as low as possible either by reducing the height of the wheels, or by cranking the axle downwards. This reduces the leverage of the overturning force.

(d) Increasing the length of the trail. This increases the leverage of the steadying force.

The well designed gun carriage is one that combines these factors in a practical way so as to give the greatest possible steadiness to the carriage at the same time keeping within the limits of weight imposed by the necessity of mobility.

Gun carriages are constructed so as to permit movement of the tube in the vertical and generally in the horizontal plane. These two motions may be made simultaneous if so desired by proper combination of the two motions and the axis of a gun aligned in any desired direction within the limits of motion of its mount. The two motions referred to are designated as follows: (a) Rotation of the piece about a vertical axis, its inclination with the horizontal

remaining unchanged is called “traverse.” (b) Movement of the piece in a vertical plane, the direction of the horizontal projection of the axis of the bore remaining unchanged is called “elevation.”

In order to permit of the two motions mentioned, gun carriages are provided with mechanisms for giving the piece accurately controlled motion in both elevation and traverse. The elevating gear of most American guns is an application of the Chinese or Telescopic screw. This gives a short assembled length with the necessary extended length required for modern ranges. It also gives the necessary rapidity for action. An entirely different mechanism is used in our howitzers and American 75s. In this case motion is communicated to the rockers, which carry the gun and cradle, through the engagement of worms with teeth cut on the lower circular edge of the rockers, the latter being pivoted on the cradle trunnions.

TRAVERSING MECHANISMS.

Movement of the gun in traverse is accomplished in two general ways.

(**a**) Pivot on the gun carriage axle.

1. The gun and cradle move around a vertical pintle or pivot placed in a saddle or rocker which itself pivots on horizontal trunnions or bearings usually attached to the axle. The rear end of the rocker forms a seat or bearing on which the cradle and gun move in traverse. The upper end of the elevating screw is also attached to the rear end of the rocker. This allows the rocker and cradle to be moved together in elevation and the cradle to move on the rocker in traverse.

2. The gun and cradle are mounted by means of horizontal cradle trunnions on a top carriage. The top carriage moves in traverse around a vertical pintle or bearing attached over the axle and between the front end of the trail flasks. The rear end of the top carriage moves on bearings attached to the top of each side of the trail flasks. This allows the gun, cradle and rocker to move in elevation with respect to the top carriage and the top carriage bearing the gun, cradle rocker and elevating mechanism to move in traverse with respect to the bottom carriage.

(**b**) The gun, cradle and trail move in traverse by sliding along the axle of the carriage on bearings provided for that purpose. In this case the trail spade is the point of pivot.

The first system is the one generally used on all American gun carriages except the 155-mm Howitzer. It gives ease and speed in the manipulation of the piece in traverse, but has the disadvantage of rendering the carriage less stable in firing due to the fact that the direction of recoil of the gun is in the direction of the line joining the trail spade and the central pivot, *only* when the gun is absolutely in the center of its traverse. In all other positions, which will be the usual case, there is a component at right angles to the line of trail spade-central pivot which tends to throw the gun off from its proper direction making it necessary to relay each time the gun is fired. The second method is that in use on the French 75-mm gun and the French and American 155 howitzer. While not so easy of manipulation and giving less freedom of movement in traverse (about 106 mils) it still has the advantage in that it gives greater stability in firing due to the fact that the gun always recoils along the line

through the trail spade, perpendicular to the axle.

ELEVATING MECHANISMS.

There are two general classifications of gun carriages according to the manner in which the laying for elevation is effected. The 3” gun is an example of one type in which the total quadrant angle of departure is laid off as one angle necessitating at each resetting of a range a new resetting of the range bubble. It is evident that this militates against both speed and accuracy in laying for elevation. The other type is illustrated by the American 75 and by the French and British 75-mm gun carriages which have what is called the “independent line of site.” It differs from the other type in that there is placed between the top carriage and the cradle an intermediate carriage or rocker arm pivoting on the gun trunnions at one end, and carrying at the other the support for the elevating device which gives to the cradle and the gun the proper elevation for the range. This intermediate carriage or rocker arm has a toothed edge geared with a pinion fastened to the trail flask, by means of which, gun cradle and elevating device may be moved in elevation without disturbing the relation between itself and the gun, this being done by gears independent of the elevating mechanism. An angle of site may be set off for the intermediate carriage and after the bubble is centered this actuating pinion may be blocked and no further concern be paid to the angle of site. A cannoneer therefore has only to set his range accurately on the index to give the changes in range ordered.

Elevation is accomplished by telescoping screws, by circular racks and pinions, and by worms and

arcs. Telescoping screws are good for from 15 to 20 degrees in elevation only, as for greater angles they become rather too large and cumbersome. The elevating arc is attached on the top, on the bottom or on the side of the cradle and, if possible, at its center. When the latter is not possible, two arcs are generally used to prevent torsional strains developing. Top racks are exposed to fire, side circular racks or arcs interfere with the traverse, with the placing of the sights, and with the general handling of the carriage. The bottom of the cradle is perhaps the best location for the rack. As in the traversing mechanism, a train of bevelled gears transmits the power from the hand wheel to the elevating mechanism.

In both the traversing and elevating mechanism, strength, simplicity, power, accessibility, non-interference and absence of lost motion are the features sought. To secure these is one of the most difficult things in gun-carriage design; for, since the traversing and elevating are the last two elements considered, they must, therefore, be the ground for modification and the means of adapting the great main elements—namely, wheels, axle, trail, recoil mechanism and gun—into a unit.

RECOIL MECHANISM.

The recoil system of the gun carriage consists of a recoil brake, a counter recoil mechanism and a counter recoil brake. The function of each part is apparent from its name. Various systems of checking recoil on field guns have been used, among them may be mentioned; friction devices including brakes on the wheel, inclined planes, pneumatic and hydraulic brakes. All have either been superseded by

the last named or are used in connection with hydraulic brakes. The power of the brake lies in the pressure produced in the cylinder through the resistance to motion offered by the liquid flowing through apertures. By varying the size of these apertures the braking effect may be controlled so as to fulfill the conditions demanded by the service. In designing the brake, the effect of the counter recoil system, angle of fire, length of recoil, friction and pressure within the cylinder must all be considered. In howitzers which are designed to be fired at high angles of elevation, the recoil must be shortened to prevent the breech striking the ground, a condition successfully met. Since the pressure due to recoil is ultimately led into the ground through the trail and spade, consideration must be given to the problem of the moment of inertia about the trailspade. The tendency to turn over backward about the spade as the center is offset by the amount of the weight of the carriage with respect to the same point. This raises the question as to how much pressure may be allowed to act to the rear; all of which must be considered in designing the carriage. The counter recoil systems in general use are two: spring or pneumatic. The former is illustrated in our 3” and 75-mm field guns, the latter by the French 75-mm gun and 155-mm howitzer. Their purpose, of course, is to return the gun “into battery” after it has recoiled on the carriage.

The recoil mechanism is a study in itself, of which there are two schools—the advocates of the spring and of the air recuperators. Great Britain, Germany and the United States have been the advocates of spring recuperation and France of air recuperation. Great Britain and the United States were of the spring school, undoubtedly, because of the lack of a

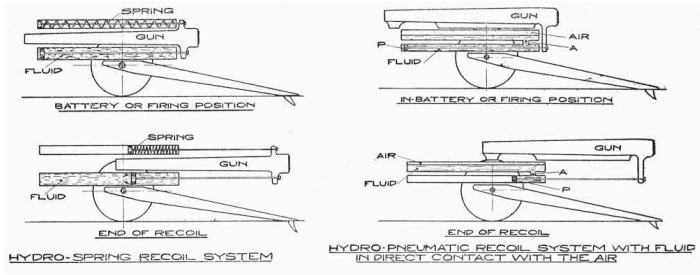
satisfactory air recuperating system; which is rather strikingly proven by the fact that both countries have adopted air recuperation since they have procured or developed satisfactory types.

Both schools have grounds for their position, however. The spring school has in its favor simplicity of design and manufacture and ease of replacement, which can be done in the field. On the other hand, spring recoils have many breakages and greater weight combined with a high replacement of weakened springs, the life varying from 3000 to 8000 rounds.

The air school has in its favor a high order of efficiency—smoother action, general all around efficiency and less weight. But the air recuperator is difficult to manufacture, costly, and when damaged must go to the rear to be repaired; which, however, it seldom needs.

In mounting the spring recuperator, the most recent practice has separated the recoil mechanism from the springs in order to distribute the piston rod pull, thus preventing whip and allowing easy access to the various parts for replacement, refilling and repairs. In order to lower the center of gravity, the gun is slung under the recoil cylinder with the two spring recuperators below and on either side.

Air recuperators are invariably located below the gun for protection and because of their large size and shape, which adapt them for attaching the elevating mechanism.



BATTERY OR FIRING POSITION

IN-BATTERY OR FIRING POSITION

HYDRO-SPRING RECOIL SYSTEM

HYDRO-PNEUMATIC RECOIL SYSTEM WITH FLUID IN DIRECT CONTACT WITH THE AIR

In either system, the recoil is taken up by means of oil or glycerine and water passing through an orifice created by a slotted piston passing over ribs of varying height, or through a valve on the pressure side of the piston, or by a solid or perforated piston passing through a perforated intermediate cylinder.

The latter type is particularly adapted to variable recoil guns as the intermediate cylinder can be rotated, thus throwing varying orifices into position for the flow of oil.

Counter recoil is accomplished by the springs or by the air pressure in the hydro-pneumatic system, in which the air pressure is sufficient to hold the gun in battery at all elevations and is built up at recoil.

In all counter recoil systems, it is necessary to insert a buffer to take up the remaining energy of the springs or air pressure so as to bring the gun into battery without appreciable jar. Numerous types have been developed and perfected.

The counter recoil brake or buffer in our 3”-gun is a slightly tapered bronze rod, tightly fitting in the cylindrical bore of the piston rod. The retardation caused by forcing the oil in the piston rod out through the small clearance between the buffer and bore of the piston rod eases the return to battery without jar to the gun, which has been forced back by the counter recoil springs.

The physical law that action and reaction are equal has a peculiar emphasis when applied to the firing of a piece of high powered artillery. The force exerted to throw a heavy projectile 7 miles or more from the muzzle of the gun is toward the breech of the weapon in its recoil. How some of these forces are handled safely and easily by mechanical means are almost beyond the mind’s grasp. Not long ago a touring car, weighing two tons, traveled at the rate of 210 miles an hour along a Florida beach. Conceive of such a car going 337 miles an hour—which is much faster than any man ever traveled; then conceive of a mechanism which would stop this car, going nearly six miles a minute, stop it in 45 inches of space and one-half a second of time without the slightest damage to the car. This is precisely the equivalent of the feat performed by the recuperator of a heavy howitzer after a shot.

SHIELDS.

Although cover for the cannoneers had been used off and on since the invention of guns, it had fallen into disuse until it was firmly established as an essential feature by the French on their 75-mm in 1897. All modern field guns have such protection both for the cannoneers and for the delicate parts of the material which would be damaged by shrapnel

balls or shell fragments. The shield is made of hardened steel capable of withstanding the impact of a bullet of a service rifle at a 100 yds. range at a standard velocity. For convenience the shield is divided into three parts known as the top shield, main shield and apron, with suitable ports equipped with shutters for the line of vision from sights. The main is fastened to the axle and is rigid. The apron is hinged to the main shield or the axle-swinging forward for the traveling position. The top shield is fastened to the main shield by hinges and swings forward and downward for traveling position.

SIGHTS.

The sights serve three important functions. They improve the vision of the gunner and lay the gun in elevation and direction. The simplest sight is the one over the line of metal which lays for direction only, the second is the tangent sight mounted on a range arc centered on the axis of rotation in elevation usually having a deflection scale to correct for drift and to lead the moving target. This unit lays for range and direction. The last sight is the telescopic or panoramic sight which is mounted on a range arc and lays for direction only, it is the unit for indirect fire, laying for direction, and markedly improving the vision of the gunner. The latest model of the American panoramic sight is superior to any in existence.

For precision in indirect fire, practically all carriages are equipped with some form of range quadrant, containing a means of setting off the angle of site and the range angle. All instruments are equipped to compensate for difference in wheel level. The British carriage automatically corrects for

deviation, simplifying the firing date by that element.

WHEELS.

The height of the wheels affects the draft, weight, clearance, and stability of the carriage both as to road stability—i. e., low center of gravity; and firing stability—i. e., the overturning movement about the end of the trail. It is now believed that entirely too much stress has been laid on road clearance. Reducing the height of wheel reduces the weight and road clearance, lowers the center of gravity and increases the firing stability; but it also reduces the angle of gun elevation unless the trail is shortened. Firing stability in general is increased by adding to the weight of the gun, lengthening the recoil, slinging the gun as low as possible and lengthening the trail. The less the height of the wheel exceeds four feet the better, despite the poor draft feature, which is compensated for to some extent by a reduction in weight and turning radius.

AXLES.

Axles are straight or of the offset type. The straight axle is stronger for its weight. The drop axle allows the center of gravity to be lowered.

TRAILS.

Most modern trails are of the sectional built-up type. Some, however, are of tubular and telescopic. The most variable portion of the trail is the spade. It consists of two parts, the spade proper and the float.

The former prevents recoil, the latter the burying of the trail. The spades proper are of three types: the fixed, as in the French 75-mm; semi-fixed, as in the 155-mm howitzer; and driven, as in the Deport and American 1916 75-mm. Each has advantages and disadvantages. The driven spade is considered essential for the split trail carriage, as the latter has no means of seating itself; and should one spade take, and not the other the carriage might be damaged when the gun is fired at an extreme traverse.

Split trails introduced a novelty in field gun carriages, in that a compensating device became necessary to adjust for the difference in ground level of the two spades.

CONCLUSION.

Guns are designed to function in a certain way. They are not temperamental. They follow absolutely and certainly fixed mechanical laws. If they fail there is a reason and it can be remedied. Certain parts are given certain shapes and forms, are machined to nice adjustments, and in taking down and assembling them, brains and dexterity are the tools to use rather than force and sledge-hammers. Learn from your text when and how to apply force and above all when not to use it. Treat these guns as you would a friend on whom you know you can depend. They will not fail you.

CHAPTER IV
MODERN ARMAMENT.

THE ARTILLERY OF A FIELD ARMY; ITS FUNCTIONS.

The artillery assigned to a field army should be of such mobility, power, variety and number as to insure the success of its purpose and to enable this success to be gained with the minimum of casualties. The latter point must receive careful consideration in studies of organization, for without adequate artillery preparation and support the successes of the most gallant infantry can in a series of actions become little more than pyrrhic victories. Many actions of our divisions in France resulted in casualties whose numbers decreased in proportion to the number of guns with which divisions were supported. The proportion of guns to the thousand gross strength of infantry, cavalry, and machine guns adopted by the armies of the first class powers before the opening of the present European War in 1914 was:

British, 6.8; French, 4.6; German, 6.4; American 3.2 (Greble Board).

During the war this proportion was constantly increased until at the close under conditions of position or entrenched warfare it was between 8 and 12 per thousand; this varied of course with the activity in different sectors. In quiet sectors and

under conditions of maneuver, or open warfare, which necessitated leaving much artillery behind, it was about 6 per thousand.

A program of types of artillery weapons should be founded on the object and the means—that is, the destruction of the target and the projectile to accomplish this. In the study of an artillery program there are two methods of approaching the subject. First, by starting with a minimum weight of projectile and working up to a reasonable maximum, according to some law and taking the corresponding calibers, a theoretical series of guns and howitzers can be expressed. For instance, if the law be doubling the weight of the projectile the series of types could be:

Projectile of	13	pounds, caliber	3”.
Projectile of	26	pounds, caliber	4”.
Projectile of	52	pounds, caliber	5”.
Projectile of	104	pounds, caliber	6”.
Projectile of	208	pounds, caliber	8”.
Projectile of	416	pounds, caliber	10”.
Projectile of	832	pounds, caliber	12”.
Projectile of	1664	pounds, caliber	14”.

The second and more logical method, and one followed in our service, is to consider the artillery missions and determine the types best suited irrespective of any theoretical series of weights and calibers. However, in the discussion of artillery missions and the proper types for their fulfillment there is a remarkable degree of unanimity of thought on these subjects; and the above table actually contains, with slight variations, the types that are

most strongly recommended. While granting the great variety of artillery missions that often shade into each other, it is believed that they can best be considered in three great classes that follow the tactical composition of a field army: those of division, corps and army artillery.

DIVISION ARTILLERY.

Missions. The division artillery, first of all, must have the mobility that will permit it to accompany the infantry of a division and the maximum power consistent with that mobility; its object must be primarily the infantry of the opposing division. It is therefore bound to its own infantry with the closest bonds and its tactical use cannot be separated from that of the infantry. The division artillery must fire, accurately, a man killing projectile and be prepared for quick changes of targets; it must have a great range because of depth, both of its own and the enemy division; it must continually harass the enemy, prevent his movement and force him into cover or protected trenches. On the defensive it must break up the opposing infantry formations by preparing a counter-offensive fire and by annihilating fire on points from which the enemy attacks emerge; and, failing in these, be prepared to use the barrage and shrapnel fire at close range. In the offensive the division artillery must play its part in the complex schemes of artillery preparation by cutting wire, destroying machine gun nests, gassing areas, concentrating on infantry positions and taking the principal part in the deep barrage that should precede the infantry attack. Its fire, accompanying the infantry movement, requires its own movement and by its mobility it often becomes for some time

the sole artillery protection in the preparation and holding of a position which has been taken.

Light Gun and Howitzer. The consensus of opinion of artillery officers is that the division artillery missions are best fulfilled by a light field gun and a light field howitzer having a range of at least 11,000 yards. While differing in mechanical features, the field guns of the different European countries are practically of the same type and, though constant effort is being made to improve details, they can be stated as generally satisfactory to their own governments and not liable to any radical changes. The general type of field gun, while capable of fulfilling most of the division artillery missions, must be supplemented by a proper howitzer. There are many instances where the terrain or the lay of the land offers such protection to the infantry that the field gun cannot bring an effective fire. The howitzer has the great advantage that with the proper set of propelling charges and, therefore, choice of trajectories for the same range, protected positions can be chosen for howitzers that guns could not use, and angles of fall obtained on objectives that the normal ammunition of guns would not give. The low muzzle velocity of howitzers admits of their almost continuous use in harassing fire and allows the use of a projectile double the weight of that of a field gun. Such a howitzer renders excellent service in wire cutting and is a useful projector of gas shells. To insure the mobility required of all divisional artillery the weight of the howitzer and carriage should not exceed that of the field gun, or about 4,500 pounds.

Light Gun Discussion. The consensus of opinion of all artillery officers—French, English and

American—is that the 75-mm gun, or approximately this caliber, firing a 15-pound projectile or a projectile of approximately this weight, and having a range of not less than 11,000 yards, is a satisfactory weapon at the present time for use with the division artillery. The projectile in question, whether a shrapnel or a high explosive shell, satisfies adequately the criterion of man-killing. At the close of the war the nations were not entirely in accord with respect to their conception of an up-to-date carriage for a light field gun. All the nations whose tendencies have been considered in this report have experienced to a varying degree with field gun carriages, particularly in a desire to design a carriage permitting a greater angle of elevation and greater movement of the gun in the traverse. The Italians have expressed themselves in the modified Deport Carriage; this vehicle is of the split trail type and permits an elevation in excess of 75 degrees, and a traverse on each side of the center of the carriage of about 20 degrees—about 356 mils. Up to the time that the board left France it was not possible to learn the French decision in the matter of a split trail carriage for their light field gun. It is known, however, that several types of this carriage have been designed and tested; it is known, also, that considerable favor has been found with the American 1916, which type has been tested under the auspices of the French Government. In England, however, the board was not able to develop any enthusiasm for the split trail type, although the matter had been seriously considered. In that country the up-to-date field gun carriage appears to be adequately expressed in their new 18-pounder. The vehicle upon which this gun is mounted permits an elevation of 37 degrees and an axle traverse of 4½ degrees on each

side. The trail is a box trail and the carriage is simple and steady in its construction and lends itself to rapid production.

Motorization. At some time in the future it is probable that all the division artillery will be motorized. The result of such a change in the prime mover would be to remove the present restriction as to weight of gun and carriage. The board senses a demand in the near future for a light field gun having a maximum range of approximately 15,000 yards; such a range may be achieved by increasing the muzzle velocity and, perhaps, the weight of the projectile, although change in the form of projectiles will give some improvement over the present ranges. It is probable that the limiting features in the design of field guns of the future will be the requirement that it should pass safely over temporary pontoon bridges and that the weight and form and size of ammunition must be such that the present rate of fire will not be slowed down. The board is of the opinion that, except as to perfection of details, the limit of carriage design, as expressed by the most modern type of box-trail and split-trail carriages, has been reached; and feels that with the advent of motor transportation the tendency will be toward a gun mounted on a self propelling carriage and expressing the desires of the field artillery with respect to maximum horizontal and vertical arcs of fire.

Light Gun. Ideal. A gun of about 3” caliber on a carriage permitting a vertical arc of fire of from 5 degrees depression to 80 degrees elevation and a horizontal arc of fire of 360 degrees; a projectile weighing not over 20 pounds, shrapnel and high explosive shell of satisfactory man-killing characteristics with maximum range of 15,000 yards;

fixed ammunition, smokeless, flashless propelling charge; time fuse for shrapnel. With shell having safe fuses with different lengths of delayed action after they land. The high explosive shell should be of one type only. Two propelling charges should be furnished, a normal charge for about 11,000 yards range and a super charge for maximum range. The proportion should be 90% of the former and 10% of the latter. A maximum rate of fire of 20 rounds per minute is deemed sufficient.

Light Gun. Practical. For the present, arm brigades with 75-mm materiel. Models 1916, 50%, and 1897 (French), 50%.

Transport. Ideal. Mechanical transport is the prime mover of the future. The introduction of mechanical transport will undoubtedly cause far-reaching changes in the types of gun carriages. It is not possible now to state just how far this will go or whether a gun mounted on a self propelled vehicle or one mounted on some type of trailing vehicle will be the final result. Both types may be necessary. It is urgent that study and development be carried along these lines, as we are on the verge of changes fully as radical as the introduction of the long recoil field gun and carriage, and the country first utilizing the new capabilities opened up by mechanical traction and the caterpillar will have a great advantage in the next war. A limit of 4,500 pounds behind the team has heretofore been imposed on the artillery of this class. The corresponding limit in the future will probably be that imposed by pontoon bridges.

Transport. Practical. Therefore it is thought that four regiments of 75-mm guns (two regiments of French Model 1897, and two regiments of U. S. Model 1916) should be immediately equipped with

motors, the remainder to be horsed; mechanical transport to gradually replace horse only after the tractor demonstrates its superiority in service.

Light Howitzer Discussion. The consensus of opinion of American army officers consulted is that a howitzer about 4" in caliber, firing a projectile weighing from 25 to 30 pounds at a maximum range greater than 10,000 yards, is required. This opinion is concurred in by the French, Italians and English, and it appears to be definitely established that the mobility of the light field howitzer should be practically the same as that of the light field gun. The British army was equipped with a 4½" howitzer, firing a projectile weighing 35 pounds and with a maximum range of 7,700 yards; the weight of the howitzer limbered is 4676 pounds—150 pounds more than the weight of the 18-pounder field gun. No evidence was found that the British Government intended making any alterations in the design of this howitzer; naturally they will attempt to increase the range, power and accuracy of the projectile by change in its weight, its capacity and its form. The French artillery was not equipped with the light field howitzer of approximately the same weight as the 75-mm field gun. During the war it was found impracticable to construct a lighter howitzer without interfering with the production of other calibers which were considered more important. In the earlier stages of the war the Italian artillery was not equipped with a light field howitzer; however, before the end of 1917 orders were placed for several hundred howitzers of the 105-mm type. It should be noted that several hundred howitzers of this caliber were being constructed before the armistice and that many have been captured from the Austrians by the Italians; this, so far as the Italians were concerned,

makes it certain that a light field howitzer will be furnished by the Italian army. The German and Austrian armies were equipped with a howitzer of the light field type; this weapon had a caliber of 105-mm type.

It fired a projectile weighing 34.54 pounds at a maximum range of 10,500 yards. (Streamline shell.) The weight of the howitzer limbered was 4,500 pounds. In the opinion of the board, the Germans have proceeded on sound principles in their development of the light field howitzer. Their ’98 model was a companion piece to their ’96 field gun and in the years that passed from 1898 to 1916, which included their early war experience, they kept to the idea of the relation of the two pieces even to the extent of including in a field artillery regiment one battalion of light howitzers. Their 1916 models of both light gun and howitzers show the endeavor to keep the pieces in the same class; that is, the weight of the gun and howitzer in action nearly the same, 2,750 pounds and 2,700 pounds; the weight of the gun limbered and the howitzer limbered are the same, 4,500 pounds; the elevation of both the same —minus 10 to plus 40 degrees; the carriages are of the same type; and the extreme ranges of gun and howitzer are respectively 11,700 and 10,500 yards. From the foregoing it is seen that all the important belligerents except the French and the Americans were equipped with a light field howitzer firing a projectile about twice the weight of the light field gun projectile and having otherwise the same general characteristics. There is no evidence to show that the fire of the French and the American artillery was not fully effective as that of any other artillery; however the testimony of the French and American artillery officers is to the effect:

(a) That the lightest howitzer in use, i. e., the 155-mm, was not sufficiently mobile to be a suitable companion piece for the 75-mm gun.

(b) That many times the fire of the 75-mm gun proved ineffective due to its flat trajectory; a howitzer would have been more effective in the attack of certain targets.

(c) That a large volume of fire is necessary.

(d) That while the 155-mm howitzer is more powerful than the light field howitzer its consumption of ammunition for many purposes is wasteful and extravagant and its volume of fire is insufficient.

(e) That the light howitzer is particularly suited for the destruction of wire entanglements; its better accuracy and more powerful projectile make it more suitable than the field gun for that purpose.

(f) That the 75-mm field gun projectile is not so satisfactory a gas shell as the howitzer projectile which has greater weight.

Light Howitzer. Idea. A weapon of about 105-mm caliber on a carriage permitting a vertical arc of fire from minus 5 degrees to plus 65 degrees, and a horizontal arc of fire of 360 degrees. Efforts should be made to develop a carriage which can be used interchangeably for the division light gun referred to above and this howitzer. The projectile should weigh about 30 to 35 pounds and should include both shell and shrapnel. A maximum range of 12,000 yards will be satisfactory. Semi-fixed ammunition with varying charges should be used, otherwise the ammunition should be similar to that provided for the 75-mm guns.

Light Howitzer. Practical. For the present, the division should be armed with the 155 howitzer, Schnieder, but active development and test should be made on a type as stated under “Ideal” above, and with the ammunition and other accessories to it. Upon the development of the carriage as nearly approximating the ideal as may be practically possible, efforts should be made to secure quantity production in order that it may be incorporated in the division as recommended. In addition, a split trail carriage for this howitzer should be developed.

Transport. The light howitzer should have the same means of transport as the light field gun and the same remarks heretofore made as to the probable future development of the field gun also apply to the howitzer carriage.

CORPS ARTILLERY.

Missions. It will be noted above that the division artillery missions did not include their own protection against the enemy artillery. This counter-battery work is the principal mission of the corps artillery. The corps artillery has also the mission of extensive harassing and interdicting fire along the corps front and to a greater depth than the capabilities of the division artillery; also of destructive fire on strong points as well as on railroad facilities and points of supply. For the accomplishment of these corps artillery missions there are two types of artillery necessary, a gun and a howitzer, each having 16,000 yards range and each weighing with the carriage about 11,000 pounds. There is another class of artillery called anti-aircraft artillery to be considered. This is used first in providing anti-aircraft defense for army zones, for

certain areas in rear of armies or along a certain line of anti-aircraft defense.

Medium Gun Discussion. The consensus of opinion of artillery officers—Italian, English and American—is that a medium gun of about 6” caliber is necessary. The medium type gun furnished to the American army was the 4.7 (Model 1906). This gun has a maximum elevation of 15 degrees with a corresponding maximum range of 8,750 yards. The British army was equipped with the 5” gun—the carriage permits a maximum elevation of 21 degrees and 30 minutes, giving a maximum range of 12,500 yards. The French army was equipped with, to a certain extent, the 105-mm and the 140-mm gun. The 105-mm gun a maximum elevation of 37 degrees, with a maximum range of 13,900 yards. The 140-mm gun has a maximum elevation of 30 degrees and, with a high velocity, has a maximum range of 19,500 yards. The French 105-mm gun is a modern weapon (1913). The German artillery was equipped with a 105-mm gun (M-1917) with a maximum elevation of 45 degrees, and a maximum range of 16,000 yards. The German army was also equipped with the 130-mm gun, having a maximum range of 16,500 yards. The Austrian army was similarity equipped. The Italians were equipped with a 105-mm gun essentially of the same characteristics as the French 105-mm M-1913.

Medium Gun. Ideal. A caliber of between 4.7 and 5” on a carriage permitting a vertical arc of fire of from minus 5 degrees to plus 80 degrees; a horizontal arc of fire of 360 degrees. Shrapnel and shell weighing not over 60 pounds, maximum range 18,000 yards; with semi-fixed or separate loading ammunition permissible.

Medium Gun Practical. Corps artillery should be armed with the present type 4.7" gun, Model 1906, except that at least one regiment should be armed with the British type 5"-guns purchased abroad.

Transport. All corps guns should be developed for long, rapid hauls. Similar ammunition vehicles should be developed. The wheels for the gun carriage should be rubber-tired.

Medium Howitzer. In the opinion of the French, Italians, British and the Americans, the 155-mm howitzer (Schnieder) was conspicuously successful in the present war. It should, therefore, be retained as a type. The howitzer and carriage as it stands at present, is a highly satisfactory and efficient piece of armament. For the future it is believed that effort should be made to increase the range by improvements in the form of projectile, and it is believed that the form of howitzer and carriage should be studied with a view of obtaining, through modifications, a maximum range of approximately 16,000 yards.

Many batteries of 155-mm howitzers (Schnieder) were motorized in the American Army in France, and the consensus of opinion is definitely toward the retention of this form of prime mover. It is interesting to note that all the important belligerents have settled upon a howitzer of approximately 6" in caliber, and otherwise essentially of the same ballistic characteristics as the type in question. The projectile of this caliber is the smallest projectile which can be called upon to give adequate mining effect against material targets of semi-permanent nature. The place of this howitzer is, therefore, determined by considerations of its destructive ability. It is a splendid destruction and neutralizing

weapon.

Medium Howitzer. Ideal. A caliber of about 155-mm on a carriage permitting a vertical arc of fire of from minus 5 degrees to plus 65 degrees; and a horizontal arc of fire of 360 degrees. The projectile should not weigh over 100 pounds and should be interchangeable with projectiles for other guns of this caliber referred to later on. High explosive shell, only, should be supplied.

Medium Howitzer. Practical. The corps should be armed with the 155-mm (Schnieder) howitzer referred to above. The type of fuses for shell should be super quick and long delay.

ARMY ARTILLERY.

Missions. In addition to the division and corps artillery fulfilling the missions outlined above there must be additional artillery available. There are missions of interdiction, neutralization and destruction which fall beyond the activities or capabilities of the normal corps or medium field types; there must exist a surplus of division or corps types, properly transported, for strategic reinforcements of divisions and corps during such times as the normal allotment to such units is insufficient; there must be artillery of special purpose —mountain artillery, trench and super guns and howitzers. Of the above additional artillery, a type of heavy field gun and a type of heavy field howitzer are considered normally necessary in the armament of a field army; the gun should have a range of approximately 25,000 yards, and the howitzer a range of about 18,000 yards. These weapons are more powerful than the medium field types, add

range to the interdiction and harassing and to the neutralization and destruction possible with the corps type. Considering the paragraphs pertaining to divisional artillery and the introduction to corps artillery *it will be seen that the normal artillery of a field army can be accomplished by the assignments of two caliber, i. e., two light weapons, two medium weapons and two heavy weapons—a gun and a howitzer in each class—and a satisfactory anti-aircraft gun.*

Heavy Field Gun. The consensus of opinion of all artillery officers—British, Italian and American—is that the heavy field gun should be of approximately 6" caliber and that guns of greater caliber than this are necessary in limited number for field operations. The French were constructing 194-mm guns during the latter stages of the war. It is believed that in developing this type of gun the French were actuated almost entirely by the necessity for increased range, since the German 150-mm gun, Model 1916, outranged the G. P. F. by approximately 5,500 yards. The French have recently made considerable progress in securing the necessary increase in range with the G. P. F. All of the principal nations engaged in the war used a heavy field gun of approximately 6" caliber. This type has given such general satisfaction that its continuance is assured. The principal mission of the heavy field gun is harassing and interdiction fire, and for these uses the 6" projectile is sufficiently heavy. The maximum practicable traverse and elevation should be provided by the carriage of the heavy field gun. The G. P. F. carriage has given general satisfaction, but its wide tread and the excessive time required to occupy a position are very objectionable features. It is the consensus of all artillery officers—French, British and American—that the heavy field gun

should be of approximately 6” caliber and with a range in excess of 25,000 yards, with not less than 60 degree traverse, weighing not more than 12 tons, limbered, capable of occupying and leaving a position quickly, and with a width of tread which does not prevent two-way traffic on ordinary roads. The Italians differ from this opinion only in that they are satisfied with a maximum range of 18,000 yards.

Heavy Field Gun. Ideal. A caliber of about 155-mm on a carriage permitting a vertical arc of fire from 0 degrees to plus 65 degrees; with a horizontal arc of fire of 360 degrees. The maximum range should be about 25,000 yards.

Heavy Field Gun. Practical. Arm with the present type 155-mm G. P. F. and carry on experiments for type of carriage as outlined for division field gun. The fuses should be super-quick and short delay.

Transport. All artillery of this type should be motorized and tested and experiments for ammunition vehicles to correspond with the types of carriages developed, and should be carried on simultaneously.

Heavy Field Howitzer. No type of heavy field howitzer developed during the war has given general satisfaction. The consensus of all army artillery officers—French, English and American—is that two calibers of howitzers are necessary—one a companion piece for the 6” gun and one of the maximum possible power consistent with the necessary mobility. The lighter of these two howitzers should have the same mobility as the 6” gun, with a caliber of about 8” and a maximum range of not less than 16,000 yards. The heavy field howitzer should be of about 9.5” caliber with a range in excess of 16,000 yards; the carriage should

provide for wide traverse and must have sufficient mobility to accompany the army in the field. It will probably be necessary to transport this howitzer in more than one load, and the maximum weight of any load should not exceed 12 tons. The average time necessary for occupying a position should not exceed six hours under actual field conditions.

Heavy Field Howitzer. Ideal. A caliber of about 8” on a carriage permitting a vertical arc of fire of from 0 to plus 65 degrees; and a horizontal arc of fire of 360 degrees. The maximum range should be 18,000 yards.

Heavy Field Howitzer. Practical. Use at present 8” material of British design which is on hand.

Railway Artillery. The war has demonstrated the necessity for long range and powerful guns for distant interdiction and harassing work and for super-heavy howitzers for the destruction of semi-permanent fortifications. Artillery of these types can best be mounted on railway carriages and this type of mount offers no serious disadvantages since these guns will not be used except with large forces which require extensive railroad systems for their supply. This does not apply to guns of the type used to bombard Paris; such guns have no military value and their construction is not justifiable.

ANTI-AIRCRAFT GUNS.

Light Gun. Ideal. Caliber about 3” with initial velocity of at least 2,600 f. s.; semi-automatic breechblock, mounted on carriage, permitting 80 degrees elevation and 360 degrees traverse; projectiles weighing not less than 15 pounds, of one type high explosive shell with maximum ballistic

qualities and as large explosive charge as possible; fixed ammunition; smokeless, flashless powder, mechanical fuse. In this type every effort must be made to increase the rate of fire and decrease time of flight; this latter is limited only by considerations of a reasonable accuracy life for the gun.

Light Gun. Practical. Arm units with present 3” anti-aircraft equipment. Continue experiments leading to the development of the ideal.

Transport. Ideal. Caterpillar mount or caterpillar trailer mount drawn by caterpillar tractor, each unit to permit a sustained speed of 12 miles per hour.

CHAPTER V
THE 3-INCH FIELD GUN.

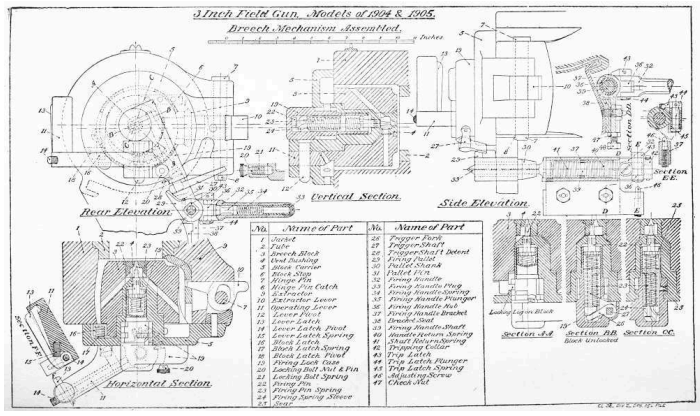
THE GUN.

The **Gun** is known officially as the *3-inch Field Gun, Model 1905*. It is a built-up construction of nickel-steel and consists of a tube with a rifled bore, 3 inches in diameter, upon which are shrunk the jacket, locking hoop and front clip hoop. The jacket reinforces the rear half of the tube. The locking hoop serves to secure the jacket from any longitudinal movement to the rear. On the under side of the gun, extending the entire length of the jacket, locking hoop, and front clip, are formed two recoil guides or clips which fit over and secure the gun to the guide rails of the cradle. When the gun is fired, it slides along the guide rails. The dust guard covers the part of the guide rails between the locking hoop and the front clip. The rifling of the bore is right-hand twist and starts with 0 turns at the breech increasing to 1 turn in 25 calibers at 10 inches from the muzzle, then uniform to the muzzle.

Weights and Dimensions.

Weight of gun	788 lbs.
Calibre	3 inches
Length	about 7 feet
Number of lands and grooves	24

Muzzle velocity	1700 ft. sec.
Maximum pressure per sq. in.	33,000 lbs.
Limit of depression	(90 mils.) 5 degrees
Maximum elevation	(265 mils.) 15 degrees
Maximum range, trail sunk, about	8,500 yds. (5 M)
Range at 15° elevation (265 mils)	6,000 yds. (3½ M)



3 Inch Field Gun, Models of 1904 & 1905.

Breech Mechanism Assembled.

Nomenclature of parts of Gun:—

Jacket.
Locking hoop.
Tube.
Bore.

Rifling.
Lands.
Grooves
Breech recess.
Front clip.
Muzzle.
Dust guard.
Recoil guides or clips.
Chamber.
Recoil lug.
Line sight (front and rear).
Handy oilers.

THE BREECH MECHANISM.

The **breechblock** is of the interrupted-screw type, and is provided with four threaded and four slotted sectors. The front end of the axial recess in the block is closed by a bushing. Four ventholes lead from a cavity in the bushing and permit the escape of gas to the rear in case of a ruptured primer. On the rear face of the breechblock are cut gear teeth, in which the gear teeth of the operating lever bevelgear mesh. The breechblock is concentrically mounted on a hub on the block carrier, in which the firing-lock case is fitted. Its position in the breech of the gun with reference to the axis of the bore is eccentric.

The breechblock is closed or locked by a continuous movement of the operating lever. When the block is swung to the closed position the front face of the block latch comes in contact with the rear face of the breech of the gun, thus forcing the latch out of the notch in the breechblock and back into a recess in the carrier. By continuing the motion of

closing the mechanism, the breechblock is then rotated on the hub of the carrier and its threads engage with corresponding ones in the gun. When the breechblock is in the closed position, a lug on the firing-lock case serves to lock the carrier to the breechblock and prevents displacement due to a blowback.

The firing mechanism belongs to that type known as a continuous-pull mechanism; that is, no cocking of the firing-pin is required.

The firing-lock case is eccentrically fitted in the hub of the block carrier, in such a position that the axis of the firing-pin is always in line with the bore of the gun. The vent bushing in the front end of the breech block through which the firing pin passes when in the fired position, is fitted eccentrically with reference to the breechblock. This eccentric arrangement of the breechblock, masks the point of the firing-pin and prevents any possible contact between the pin and the primer in the cartridge case when the block is unlocked. The block will be practically fully locked before any contact between the firing-pin and primer can take place.

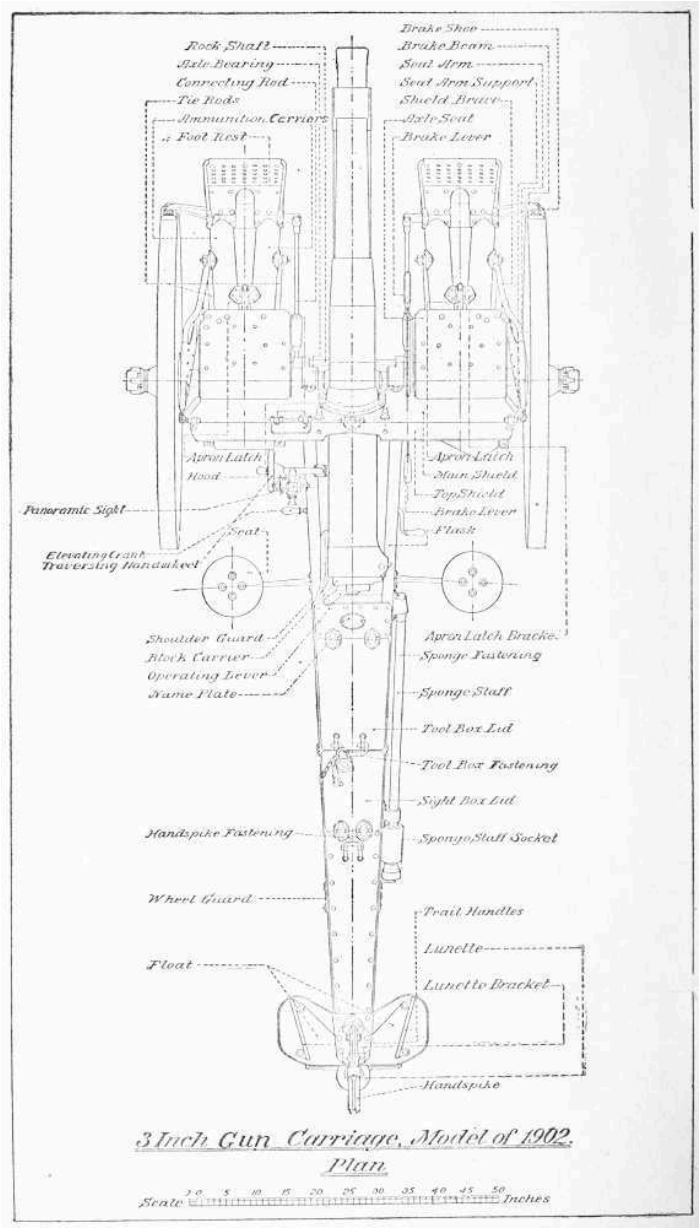
Nomenclature of important parts of Breech & Firing Mechanism.

Mod. 1905:—

Name of Part	*Where located*
Breech Block	On block carrier
Vent Bushing	Front end of block
Block Carrier	Hinged to jacket; supports block

Block Stop	Screwed into front face of carrier
Hinge Pin	Hinges carrier to jacket
Hinge Pin Catch	In hinge pin
Extractor	In breech recess
Extractor Lever	Mounted on hinge pin
Operating Lever	Pivoted on block carrier
Lever Pivot	Pivots lever on block carrier
Lever Latch	In operating lever
Lever Latch Spring	In operating lever, lower part
Lever Latch Pivot	In operating lever, lower part
Block Latch	In recess in carrier
Block Latch Spring	Around latch bolt
Firing Lock Case	In hub of the block carrier
Locking Bolt Nut and Pin	On firing lock case, rear face of carrier
Firing Pin	In axle hole, center of firing lock case
Firing Pin Spring	Around firing pin
Firing Spring Sleeve	Around firing pin spring
Sear	In slot in firing lock case
Trigger Fork	Rear end firing lock case
Trigger Shaft	On rear end firing lock case

Trigger Shaft Detent	On trigger shaft
Firing Pallet	On pallet shank
Pallet Shank	On recoil lug of gun
Firing Handle	On firing handle shaft
Firing Handle Bracket	Attached to right side of cradle
Firing Handle Shaft	Assembled in bracket, right side of cradle
Trip Latch	Attached to trip latch plunger
Trip Latch Plunger	Assembled to firing handle
Adjusting Screw	Assembled to firing handle bracket
Check Nut	Assembled in adjusting screw



3 Inch Gun Carriage, Model of 1902.

Plan

THE GUN CARRIAGE.

The gun carriage for the 3-inch gun Model 1905 is of the type known as the long-recoil, in which the gun is permitted a sufficient length of recoil (about 45 inches) upon the carriage to render the latter stationary under firing stresses. The gun is mounted upon a cradle which forms a housing for the recoil controlling parts. The cradle rests upon the rocker and has a small traversing motion of 70 mils on each side of the axis of the carriage. The rocker is journaled upon the axle and its rear end is supported by the elevating mechanism, which is seated in the trail.

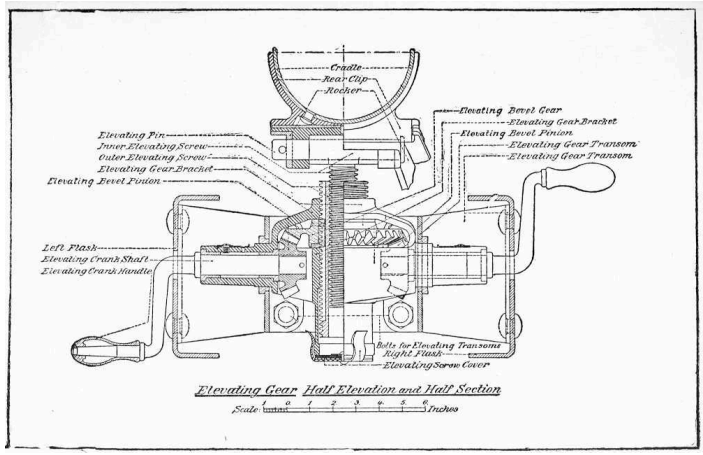
The principal parts of the carriage are the wheels, axle, trail and elevating mechanism forming the lower carriage, the cradle and recoil-controlling parts constituting the upper carriage, and the rocker and traversing mechanism intermediate between the two. In addition there are provided shields, ammunition carriers, the road brake, and the axle seats.

The Wheels and the Axle. The wheels are a modified form of the Archibald pattern, 56 inches in diameter, with 3-inch tires. The axle is hollow and forged from a single piece of steel. The wheels are held on by the wheel fastenings.

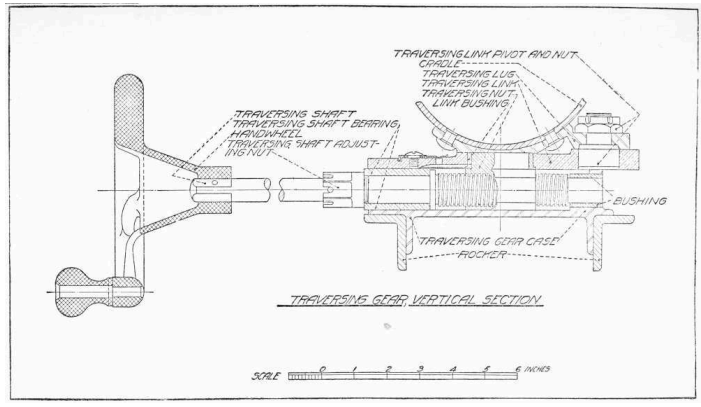
Trail.—The trail consists of two steel flasks of channel section with the flanges turned inward, tied together by transoms and plates to form the sight and the tool boxes. Attached to the trail are the trail spade, float trail handspike, trail handles and the lunette.

Elevating Gear.—The elevating gear is of double-screw type and consists of an inner and outer elevating screw, an elevating-gear bracket, an elevating bevel gear, two elevating bevel pinions, and two elevating crank shafts. The inner elevating screw is a steel screw, threaded with a right-hand thread. It is attached at its upper end by the elevating pin to the rear end of the rocker. The outer elevating screw is of bronze and is threaded on the exterior with a right-hand thread to take the inner elevating screw. On the exterior are also cut two longitudinal keyways, in which the keys of the bevel gear work.

Traversing Mechanism.—The traversing mechanism consists of a shaft, called the traversing shaft, mounted in bearings in the traversing-gear case, and a traversing nut moving longitudinally on the shaft, but restrained from turning with it by its bearings in the gear case. A cylindrical lug on top of the nut fits in a hole in a bronze traversing link, the right end of which is pivoted by the traversing-link pivot to the traversing lug on the underside of the cradle. This pivot is secured to the cradle-traversing lug by a nut and split pin. The left bearing of the traversing shaft is split for the purpose of assembling and rests between two collars on the shaft. The bearing, with the shaft in place, is slipped into its seat in the gear case, where it is held in position by two pins.



TRAVERSING GEAR, VERTICAL SECTION



Elevating Gear Half Elevation and Half Section

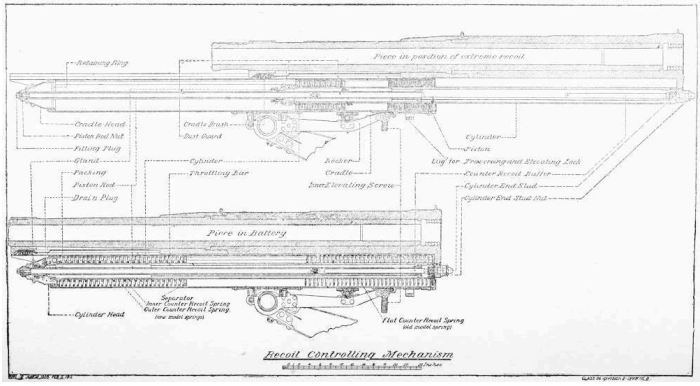
The Cradle Complete.—The *cradle* supports the gun, guides it in recoil, and forms a housing for the recoil-controlling parts; it consists of a flange steel body with the upper edges flanged outward. The flanges are bronze lined, engage the clips on the gun, forming the guide rails for the gun on recoil. Riveted to the bottom of the cradle are four steel forgings,

the pintle, traversing lug, rear clip, and elevating and traversing lock lug. The pintle fits the pintle socket in the rocker and forms a bearing upon which the cradle is traversed. The traversing lug has been heretofore mentioned as affording a point of attachment for the traversing-link pivot. The cradle rear clip, in addition to embracing the rear end of the rocker, has a broad bearing on the latter directly over the point of attachment of the elevating screw.

To relieve the pointing mechanism from all strains in travelling, an *elevating and traversing lock* is provided, by which the cradle may be securely locked to the trail.

The *recoil-controlling* parts contained inside the cradle are the *cylinder*, the *piston rod*, the *counter-recoil buffer*, the *counter-recoil springs* and the *spring support*.

To the rear end of the cradle is riveted a steel cradle head, rear, through which the cylinder moves in recoil and projects for attachment to the recoil lug on the gun by means of the cylinder end stud and nut. The front end of the cradle is closed by the cradle head, front, and the retaining ring.



Recoil Controlling Mechanism

The **cylinder** lies inside the cradle and is surrounded by the counter-recoil springs. Its rear end is closed and has a projection on the inside to which is screwed the counter-recoil buffer, a tapered bronze rod which fits with small clearance into a bore at the rear end of the piston-rod. The front end of the cylinder is closed by a bronze oiltight gland, through which the piston-rod slides. The cylinder is filled with a neutral oil called hydroline. The interior of the cylinder is cylindrical. Three longitudinal ribs or throttling bars of uniform width but varying height extend along the interior from the rear end to within 19 inches from the front end. Three notches are cut in the piston head, forming ports for the passage of the liquid from one side of the piston to the other. The height of the throttling bars is calculated so that the resistance which the liquid offers, plus the resistance of the springs, is constant and such that the recoil will be checked at the desired point. During recoil the front end of the cylinder is supported by the spring support.

The *piston rod* is of steel, and is provided with a bronze piston head, screwed against a shoulder at the rear end. The head has three notches cut in its perimeter, which fit over the throttling-bar projections on the cylinder wall. The rear end of the piston is bored out to take the *counter-recoil buffer*. In counter recoil the oil in this bore can escape only by a small clearance. In this way the return of the gun into battery is so eased and regulated that very little shock and consequent derangement of the aim of the piece occur. The front end of the piston-rod is attached to the cradle head, front, by means of the

piston-rod nut.

The *counter-recoil springs* (three in number each 36 inches long) are helical, being made from a rectangular steel bar coiled on edge. They are assembled in the cradle, end to end around the cylinder and bear in front against the spring support and in the rear against the cradle head, rear. They are assembled under an initial compression of approximately 750 lbs. which is sufficient to return the gun into battery at the maximum elevation. In place of the single counter-recoil springs a set of three inner and three outer counter-recoil springs is also being issued.

The *spring support* forms a support for the front end of the cylinder and a bearing for the front end of the spring column. It has guide lugs which fit into and glide along guide rails inside the cradle during recoil. The spring support is held in place by the retaining ring.

Action of the Mechanism.

The action of the recoil mechanism when the gun is fired is as follows:—The gun moves to the rear 45 inches on the cradle, carrying with it the cylinder and compressing the recoil springs. The piston rod being attached to a fixed part of the carriage in front, (the cradle-head) does not move. Therefore, since the cylinder moves to the rear, the oil in it must pass from one side of the piston head to the other. The energy of recoil of the gun is therefore absorbed by the resistance which the oil offers when being forced through small openings between the notches in the piston head and the throttling bars along the inside of the cylinder and also by the resistance of the

counter-recoil springs to additional compression. The energy stored up by the springs during this compression, returns the gun and cylinder to the firing or original position. This return movement is eased and regulated by the counter-recoil buffer. The piston rod pull and the spring resistance are transmitted to the carriage, but owing to the latter's weight and the resistance opposed to the trail spade by its engagement in the ground the carriage remains stationary.

Weights and Dimensions.

Weight of gun and carriage complete	2,520 lbs.
Width of track	60 inches
Length of recoil on carriage	45 inches
Amount of traverse of gun on carriage	140 mils

Nomenclature of important parts of the Gun Carriage:—

Axle
Trail, consisting of—
Flasks (right and left)
Tool box
Elevating gear transom
Rear sight box
Spade
Spade Edge
Float
Handspike fulcrum
Cradle, head, rear
Gun slides or Guide Rails
Cradle Pintle

Traversing lug
Rear clip
Lug for elevating and traversing lock
Bracket seat, firing handle
Quadrant fastening
Rear-sight bracket support
Front-sight bracket support
Spring-support guides
Retaining ring, with hasp and fastening
Cradle head, front
Shoulder guard
Cradle brush
Recoil-indicator throw
Recoil indicator
Cylinder head
Cylinder with cylinder end screwed in
Cylinder end stud and nut
Counter-recoil buffer
Rings, packing
Gland
Piston rod, with plug, screwed in
Piston
Piston-rod nut
Filling plug with gasket
Drain plug
Spring support
Counter-recoil springs
Rocker
Cradle Pintle socket
Elevating and traversing lock
Traversing mechanism, consisting of—
Traversing-gear case
Traversing plate
Handwheel with handle and spindle
Traversing shaft
Traversing-shaft bearing in two parts

Traversing link with bushing
Traversing-link pivot with nut
Azimuth pointer and scale
Elevating mechanism, consisting of—
Elevating pin
Inner elevating screw
Outer elevating screw
Wheels guards
Trail handles
Trail seats
Trail-seat supports
Sponge-staff socket
Name plate
Handspike
Lunette
Cradle, consisting of—
Cradle body
Elevating bevel gear
Elevating bevel pinions
Elevating crank shafts, with handles
Elevating screw cover
Axle seats, include—
Seat arms
Seat-arm guards
Foot rests
Tie rods
Shield braces
Apron shield
Apron latches
Main shield, consisting of—
Main shield
Hood
Shutter, open-sight port
Shutter, panoramic-sight port
Top shield, consisting of—
Top shield

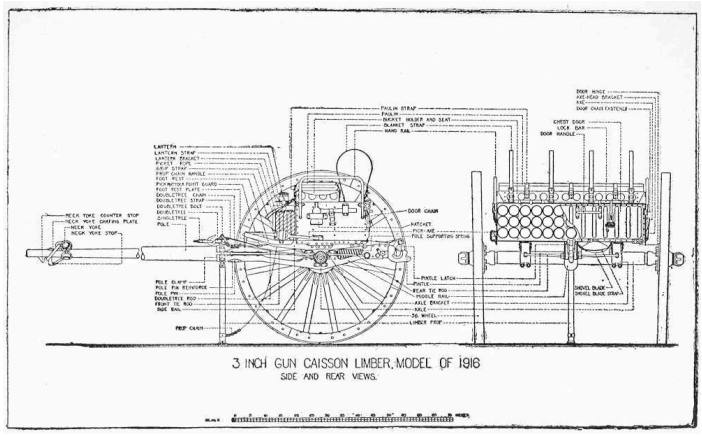
Top shield fastenings
Road brake, includes—
Brake beams
Brake shoes
Springs with covers
Brake rods
Brake lever
Brake shaft
Brake segment with two segment racks
Ammunition carriers
Range quadrant case
Panoramic sight case
Front sight
Rear sight, consisting of—
Rear-sight bracket with shank socket
Rear-sight shank
Panoramic sight
Range quadrant
Wheels, consisting of—
Felloe, segments
Spokes
Tires
Hub boxes
Hub liners
Hub-latch plungers
Oil Valve
Carriage bolts and nuts
Hub bands
Hub caps
Wheel fastenings
Plugs

THE 3-INCH GUN (CAISSON) LIMBER.

The **limber** is of metal throughout excepting the spokes and felloes of the wheels. The principal parts

are the wheels, axle, pintle, frame, ammunition chest, pole, doubletree, singletrees, and neck yoke.

The wheels and wheel fastenings are the same as, and interchangeable with those used on the carriage. Seats for three cannoneers are provided by a perforated metal bucket-holder on top of the chest. The paulin issued to each limber serves as a seat cushion and is held in place by paulin straps. Grip straps are also provided for use by the cannoneers when the carriage is moving at rapid gaits. On the sides and front of, and under the ammunition chest, suitable straps, brackets and connections are provided for securing all tools and accessories. With each limber are issued three tubular oil cans, each in the form of a cartridge and with a capacity of two-thirds of a gallon. These are intended to hold hydroline, lubricating and coal oil and are carried in the central row of cartridge holes in the ammunition chest.



3 INCH GUN CAISSON LIMBER, MODEL OF 1916
SIDE AND REAR VIEWS.

Weights and Dimensions.

Weight of limber, completely equipped and loaded	1740 lbs.
Weight of gun, carriage and limber, completely equipped and loaded	4260 lbs.
Number of rounds carried	36

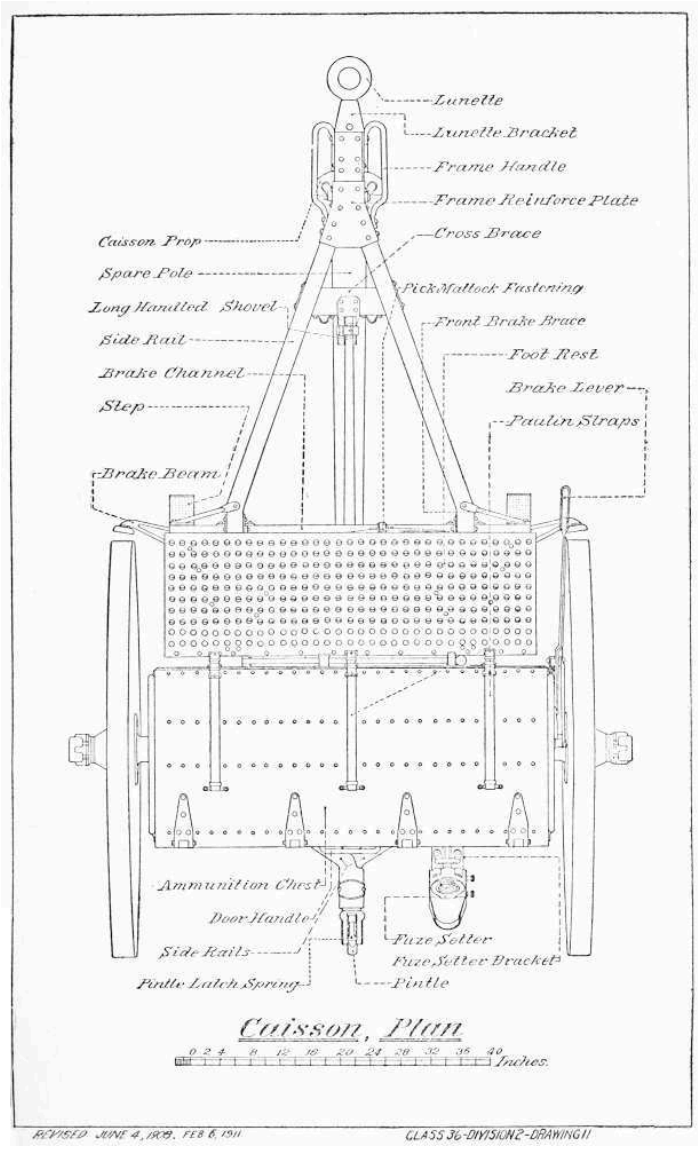
Nomenclature of important parts of limber:—

Pole, complete, consisting of—
Pole body
Neck-yoke counter stop
Neck-yoke stop
Neck-yoke chafing plate
Butt reinforce
Doubletree
Doubletree rods
Name plate
Limber prop
Foot rest
Tie-rods
Pintle with bearing, consisting of—
Pintle
Pintle latch
Pintle latch spring
Wheels and wheel fastenings
Axle
Middle rail
Side rails
Ammunition chest, consisting of—
Hand rail
Door chains
Shot bolts
Bucket holder
Chest rails
Chest-rail connections

Body
Door
Cartridge holes
Diaphragms
Lantern brackets
Grip-straps
Paulin straps
Various tool brackets
Various tools
Paulins
Picket ropes
Lanterns
Canvas buckets

THE CAISSON

The Caisson is made of metal throughout with the exception of the spokes and felloes of the wheels. The principal parts are the wheels, axle, pintle, lunette, apron shield, fuze setter bracket, frame, road brake, and ammunition chest.



Caisson, Plan

The wheels and wheel fastenings are

interchangeable with those of the gun carriage and the limber. The caisson road brake is modeled after that of the gun carriage, all parts as far as possible being interchangeable. The frame upon which the ammunition chest rests, is diamond shaped, and consists principally of two steel side rails riveted to lugs on the axle, meeting in front to form the lunette for attachment to the limber, and in rear to form a pintle for attachment of another caisson in case it is desired to tow several caissons by one team and limber, as for instance in the ammunition train. In other respects the construction is similar to that of the limber excepting that the ammunition chest is much larger and has a capacity of 70 rounds. The front of the chest and the chest door are made of armor plate. A bracket for the fuse setter is also provided. An apron shield, similar to the one on the gun carriage is hinged under the axle, giving the cannoneers at the caisson full protection. A spare-pole body can be carried under the caisson frame, large end of pole to the front. On the sides and front of, and under the ammunition chest, suitable straps, brackets and connections are provided for securing all tools and accessories. To lock the caissons and limbers, a padlock is provided. These locks are interchangeable and can be unlocked by the same key. This key is marked “Ammunition.”

Weights and Dimensions.

Weight of caisson only, completely equipped and loaded	2820 lbs.
Weight of caisson and limber, both completely equipped and loaded with 106 rounds	4560 lbs.

Number of rounds of ammunition carried in caisson only 70

Nomenclature of important parts of Caisson:—

Wheels
Wheel fastenings, complete
Axle
Middle-rails
Side rails
Pintle with bearing, consisting of—
Pintle
Pintle latch
Pintle-latch spring
Name plate
Channel supports
Frame handles
Lunette, with nut
Caisson prop, with chains
Road brake, consisting of—
Brake-beams
Brake shoes
Brake rods
Brake-rod springs and covers
Brake shaft, with two keys
Brake segment
Segment rack
Brake lever
Spare-pole fastening
Ammunition chest, consisting of—
Diaphragms
Grip-straps
Paulin-straps
Chest rails
Foot rest
Handrails

Door props
Door handles
Hand rails
Supports and Brackets for attaching various tools and accessories
Apron
Apron latches
Fuze-setter bracket
Fuze-setter latch
Fuze setter
Paulin
Picket ropes
Various tools and accessories
Spare pole

To Dismount and to Assemble Parts of the Gun and Carriage.

To dismantle and to assemble the breech mechanism.—Grasp the operating lever and open the breech; when the block is open, force the block latch out of its seat in the block by gently pressing it into its seat in the carrier. Take hold of the block and revolve it to the left until it stops; then pull it to the rear, taking care not to drop it. The block latch can now be readily removed. After the firing-lock case has been removed the operating lever can be removed by forcing its pivot up from beneath by a gentle pressure from the palm of the hand. The lever latch can be removed by pressing in on the latch at a point near its lower end opposite its pivot; a hole in the latch is cut eccentric with reference to the pivot and a shoulder on the pivot prevents their displacement until the latch is forced in and the hole is concentric with the pivot. When this occurs, the pivot can be readily pulled out and the latch

removed. To remove the block carrier force the hinge pin up by hand until it can be caught by the head, and by swinging the carrier back and forth, if the pin sticks, it can readily be removed, taking care not to drop the extractor lever. The extractor can now be removed from the gun.

To dismantle and to assemble the firing-lock case and mechanism.—Take hold of the milled headed locking bolt situated at the lower end of the firing-lock case, pull it to the rear; at the same time revolve the firing-lock case upward about 45° and pull it gently to the rear. This will remove the case with the firing mechanism complete from the gun. Press the trigger-shaft detent until it disengages from the notch in the firing-lock case. This will allow the trigger shaft with its detent, to be withdrawn. Then gently press on the front end of the firing pin, forcing it back into the casing. This will allow the trigger fork to fall out. Then, with one finger placed on the front end of the sear, force it outward; at the same time grasp the front end of the firing pin, which is roughened for the purpose. Give it a sharp pull. This will remove the firing-pin spring and sleeve from the casing. Then place the front end of the firing pin against a block of wood, bear down on the firing-spring sleeve until the spring is compressed sufficiently to disengage the slot in the rear end of the sleeve from the small lug on the rear end of the firing pin; slightly turn the sleeve, and then the sleeve can be separated from the spring and pin. By an unscrewing motion the spring can be removed from the pin. The sear can be removed by gently pressing it in toward the center of the casing.

To assemble, reverse these operations, taking care before driving too hard on the end of the trigger

shaft that the square hole in the trigger fork is in position to receive the tapered end of the trigger shaft. No tools are required for assembling or dismantling this mechanism.

To remove the recoil indicator.—The ends of the clips of the recoil-indicator guide are bent down to form stops to hold the indicator in place. To remove the indicator, these parts are opened up sufficiently to permit sliding the indicator out of the guide. When the indicator is assembled, these clips should always be closed down to prevent its loss.

To dismount the gun.—Elevate the muzzle slightly. Remove the recoil indicator throw, unscrew the cylinder-end stud nut, and shove the gun to the rear until the clips are free from the guides. As the gun slides off the cradle, it must be properly supported. For this purpose, from 6 to 8 men working in pairs with lifting bars are required.

To mount the gun.—Depress the muzzle slightly. Shove the piece from the rear over the cradle guides with the clips engaging the guides. Assemble the cylinder-end stud nut, taking care that the locking stud on the recoil lug enters one of the recesses provided for it in the end of the cylinder. Assemble the recoil indicator throw. The dust guard should be assembled with the gun.

In moving the gun on or off of the cradle particular care must be taken to support the breech end so that the gun clips remain in line with the gun slides. The firing shaft is also quite liable to injury during this operation, and care should be taken to prevent its being struck by the nozzle of the gun or by implements in the hands of the cannoneers. The cradle should be placed at the desired elevation and

azimuth before beginning either of these operations and not changed during its progress, since the working of either the elevating or traversing mechanisms when the gun is only part way in battery brings an excessive and unnecessary strain and wear upon those parts.

To dismount the cylinder.—Bring the gun to approximately zero degrees elevation; unscrew the cylinder-end stud nut and the piston-rod nut; remove the cradle head, front. The cylinder is now free and may be pulled out to the front.

To assemble the cylinder in the cradle.—The counter-recoil springs and the retaining ring being in assembled position, shove the cylinder (turned so that the drain plug in cylinder head comes on top) into its seat from the front, with the projecting stud on the recoil lug of the gun entering one of the recesses provided for it in the cylinder end; assemble the cradle head; screw in place the piston-rod nut and cylinder-end stud nut.

Be sure that the projecting stud on the gun enters one of the holes for it in the cylinder end before screwing the cylinder-end stud nut up all the way.

To assemble the parts of cylinder after cleaning.—The parts should be reassembled immediately after cleaning and inspection, and the cylinder filled with hydroline oil issued for that purpose. The piston should be moved back and forth in the cylinder by hand to make sure that all parts are correctly assembled and are without interference. The cylinder should then be assembled in the cradle and the gun pulled from battery by hand and permitted to counter recoil rapidly to insure that all parts are in proper position for firing. *This should never be done, however, unless the cylinder is known to*

be filled with oil. In reassembling the parts the condition of the vulcanized-fibre washers between cylinder head and cylinder, and between cylinder-end stud and cylinder end should be noted; they should be replaced whenever necessary to prevent leakage. In removing and inserting the piston rod care should be taken to keep it central in the cylinder, so as not to bind, burr, or spring any parts. *The dismounting and reassembling of the parts of the cylinder should in every case be supervised by a commissioned officer.* Before firing an inspection should be made to ascertain that the different parts, especially the piston rod and the cylinder-end stud nuts, are correctly assembled.

To pack the stuffing box.—The stuffing box is packed with five rings of Garlock's hydraulic waterproof packing, 0.25 inch square. The packing is issued cut into rings of such size that the ends meet around the piston rod. The latter being assembled, each ring, placed so as to break joints with the preceding one, is forced in succession into its seat by a packing tool of copper or hard wood, one end of which is shaped like a carpenter's gouge and the other end forms a handle strong enough to stand light taps from a hammer. Such a tool may be readily improvised by one of the battery mechanics. After the five rings are firmly seated in the box, screw the gland down on the packing.

In assembling the glands be sure that *at least four* of its threads are engaged with the threads of the cylinder head; otherwise the threads of the gland may be stripped in firing. With new packing it may be found difficult to insert more than four rings and secure sufficient engagement of the gland. In such a case the box should be packed with four rings and

the piece fired a few rounds, after which the fifth ring should be inserted.

Adjustment of the gland.—The adjustment of the gland will require the exercise of some judgment. If screwed up too tight, the frictional resistance of the packing on the piston rod will be increased so much that the counter-recoil springs may fail to return the gun to battery, especially at high angles of elevation. *It should be screwed up just tight enough to prevent the leakage of oil through the stuffing box.* Ordinarily this can be done by hand, but in cases where hand power is not sufficient the wrench provided for the purpose should be used. When its proper adjustment is determined, the gland should be lashed with copper wire to prevent it from screwing up or unscrewing.

To remove the piston rod.—Unscrew the gland sufficiently to release the pressure of the packing upon the rod; unscrew and remove the cylinder head. The rod may then be withdrawn from the cylinder. In dismounting and assembling the cylinder head (and also the cylinder-end stud), the cylinder should be held from turning by a spanner applied to the head retainer or flange on the front end of the cylinder. *It should never he clamped in a vise*, as its walls are thin and not intended to withstand such usage.

To remove the counter-recoil buffer.—Remove the cylinder-end stud screw; unscrew and remove the cylinder-end stud; the counter-recoil buffer is attached to the latter.

To dismount the springs.—Bring the gun to approximately zero degrees elevation; unscrew the cylinder-end stud nut and the piston-rod nut; shove the gun about 1 inch from the battery; attach the

sleeve end of the spring compressor to the cylinder-end stud and put sufficient strain on the compressor to relieve the retaining ring from spring pressure; then remove retaining ring (and cradle head) by loosening and swinging aside the retaining-ring bolts; ease off slowly on the spring compressor until the springs are free.

To assemble the double counter-recoil springs.—With the cradle at maximum elevation and the trail horizontal, place one outer and one inner spring in the cradle until the front ends are about 2 inches in; set up a separator against the forward end of these sections and enter the second outer and inner springs, keeping the separator upheld between the sections; similarly when the outer end of the second section is 2 inches inside the cradle set up the second separator; place the third outer and inner sections on the recoil cylinder. Screw the spring centering tool onto the cylinder-end stud, the small end pointing rearward; pass the sleeve end of the spring compressor through the gun lug and the inner springs and attach it to the cylinder-end stud. Enter the rear end of the cylinder in the spring at the front end of the cradle and push the cylinder back until the springs are at free height, keeping the spring compressor taut. Attach the block and fall carried in the battery wagon to the spade of the carriage or to some improvised support and connect it to the spring compressor; put sufficient strain on the spring compressor to bring the spring column to its assembled height.

As the spring column approaches its assembled height the spring support must be turned so that its guide lugs properly enter in the spring-support guide grooves in the cradle; assemble the retaining ring,

disconnect the spring compressor and the spring centering tool from the cylinder-end stud; push the gun back into battery and assemble the cylinder-end stud nut. When the retaining ring is assembled the nuts for the retaining ring bolts should be screwed up until they just come into contact with the retaining ring. If these nuts are screwed up too tight they will deform the retaining ring, with the result that it becomes difficult to assemble and dismount the cradle head. A wrench is provided for turning the spring support to its proper position.

To assemble the single counter recoil spring.—The same method is followed except that no separators are used. The spring compressor is provided with a second eye at its large end which may be used in case the sleeve end should become broken; in case this end is used, however, it will be necessary to pass the compressor through the cradle from front to rear, through the gun lug. For disconnecting the compressor the method used is identical to that previously described.

The cylinder-end stud nut should never be removed when the gun is at an elevation, and the gun should not be elevated when the cylinder-end stud nut is not in place. To prevent the cylinder-end stud from rotating a screw for the cylinder end is provided. *This screw for the cylinder end must be removed before attempting to unscrew the cylinder-end stud.*

Since the springs are assembled under an initial load of over 750 pounds, a pull of more than 750 pounds must be exerted upon the spring compressor in assembling them. This can be done by passing a handspike through the loop at the rear end of the compressor and making use of the service of the entire gun squad, or the block and tackle may be

used as described above. *To avoid the possibility of injury to the gun squad in compressing or releasing the springs, all should be required to keep arms and bodies away from the front of the spring column during these operations.*

CHAPTER VI
FRENCH 75

GUN.

Weights and Dimensions.

Weight	1015 lbs.
Total Length	(about) 107 in.
Rifling	24 grooves
Twist—right-hand slope, 7 degrees, 1 turn in 25.6 calibers.	

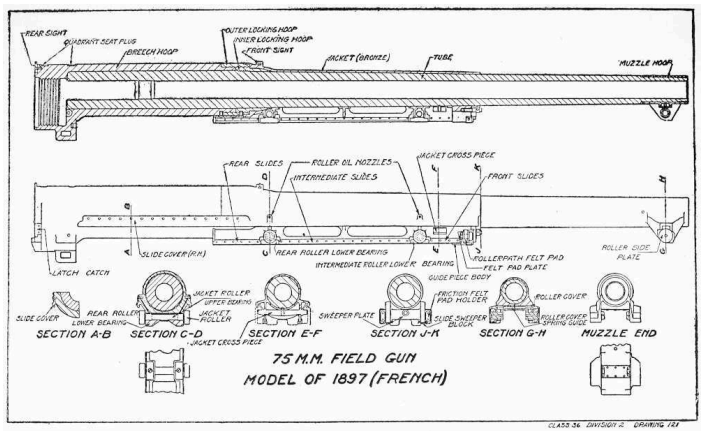
CARRIAGE.

Weights and Dimensions.

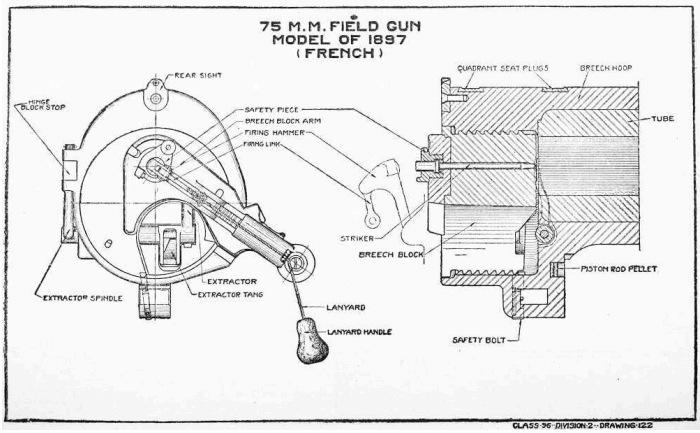
Weight complete	1642 lbs.
Weight of gun and carriage complete	2657 lbs.
Weight at end of trail, carriage limbered	114 lbs.
Diameter of wheels	52.5 in.
Length of recoil	(about) 45 in.
Maximum angle of elevation	(338 mils.) 19 degrees

Maximum angle of depression	(178 mils.) 10 degrees
Amount of traverse of gun on carriage	(106 mils.) 6 degrees

The gun is of the built-up type and consists of a forged steel tube which extends from muzzle to breech. A breech hoop is shrunk over the rear of the tube and extends beyond it to provide a breech recess. This recess is threaded with seven threads to take the breechblock. A bronze jacket encircles the central portion of the tube. Inner and outer locking hoops screw to and firmly fasten the tube, hoop and jacket together and prevent them from separating under the stresses of recoil. A muzzle hoop is screwed on the tube at the end of the muzzle.



75 M.M. FIELD GUN
MODEL OF 1897 (*FRENCH*)



75 M.M. FIELD GUN
MODEL OF 1897
(FRENCH)

A recoil lug on the under side of the breech hoop forms a point of attachment between gun and recoil mechanism through the media of a piston rod and coupling key.

The rear sight is attached to the rear portion of the breech hoop. On top of the hoop at its rear end are two quadrant seat plugs. The front sight is fixed on top of the rear end of the jacket. A sweeper plate which sweeps and lubricates the roller is secured to the front end of the jacket.

The breechblock is the Nordenfeld rotating type, cylindrical with seven threads which serve to screw it into the rear of the breech. The breech is opened and closed by rotating the block 120 degrees around its axis. The block advances during the rotation due to the pitch of its threads and forces the cartridge case into the bore. The gun cannot be fired until the block has been completely closed, a condition which

must exist before the striker of the firing mechanism is in line with the primer cartridge of the projectile.

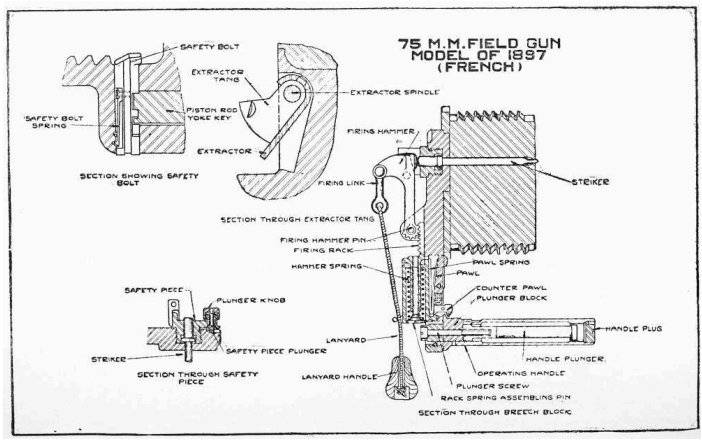
The extractor consists of three parts:

1. Two arms connected by a hollow shaft.

2. A spindle which passes through the shaft and fastens it to the breech.

3. An extractor tang.

The action of the extractor is as follows: When the breech is closed the arms of the extractor are pressed against the face of the tube by the rim of the cartridge case which bears against them. The extractor tang projects into a groove in the inner face of the breechblock known as the loading groove. This groove is circular and its depth is equal to the projection of the extractor tang. It terminates in a helical guide surface called the “ejecting ramp.”



75 M.M. FIELD GUN
MODEL OF 1897
(FRENCH)

The first part of the movement of opening the breech serves to move the grooves in front of the extractor tang. This pressure forces the extractor tang back into its slot in the breech hoop and as the extractor tang is firmly seated in the extractor, the arms of the latter are rotated around the extractor spindle. The arms being brought to the rear, press against the rim of the cartridge case, which is thereby started and ejected.

Inversely (the breech being open) when a cartridge case is smartly inserted in the chamber the rim carries the arms of the extractor forward. The extractor tang is thereby forced against the beveled surface of the ejecting ramp and automatically starts the closing movement of the breechblock.

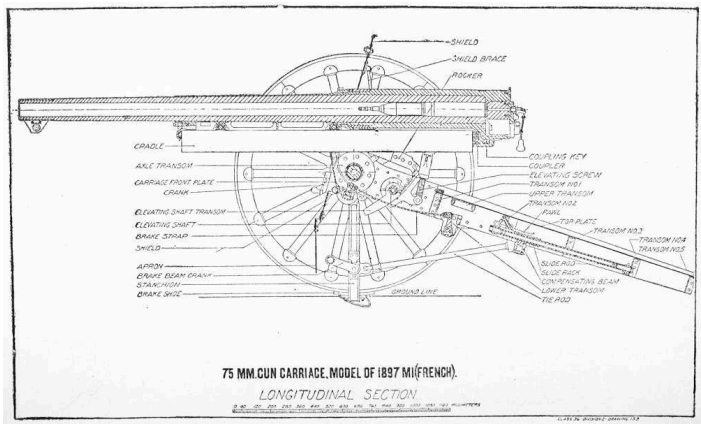
A safety catch is provided to keep the breech locked between the time that the breech is closed and the shot is fired.

The firing mechanism consists of a striker or firing pin seated in the breechblock, a firing hammer, firing rack, spring and lanyard. By pulling the lanyard the hammer is drawn back and the rack moves forward against the compression of the spring due to its being geared to the hammer. When the lanyard is released, the spring forces the rack back which in turn causes the hammer to fly forward and strike the primer. A safety device is provided for locking the hammer while the piece is in the traveling position.

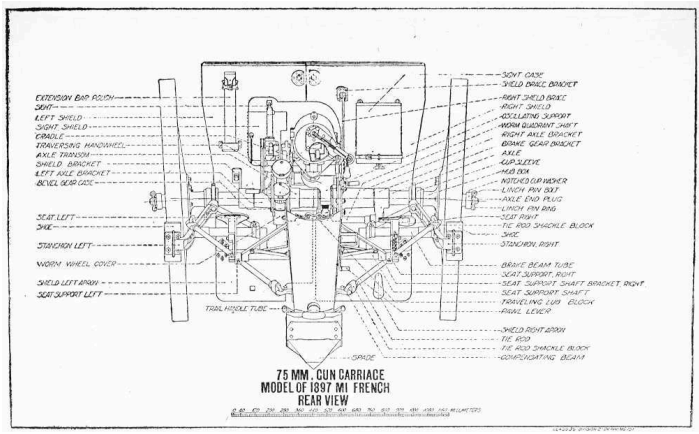
THE CARRIAGE.

The gun is mounted upon a cradle which encloses the recoil and counter-recoil mechanisms. The device for elevating the gun through the angle between the

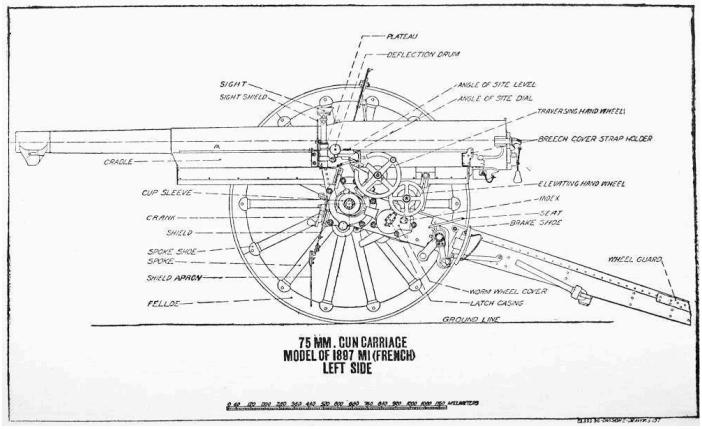
horizontal and the line gun-target (angle of site) is interposed between the trail and the rocker while the device for giving the gun elevation for range is placed between the rocker and the cradle. This arrangement is known as the independent angle of site or independent line of sight. It has the advantage over the three-inch type in that it allows the range elevation to be altered without disturbing the elevation for site.



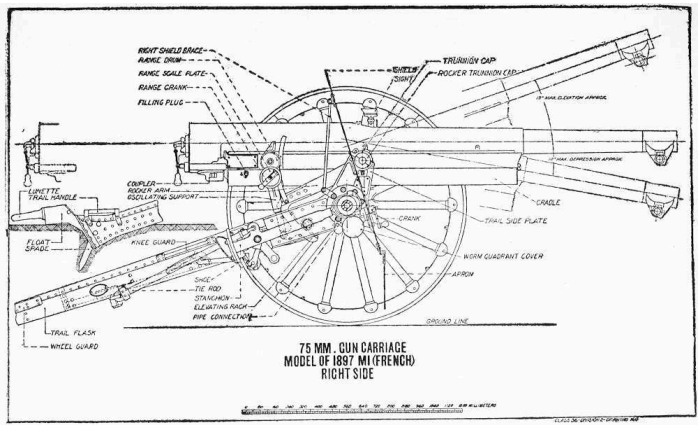
75 MM. GUN CARRIAGE, MODEL OF 1897 MI(FRENCH).
LONGITUDINAL SECTION



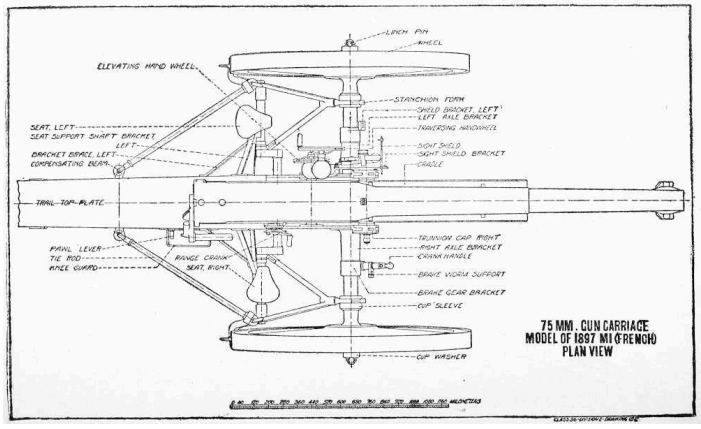
75 MM. GUN CARRIAGE
MODEL OF 1897 MI FRENCH
REAR VIEW



75 MM. GUN CARRIAGE
MODEL OF 1897 MI(FRENCH)
LEFT SIDE



75 MM. GUN CARRIAGE
MODEL OF 1897 MI(FRENCH)
RIGHT SIDE



75 MM. GUN CARRIAGE
MODEL OF 1897 MI(FRENCH)
PLAN VIEW

The principal parts of the carriage are: trail, axle, wheels, brakes, shields, angle of site elevating

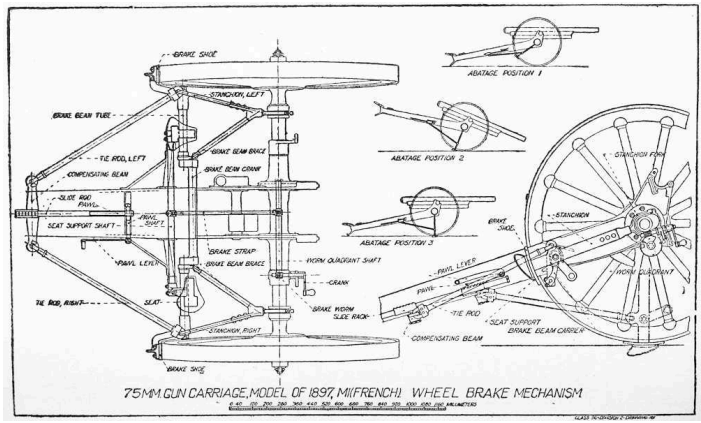
mechanism, range elevating mechanism, traversing mechanism, rocker, cradle and sights.

When traveling or resting, the tube rests on the **cradle** which supports it by means of the jacket. When firing, it recoils on the cradle by means of the rollers. The jacket has two pairs of rollers, and the muzzle hoop is provided with a single pair of rollers. On the upper part of the cradle are the lower slides, on which the jacket rollers, supporting the tube, roll during the recoil. When the jacket rollers are about to leave the lower slides, the muzzle rollers come under the upper slides; the tube is then supported until the end of the recoil by the muzzle rollers and the more forward of the two pairs of jacket rollers. This device gives the gun a long recoil upon short slides. Inclined planes are used in such a manner that when the gun returns into battery the rollers rise from the lower slides thereby relieving the slides from the weight of the tube when the tube is in the traveling position.

The carriage supports the cradle which in turn supports the tube. The cradle and the tube together are displaced, during the laying for elevation with respect to the carriage which remains stationary. The carriage is held steady on the ground by means of the trail spade which with abatage prevents the carriage from recoiling on the ground.

Abatage consists of elevating the wheels on the brake shoes which are provided with small spades which prevent lateral movement. The brake shoes are fastened to brake beams attached to a sliding rack beneath the trail in such a manner that the abatage frame may be placed under the carriage during travel. In preparing to fire, the frame may be adjusted to allow the brake shoes to slip from a

position in rear of the carriage wheels to a point directly beneath the wheels.



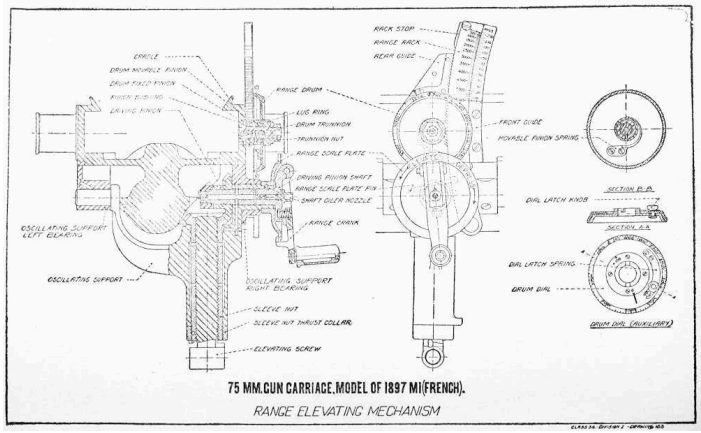
75-MM. GUN CARRIAGE, MODEL OF 1897, MI(FRENCH) WHEEL BRAKE MECHANISM

Abatage is accomplished as follows: (1) The brake shoes are dropped to the ground in rear of the point of contact of the wheels with the ground; (2) The trail is lifted, turning around the axle, until the spade is about five feet in the air. Tie rods and a slide working on a rack beneath the trail move forward in this action; (3) The trail is then brought down. The rack prevents the slide from moving to the rear and the carriage turns on the abatage frame until the wheels rest upon the brake shoes. This gives the gun a three point support, two small spades under the wheels and a larger one at the end of the trail.

Laying in direction is accomplished by traversing the piece on the axle. The trail spade is fixed and the axle is straight and rigid so that in the movement of the gun to the right and left on the axle both wheels

must turn—one to the front and one to the rear. The device for laying for direction is composed of a threaded axle, which is prevented from rotating by a spur and a sliding nut which is contained in a box fixed on the left flask of the gun. This nut bears one of the bevel gears, which is put in motion by the hand wheel. The traverse is three degrees either side of the center or a total of 6 degrees or about 105 mils.

Laying for elevation. To obtain greater accuracy and speed in firing the 75 has an independent angle of site. A rocker with two trunnions is interposed between the cradle and the carriage. The rocker trunnions are seated in the cradle trunnions and support them. This gives the same rotating axis to both rocker and cradle. This is necessary for the mechanical addition of the angle of site elevation and for the range elevation. When the angle of site handwheel is revolved it turns a pinion, which meshes in the rocker rack and thus causes the rocker to move in relation to the carriage. This gives the cradle through the rocker the elevation equal to the difference in elevation between the target and the gun. It is independent of the angle given to the gun for the elevation due to range to the target.



75 MM. GUN CARRIAGE, MODEL OF 1897 MI(FRENCH).
RANGE ELEVATING MECHANISM

The angle given the gun for range is effected through a telescopic screw. This screw is fastened at one of its extremities in the rocker and at the other in the cradle. The nut which receives the elevating screw is seated in an oscillating support which allows it to always remain perpendicular to the axis of the bore at any elevation.

The angular displacements of the cradle with respect to the rocker (angle of elevation) are recorded by the elevating system composed of a graduated arc and a range drum. The lower part of the arc is connected with the right arm of the rocker. The arc is graduated in meters. When the range handle is turned the arc does not move, but a brass slide block connected with the gun and the cradle and bearing an index slides along the arc. It is thus possible to set the range in meters.

However, the arc graduations are not very legible and it has been supplanted by a graduated range

drum having more legible readings.

The black part of the arc bears a rack which meshes with a pinion, which in turn rotates around an axle fixed on the cradle. When the cradle moves, the pinion rotates and carries with it the range drum.

The elevation on level ground varies from a minus 11 degrees to a plus 20 degrees. Greater elevation may be obtained by sinking the spade.

The Recoil and Counter-recoil mechanisms are of the Hydro-pneumatic type. Their accurate description is a secret. The following brief description will give only a general idea of the working of the mechanism. The whole apparatus is inside of the cradle through which are bored two cylinders: an upper cylinder 40 mm diameter, and a lower cylinder 66 mm diameter. These cylinders may communicate through a large hole. A piston moves in the upper cylinder, the piston rod, 24 mm diameter, being fast to the gun.

In the lower cylinder are: (1) The valve carrier pipe screwed in the rear part of the cylinder supporting **spring valves**; in the inner walls of the pipe are cut two grooves; the valve carrier pipe is ended by a circular ring. (2) **The diaphragm** with its hollow rod. (3) **The loose piston** with its small rod, which may come in contact with the upper rack of the gauge. The two cylinders are full of liquid, usually Russian oil. The front part of the upper cylinder in front of the piston may communicate freely with the air through the Front Plug. The front part of the lower cylinder is closed by a plug and contains compressed air at a pressure of 150 kg. per sq. cm.

Operation. In recoil the piston of the upper

cylinder compresses the liquid, which has to pass through the spring valves and between the circular ring and the hollow rod of the diaphragm. The passage of the liquid through these different openings constitutes the braking effect. In so moving the liquid opens the valves, which are widely opened at the beginning of the recoil and gradually close in proportion to the decrease of the speed of the recoil. At the same time, the air of the recuperator is compressed by the action of the liquid on the diaphragm.

When the recoil is finished, the compressed air pushes back the diaphragm. The liquid thus compressed acts on the small cylinder piston and obliges it to come back into its initial position, bringing with it the tube.

The liquid in flowing back completely closes the valves and must pass between the diaphragm rod and the inner wall of the pipe. At beginning of the return into battery, the space between the rod and the bottom of the groove is large. This space decreases in proportion to the progress of the return. The passing of the liquid through this constantly decreasing space causes the braking which at the end reduces the speed of the return to nil.

CARE AND PRESERVATION OF FRENCH 75.

Dismountings.

Cannoneer Dismountings.

A. Breechblock.

1. Safety piece.

2. Striker.
3. Lanyard.
4. Striker hammer.
5. Hammer spindle.
6. Spring assembling pin.
7. Rack springs.
8. Rack.
9. Latch pin. (Pawl Pin.)
10. Latch (Pawl).
11. Latch spring. (Pawl spring.)

B. Extractor.
1. Clow. (Tang.)
2. Spindle.
3. Arms.

C. Level.
D. Sight case.
E. Wheels.
F. Limber pole.
G. Fuze setter from caisson.
H. Luggage frame from limber.

Mechanic Dismountings.

A. Coupling keg.
B. Push gun back on slides.
C. Safety bolt.
D. Friction piece. (Sweeper plate.)
E. Wiper. (Guide piece.)
F. Front plug.
G. Filling hole plug.

H. Elevating screw pin.
I. Elevating screw.
J. Trunnion caps.
K. Rocker Trunnion caps. (Half Rings.)

Daily Cleaning and Lubricating.

(By cannoneers.)

1. Clean sight support and socket.
2. Lubricate oil holes 20, 21, 22, 23, 24.
3. Clean base of sight column.
4. Clean levels.
5. Lubricate range mechanism. (Holes Nos. 1 and 2.)
6. Clean and oil rocker trunnion caps.
7. Oil holes 7 and 8.
8. Clean and grease exposed parts of axle.
9. Dismount and clean breech and all its parts.
10. Clean and grease the bore if the gun has been fired.
11. Clean and grease the slides if the gun has been fired.
12. Grease the wheels if the gun has been on the road.
13. Clean fuze setter.
14. The life of a gun depends on “Daily Care.”

Forbidden Practices.

1. **Readjustment of French Sights**.
2. **Fitting with files**.

3. **Forging and Riveting**.
4. **Unauthorized Dismountings**.

Care of Recoil Mechanism.

(*Chief Mechanic Only*)

Caution.—Never remove piston rod nut, as piston is under pressure and would pull piston rod into cylinder.

The recoil apparatus proper cannot be dismounted.

If properly taken care of the recoil mechanism will not go wrong for years; but if neglected, its destruction is only a matter of very little firing.

The position of the gauge finger is the index as to whether or not the recoil is being properly absorbed.

The joints are not absolutely tight, the slight leakage which takes place during fire or even when gun is at rest is not important.

In normal firing conditions the recoil apparatus contains a slightly greater quantity of oil than absolutely necessary; this quantity is called the "reserve." When the reserve is exhausted any loss is liable to reduce the quantity strictly necessary. The loss may prevent the gun from fully returning to battery when firing.

The amount of reserve is indicated by the position of the gauge.

No reserve: The gauge finger is down deep in its recess.

Full reserve: The end of the gauge finger is level with the gauge index.

Excess reserve: The gauge finger projects beyond the index.

No firing should be done with an excess reserve.

The gauge finger should be between the index and ⅛ inch below the index.

It is the duty of the Chief Mechanic to see that the gauge finger is in the proper position before firing.

It is the duty of the Executive and the Chief of Section to see that the gauge finger is in the proper position during fire; if it moves from this position the Chief Mechanic will be called to make the proper adjustments.

When the gauge finger has been brought to the proper position there are only two conditions which call for tampering with recoil apparatus.

1. The gun goes into battery too slowly, or has to be pushed in.

In this case the gauge finger will usually be found too deep in its seat, and the pump will have to be used. If the gauge is in the proper position look at the slides. Either they will be found dirty or bits of the wiper may be nicked off. In the latter case the gun can be fired without the wiper.

2. The gun jumps badly. In this case the gauge finger will generally be found beyond the index. When this is the case the oil extractor must be used until the gauge finger is in the proper position.

If after cleaning slides, putting gun in abatage and adjusting gauge finger, the gun still jumps badly—complete draining of the reserve and refilling will

frequently remedy the trouble.

CHAPTER VII.
75-MM. FIELD GUN MODEL 1916.

THE GUN.

Weights and Dimensions.

Weight	Kg	339.74	pounds	749.
Caliber	mm	75.	inches	2.953
Total length	mm	2,308.5	inches	90.9
Length of bore	mm	2,134.	inches	84.
Length of rifled portion of bore	mm	1,847.	inches	72.72
Number of grooves				24
Width of grooves	mm	7.30	inches	.2874
Depth of grooves	mm	.501	inches	.02
Width of lands	mm	2.52	inches	.0992

Twist, right hand, zero turns from origin to a point 2.89 inches from origin. Increasing from one turn in 119 calibers at a point 2.89 inches from origin to one turn in 25.4 calibers at a point 9.72 inches from muzzle. Uniform from a point 9.72 inches from muzzle to the muzzle.

Description of the 75-MM Field Gun.

The gun is built up of alloy-steel forgings, *consisting of a tube, jacket, breech hoop, and clip*. All of the parts are assembled with a shrinkage.

The tube extends from the muzzle to the rear end of the powder chamber and two recesses are cut in its rear face to form seats for the lips on the extractors.

The jacket is assembled over the muzzle end of the tube. The jacket carries two flanges on its lower side, which form guides for the gun in the cradle of the carriage, and a lug on top near the forward end which contains a T slot, which holds the recoil cylinder in place. The rear end of the jacket is threaded on the outside to receive the breech hoop.

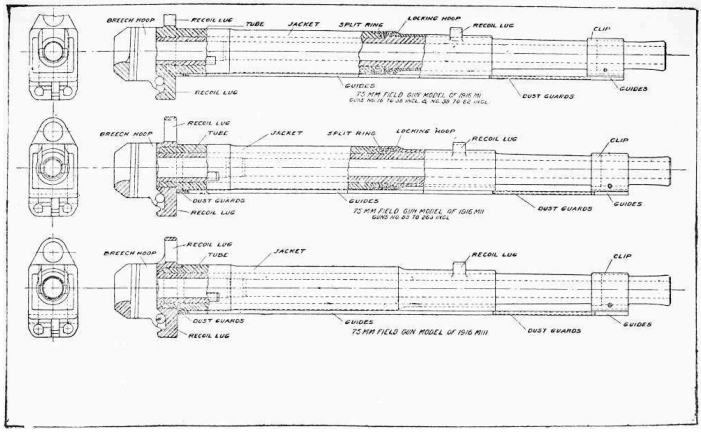
The breech hoop is threaded at its forward end and screws on to the rear of the jacket. The breech ring carries a recoil lug at the top for the attachment of the hydraulic recoil cylinder, and another lug at the bottom for attachment of the two spring piston rods. The rear part of the breech hoop is cut away to form the breech recess.

The clip is a short hoop shrunk on the tube near the muzzle. It carries two lugs on its under side which form guides for the gun in the carriage.

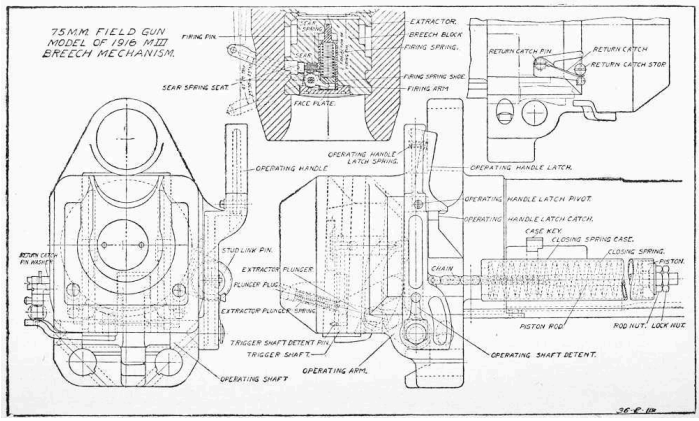
The rear ends of the guides on the jacket are extended to the face of the recoil lugs by short extensions riveted in place to prevent entrance of dust between surfaces of the guides and their bearing surfaces on the cradle. For the same purpose the forward ends of the guides on the jacket are connected by steel-plate dust guards with the rear ends of the guides on the clip.

Description of the Breech Mechanism.

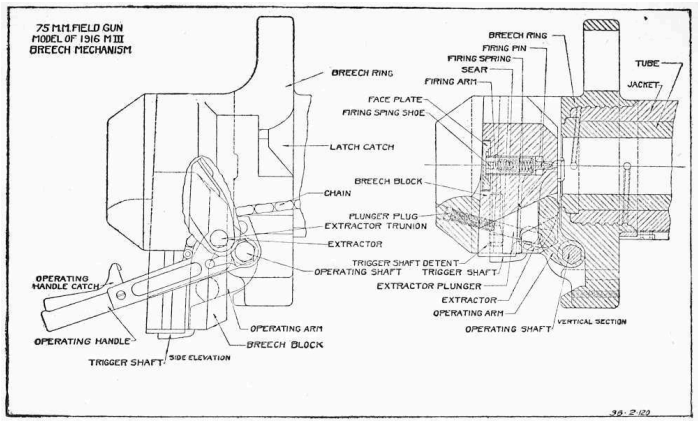
The mechanism is known as the **drop-block type**, and is semi-automatic in design in that the block closes automatically when a round of ammunition is inserted. A rectangular hole extending through the rectangular section of the breech hoop forms seat for the sliding block. The upper part of the breech hoop in rear of this slot is cut away, leaving a U-shaped opening which permits the passage of the cartridge case.



75-M.M. FIELD GUN BARREL



75-M.M. FIELD GUN MODEL OF 1916 MIII BREECH MECHANISM.



75-MM. FIELD GUN MODEL OF 1916 M III BREECH MECHANISM

Recesses cut in both the side faces of the breech recess form seats for trunnions for the two extractors. Holes bored into these recesses from the rear face form seats for the extractor plungers, springs and plugs. The block slides up and down in the breech recess under the action of the operating arm which is pivoted on the operating shaft and acts as an

oscillating crank in raising and lowering the block. The operating shaft which rotates the operating arm is actuated by the operating handle. The operating handle is provided with a latch to keep it in the closed position and is connected by a chain, piston, and piston rod to the closing spring, which is carried in the closing-spring case. The closing spring is under compression and tends to keep the block closed or to close the block when it is opened.

When the block is opened as far as it will go, it is locked in that position by the inside trunnions on the extractors. These trunnions are forced over horizontal shoulders on the block by means of the extractor plungers and holds the block in the open position. When a cartridge is pushed smartly into the gun, its rim striking against the lips on the extractor frees the trunnions from the shoulders on the block and allows the block to close under the action of the closing spring.

A continuous-pull firing mechanism is carried in the recess bored out in the center of the block and is operated by the trigger shaft which projects from the bottom of the block. This mechanism is cocked and fired by one continuous motion of the trigger shaft so that in case of a misfire the primer may be struck a second blow by releasing the shaft and rotating it again. A lanyard may be attached to the projecting end of the trigger shaft.

CARRIAGE.

Weights and Dimensions.

Weight of carriage, complete, fully equipped, without the gun	2280 pounds

Weight of gun and carriage fully equipped	3045 pounds
Weight of lunette, carriage limbered	140 pounds
Diameter of wheels	56 inches
Width of track, center to center of wheels	60 inches
Length of recoil of gun on carriage, variable recoil	18 to 46
Height of axis of gun about ground	42 approx.
Amount of elevation with elevating handwheel	42 degrees
Total limits of elevation	7 to plus 53 degrees
Maximum traverse either side of center	400 mils
Over all width of trails, spread	130 inches
Over all length, muzzle of gun to end of lunette	173 inches

Limits of elevation with angle of site handwheel, minus 7 degrees depression to 11 degrees elevation.

Description.

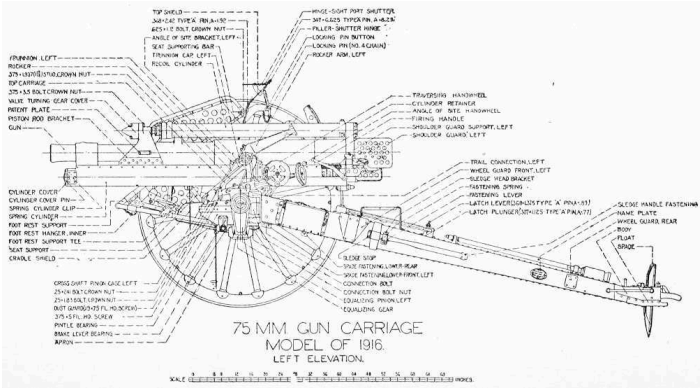
The carriage is of the split trail, variable long-recoil type. The length of recoil is regulated automatically, so that the breech of the gun will not strike the ground on recoil at an angle of elevation of less than 47 degrees. At elevations greater than 47° a hole must be dug for the breech in recoil.

The gun is mounted in slides on a *cradle* formed by the spring cylinder. The spring cylinder is suspended

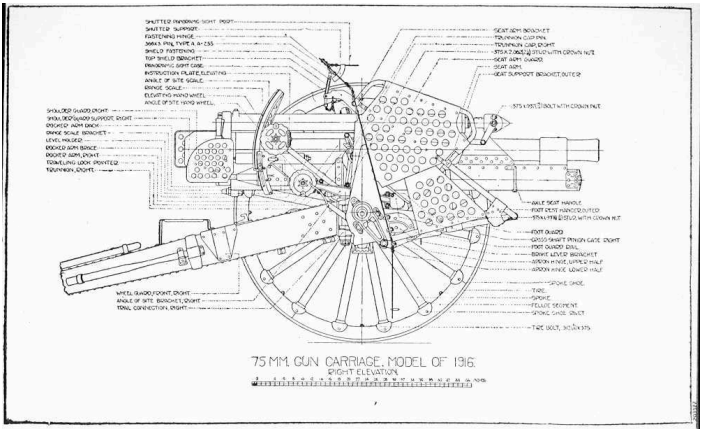
by trunnions mounted in bearings in the top carriage, which is supported by the pintle bearing to which are attached axle arms bearing in the wheels.

The carriage has an *independent angle of site* elevating mechanism, by means of which a maximum depression of seven degrees and an angle of elevation of 11 degrees may be obtained. The remaining elevation is obtained through the elevating handwheel.

The principal parts of the carriage are:
Trail
Cradle
Recoil mechanism
Top carriage
Pintle bearing
Equalizing gear
Shields
Angle of site mechanism
Elevating mechanism
Traversing mechanism
Axle seat
Brake mechanism
Shoulder guards
Firing mechanism
Sight, model of 1916
Wheels.



75 MM. GUN CARRIAGE MODEL OF 1916.
LEFT ELEVATION.



75 MM GUN CARRIAGE. MODEL OF 1916.
RIGHT ELEVATION.

The trail is made in two halves of box section built of bent and riveted steel plate. Each half is bolted to a lug on the equalizing gear, so that it may be rotated horizontally from the junction point of the trail to the point where the trail hits the wheel.

The trails are locked together in traveling position by means of a cone-shaped vertical lug on the lunette bracket which fits in a socket in the trail coupling, and is locked in place by the trail-coupling latch. Trail-coupling latch has a handle and catch with a vertical spindle seated in a socket in the lunette bracket. A handle-return spring is assembled around the spindle and the latch engages a catch on the trail coupling when trails are fixed in the traveling position. Latch is opened by moving handle forward.

Lunette consists of a ring for attaching the carriage to the limber and is bolted through the lunette bracket.

Floats are attached to the bottoms of both trails at their rear ends, consisting of flanged steel plates for the purpose of increasing bearing area of the trails on soft ground.

Spade bearings are riveted to rear of the trails and form bearings for spades in firing position. Spades are driven through the bearings, and their upward movement relative to the trails is prevented by spade latch.

Spade-latch bracket consists of a bronze plate with a cylindrical chamber for a spring and plunger and two bearings for latch-handle pin. Bracket is riveted to the inside top of trail in front of the spade. Spade-latch plunger, with a spring assembled around it, is seated in the chamber and the spade-latch handle is pinned in the bearing. Top of handle extends through the trail and is roughened for use as a foot pedal. Lower part of handle engages with the plunger. When the spade is driven the plunger is forced into a notch in the spade by means of the spring, and the slope on face of plunger allows a downward movement of the spade and prevents upward

movement. To release spade the foot pedal on latch handle is pressed down, disengaging plunger from spade, and the spade is removed.

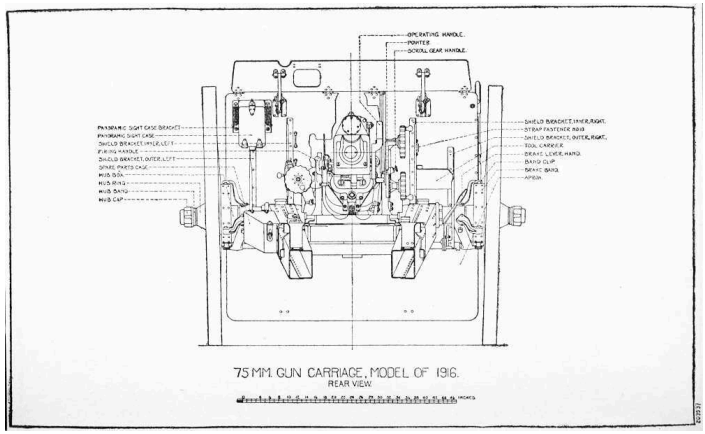
Trail handles are riveted to outside of both trails for lifting trails. Name plate is riveted to outside lower left trail. It is important that the number of carriage on this plate be recorded by the officer in charge of the unit to which it is assigned and that this number be used as a reference in all correspondence. Wheel guards, rear, are plates riveted to the outside lower left of both trails for the protection of trail bodies against contact with limber wheels on short turns. Trail guards are bent plates riveted to the top of trail in front of trail-coupling latch to prevent battering of trails by sledges used for driving the spades.

Sponge-staff fastenings are riveted to tops of both trails. Sponge staffs are inserted in upper rings of staff fastenings and the lower ends are clamped in place. The smallest section of sponge staffs fits in sponge fastenings.

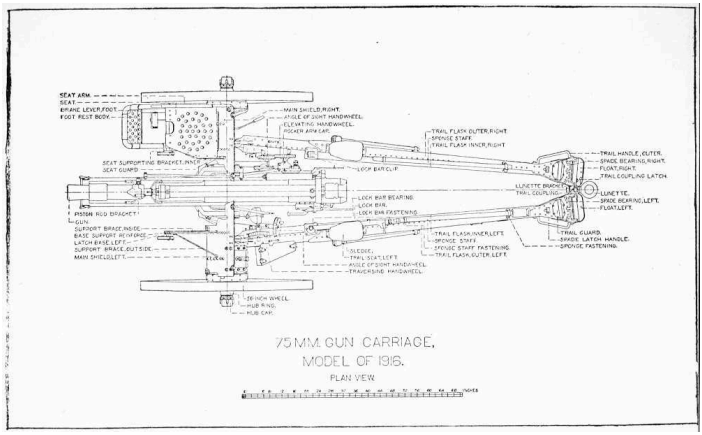
Sledge fastenings are similar to sponge staff fastenings and are riveted to the outside of each trail. Wheel guards (front) are plates riveted to the outside of trails near the front to prevent contact of trails with wheels when the trails are separated.

Spare parts case is a steel box with a hinged steel cover provided with a bolt snap and padlock riveted to the outside of front left trail. This case contains spare parts for emergency use.

Trail seats are made of formed bent plates riveted to the tops of trails near breech of gun. Oiler support with springs is under the right-hand trail seat. Oiler rests on this support and is held in place by springs.



75-MM. GUN CARRIAGE, MODEL OF 1916.
REAR VIEW.



75 MM. GUN CARRIAGE, MODEL OF 1916.
PLAN VIEW.

Traveling lock bar consists of a forged steel bar pinned to lock bar bearing on left trail and made to swing across trails in traveling position and along left trail in firing position. In traveling position the

socket in the middle of the lock bar engages with the traveling lock stud in the bottom of cradle, and right end of lock bar is held in lock bar clip on right trail by the latch. To disengage the latch for firing, the latch handle is lifted and the lock bar swung to fastening in left trail, where it latches.

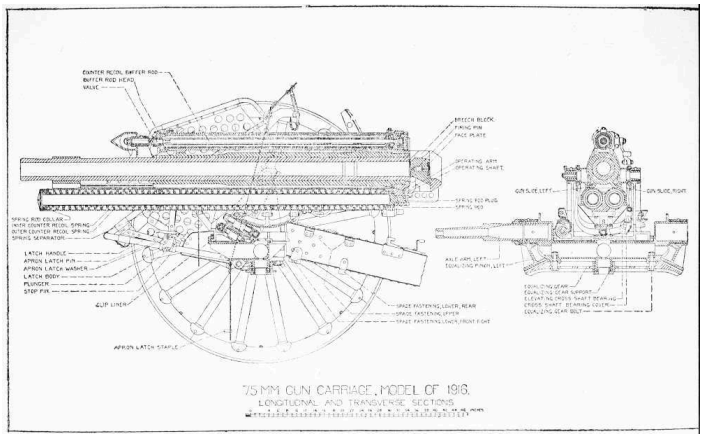
To lock the cradle, the gun is brought to 0 azimuth and the traveling lock pointer on right trunnion cap brought to line marked “March.” In this position the traveling lock socket fits over stud, and the lock is latched. The latch consists of a lever pinned at one end to the lock bar with a plunger pinned in center extending through the bar with a spring around the plunger body to hold the latch in place.

Trail connections are riveted to front end of trail and bolted to equalizing pinions.

The cradle comprises the spring cylinder with attached parts.

The spring cylinder is below and shorter than the gun. It is in the form of two cylinders joined at the center, with axes in the same horizontal plane. Above the cylinders are the gun ways, parallel to the cylinders, bronze lined, and opening toward the center line of cylinders. Traveling lock stud is bolted through a lug at the rear and below the cylinders. Firing-shaft bracket is riveted to the left side and range-scale bracket to the right side of the cylinder at its rear end. Shoulder guards are pinned in sockets in both firing-shaft and range scale brackets to prevent contact of the gun during recoil, with the cannoneers. Trunnions are riveted and keyed to the cylinder near center. Elevating arc is bolted to lugs on the bottom of cylinder at trunnions. Piston-rod bracket is riveted to projections on the cylinder above the gun slides near the front end. Cylinder

cover is pinned to cylinder clips, which are riveted to the front of spring cylinder. (Note: On some carriages the clips are made integral with the cylinder.)



75 MM GUN CARRIAGE, MODEL OF 1916.
LONGITUDINAL AND TRANSVERSE SECTIONS

The recoil mechanism is designed for variable recoil, the length of which is regulated automatically by the elevation of the gun. The following table gives lengths at various elevations: (These lengths are based on theoretical calculations. Actual lengths of recoil between 8’ and 45’ elevation are generally greater.)

Elevation.	Length of Recoil.
-7.0 to plus 8.0 degrees	46 inches.
-8.0 to plus 16.47 degrees	46 to 28 inches.
-16.47 to plus 27.20 degrees	28 inches.

-27.20 to plus 36.7 degrees 28 to 18 inches.
-36.7 to plus 53 degrees 18 inches.

The breech of the gun on short recoil will strike the ground at the level with the bottom of the wheels at an elevation of 47 degrees or over.

The recoil mechanism is of the *hydraulic spring type*, with the *recoil cylinder* mounted above the gun and the counter-recoil springs in the cradle below the gun. The recoil cylinder is held in place by a slot machined in the gun jacket at the front and rests in the cylindrical opening in the gun lug above the rear of the gun. It is held in place by the cylinder retainer, which screws into the rear cylinder parallel to the center line.

The recoil valve is a cylinder with a collar at the front end and three lands inside and parallel to the bore. Three rows of holes are bored at the lands. The recoil valve fits inside the cylinder, resting on the lands, and is held in place by a collar bearing against the edge of the counterbore in the cylinder at the front, while the rear end of the valve bears against the inside rear end of the cylinder.

The piston is screwed and pinned to the piston rod and is of bronze, slotted to fit lands and grooves in the recoil valve. The piston rod is hollow for almost the entire length. The front end passes through the gland in the cylinder head and piston-rod sleeve. The front of the recoil cylinder is closed by the front cylinder head, which is screwed in place with a gasket. A bronze gland with four rings of $^{5}/_{16}$ inch Garlock packing prevents leakage around the piston rod.

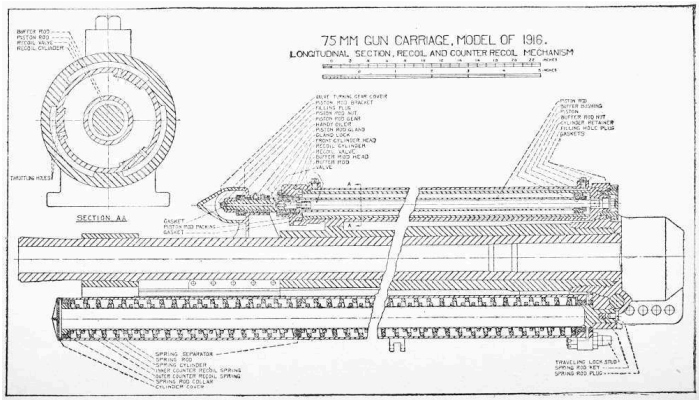
The counter-recoil buffer consists of a buffer rod

screwed into the buffer nut at the rear end of the recoil cylinder, and extending through the buffer bushing into the interior of the piston rod. The buffer head is screwed and pinned into the front end of the buffer rod. The buffer head is of two diameters and connected by a short cone. The rear end is the smaller diameter and is threaded inside to screw over the buffer rod. The coned surface contains slots leading to a hollow chamber in front. The front end of head is faced and provided with a central bearing for valve stem. The bearing is supported by webs to main body of guide. Valve stem has a stop on rear and a valve screwed to front. Valve is faced to seat on front of the bearing, webs and circular face of main body of guide.

The counter-recoil springs are assembled around *spring rods* in *spring cylinder*. Spring rods fit in gun lug and are fixed in place by taper keys driven diagonally through lug and rod. The rod is hollow for entire length, except at the rear, where the outside diameter is decreased to permit entrance in gun lug. Collars are screwed and pinned to front ends of rods. *Three coils of inner counter-recoil springs* are assembled over the spring rod, surrounded by *three coils of outer springs*. Inner and outer springs are coiled in opposite direction to prevent nesting, and sets of coils are separated by a bronze separator. Rear ends of cylinder are bushed for spring rods.

The operation of recoil mechanism is as follows:

When the gun is fired it moves back in slides on cradle, carrying with it spring rods, buffer rod, recoil cylinder, and recoil valve. The piston, piston rod, and spring cylinder remain stationary, being fixed to carriage.



75 MM GUN CARRIAGE, MODEL OF 1916.
LONGITUDINAL SECTION, RECOIL AND COUNTER RECOIL MECHANISM

The recoil cylinder being full of oil, this oil is forced by the piston through holes in recoil valve in front of piston up into annular space between valve and cylinder and into space behind and vacated by the piston. The hydraulic resistance caused by forcing the oil through the holes in valve absorbs most of the recoil energy of the gun, and the remaining energy is taken up by compression of the counter-recoil springs and friction.

When the gun reaches the end of recoil all of the recoil energy has been absorbed and the counter-recoil springs acting against spring-rod piston force the gun back to battery position. The purpose of the counter-recoil buffer is to overcome the tendency for gun to return to battery too rapidly, at the same time allowing sufficient speed of counter recoil to permit maximum rapidity of fire. Buffer action is necessary, as the strength of springs required to return the gun to battery at high elevations is greater than is

required at lower elevations.

The action of counter-recoil buffer is as follows:

As the buffer rod moves backward in piston rod the valve in buffer-rod head is opened by the pressure of oil in back of valve and the vacuum in front, which forces oil into buffer chamber in front of the buffer-rod head. At full recoil the buffer chamber is full of oil and buffer-rod head is inside the rear end of piston rod. When springs force gun back in counter recoil, buffer rod moves forward, compressing oil in chamber and forcing valve closed. This prevents escape of oil through valve and forces oil to throttle between outside surface of buffer-rod head and inside surface of piston rod, offering resistance to spring action and thus easing the gun into battery. The inside bore of piston rod is tapered at front end to increase resistance and obtain desired decrease in counter-recoil velocity.

If guns fails to return to battery after a few rounds of rapid firing, it is probably due to expansion of oil. This may be determined and corrected by loosening filling plug. If oil spurts out, allow it to run until gun is back in battery. It may be necessary to relieve oil two or three times immediately after filling. Gun should never be allowed to remain out of battery more than 1 inch on counter recoil without determining and correcting the cause.

If gun remains out of battery and the relief of oil does not cause it to return, it is due to:

(a) Weak or broken springs; (b) piston-rod gland too tight; (c) dirt or lack of lubrication in gun slides; (d) distortion of gun on gun ways; (e) distortion of piston rod due to improper counter recoil action.

The majority of cases are due to (a), (b) and (c).

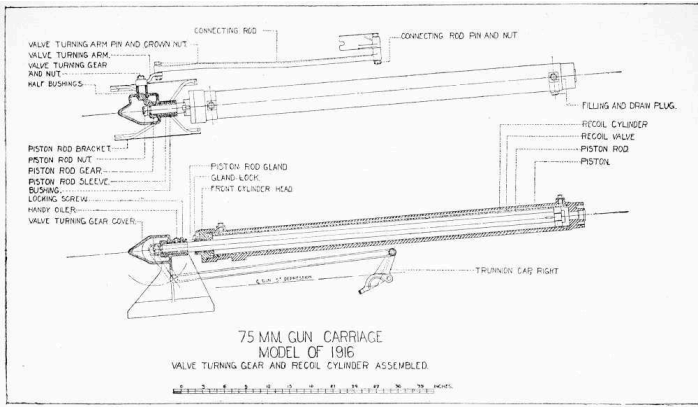
(a) Can be determined only by removing springs, and should be undertaken only after all other methods have been tried.

(b) Can be determined by loosening piston-rod gland. If gland is too tight, gun will return to battery when it is loosened. If gland cannot be loosened, piston-rod is probably distorted.

(c) Flood slides with oil, and if possible retract gun and examine gun ways and slide for dirt.

(d) If possible allow gun to cool for 15 or 20 minutes. In case of (a), (c) or (d) gun can generally be pushed back into battery by hand.

(e) If piston rod or interior mechanism is distorted, mechanism must be disassembled and defective parts replaced. If distortion has occurred, it can generally be identified by very rapid counter recoil for round on which gun does not return to battery. This may be caused by foreign matter in oil causing buffer valve to stick, or by lack of sufficient oil. If distortion has occurred, it will be near gland and can generally be felt by running hand along rod from bracket to gland.



75 MM. GUN CARRIAGE MODEL OF 1916
VALVE TURNING GEAR AND RECOIL CYLINDER ASSEMBLED.

In case of any improper functioning of recoil mechanism during recoil or counter recoil, cease firing until cause has been determined and corrected. A piece is out of action when recoil mechanism is not operating properly and will almost certainly be damaged seriously if further firing is attempted.

After dismounting any part of recoil mechanism or filling recoil cylinder, gun is to be retracted and released to allow counter recoil if possible. In performing this test, valve-turning mechanism must be disconnected and valve turned to correspond to an elevation of carriage of 53° before gun is retracted. Gun must not be held out of battery more than 10 seconds before being released.

Variable recoil is obtained by varying the area of effective throttling holes in the recoil valve. An arm on the trunnion cap is connected by means of connecting rod, valve-turning arm, valve-turning gear, and a piston-rod gear, to the piston rod itself. As the gun is elevated the relation of the cylinder to

the trunnion changes, causing the piston rod to turn by means of the valve-turning mechanism. Slots in the piston engage lands in the valve, causing the valve to turn with the piston. As the cylinder remains stationary the location of the lands inside of the cylinder change with relation to the three rows of holes in the valve, and these rows of holes are covered to produce variations in the length of recoil. At long recoil all the rows are uncovered; at intermediate recoil one row is uncovered; and at short recoil two rows are uncovered. The setting of the valve in degrees elevation is shown by the scale on the piston-rod sleeve and index mark on the edge of the piston-rod bracket bushing at the top of the piston rod.

The top carriage carries trunnions of the spring cylinders and rests on pintle bearing. The top carriage bears on the circular bronze slides in upper part of pintle bearing and is centered on the bronze pintle collar of the pintle bearing.

The pintle bearing carries the top carriage, the equalizing pinions and the equalizing gear, and is supported by the axle arms, which are shrunk in the arms of the pintle bearing. Axle arms bear in the wheels.

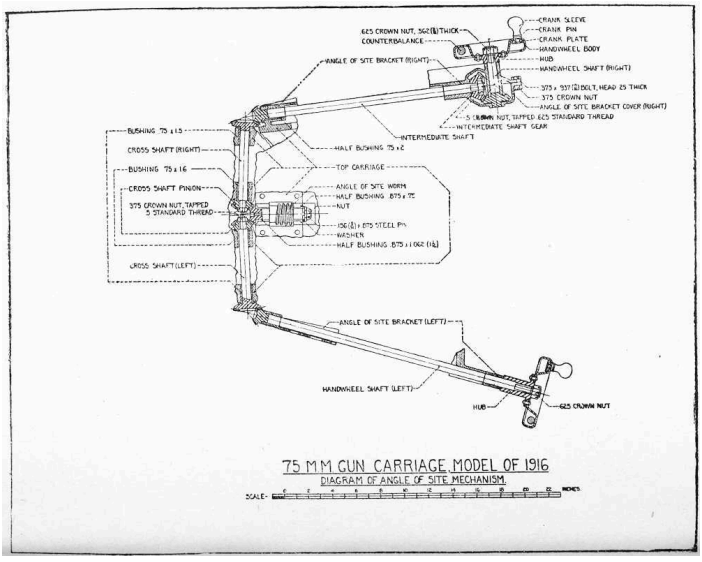
The object of the **equalizing gear** is to increase the stability of the carriage in firing when the wheels are at different elevations. Equalizing gear is an H-section with bevel tooth sector on each end and bronze-bushed bearing in the center. It bears over the vertical journal below the pintle bearing and is held in place by equalizing-gear support screwed inside the journal. Vertical deflection is prevented by the equalizing-gear bolts which are fixed to the pintle bearing by means of nut and shoulder, pass

through slots in equalizing gear, and support gear on bolt heads. Equalizing pinions are bevel pinions sectors, bronze bushed, bearing over the arms of the pintle bearing, and have the lugs for trail connection bolts. Pinions are held in place by locking rings screwed over axle arms and are free to revolve about the pintle bearing arms.

Equalizing pinions mesh with equalizing gear.

When the carriage is laid with wheels at different elevations, it is more unstable than when wheels are level. If fired under this condition, the force of recoil tends to overturn the carriage. The function of the equalizing gear is to overcome this tendency. When carriage is fired, firing stresses are transmitted to trails, and the side on which the smaller stress is exerted tends to rise. This motion is transmitted through equalizing pinion and equalizing gear to equalizing pinion on other side, applying downward force on this trail and preserving the stability of carriage.

The angle of site mechanism is designed to give the gun a maximum depression of about 6° and a maximum elevation of 11°, independent of the elevating mechanism. The mechanism is operated by two handwheels, one on each side of gun.



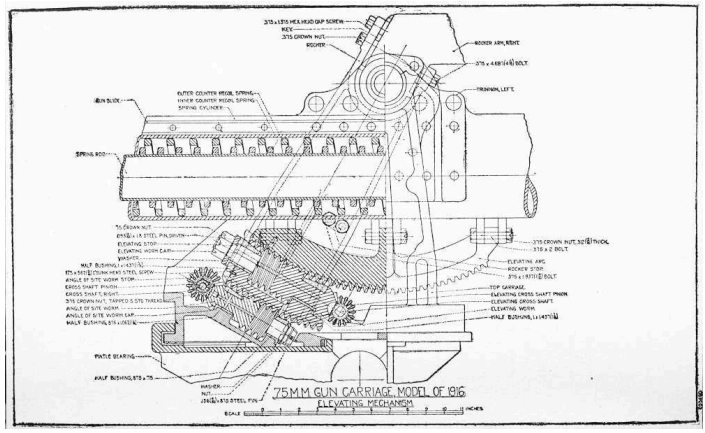
75 MM GUN CARRIAGE MODEL OF 1916.
DIAGRAM OF ANGLE OF SITE MECHANISM.

Handwheel on right side operates through bevel gear on handwheel shaft and intermediate shaft, both mounted in angle of site bracket, right, and cross shaft mounted in bronze bushings in top carriage. Handwheel on left side operates through bevel gears on handwheel shaft, mounted in angle of site bracket, left, and cross shaft mounted in bronze bushings in top carriage. Bevel gears on ends of both cross shafts mesh with bevel gear on angle of site worm, which is mounted in bushings in top carriage and held in place by angle of site-worm caps. This worm meshes with teeth cut in rocker.

Rocker is a U-shaped piece with bearings at the tops of both arms and teeth cut in bottom of U. The bearings bear over and are free to revolve about trunnions on cradle independent of trunnion bearing

in top of carriage. Top half of right bearing is formed by rocker arm, right, which extends back and carries angle of site scale, pointer, rack, and level and forms a bearing for elevating handwheel shaft. Rear of rocker arm, right, is braced by rocker arm brace, a diagonal hollow rod attached to rocker arm and rocker. Top half of left bearing is formed by rocker arm, left, a diagonal arm extending upward to the rear to form a support for sight. Movement of the angle of site mechanism is limited in elevation by the rocker stop bolted to the side of the rocker and in depression by a screw in the arc.

The elevating mechanism is designed to allow an elevation of the gun of 42° independent of the angle of site mechanism. The mechanism is operated by one handwheel on the right side of carriage, which is turned in a clockwise direction to elevate gun.



75 MM GUN CARRIAGE, MODEL OF 1916.
ELEVATING MECHANISM.

The elevating mechanism is operated through bevel gears on elevating handwheel shaft mounted

on a rocker arm, right, elevating intermediate shaft inside rocker-arm brace, elevating cross shaft, mounted in an elevating cross-shaft bearing bolted to the rocker, and the elevating worm, which bears inside lower part of the rocker. The elevating worm meshes with the elevating arc, which is bolted to the bottom of the spring cylinder.

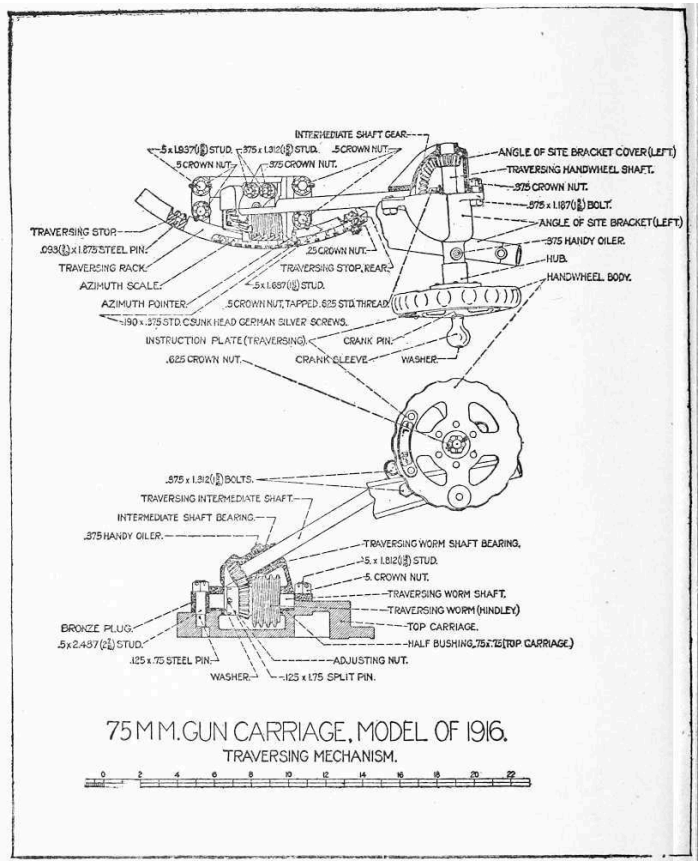
In indirect fire the angle of site in mils is laid off on the angle of site scale with the pointer and the desired range of graduation brought opposite the pointer by means of the elevating handwheel.

Operation of the Angle of Site and Elevating Mechanism. The angle of site mechanism is operated by turning handwheel, the movement of which is transmitted through the shafts and gears to the angle of site worm meshing with the rocker. Movement of the rocker is transmitted directly through the elevating worm, elevating arc, and spring cylinder to the gun, and through the rocker arms to the elevating mechanism, gun, cradle, and sights. The elevating mechanism moves only gun and cradle through movement of handwheel shafts, and the elevating worm inside the rocker, which meshes with the elevating arc.

The angle of site scale is graduated in mils from 170 to 500. The range scale is graduated in meters. The zero setting of the gun is with O on the range scale opposite 300 on the angle of site scale and the level bubble on the rocker arm, right, at the center of the tube. This allows the maximum depression of 7 degrees (about 130 mils) or the maximum elevation of 11° of angle of site mechanism to be read on the angle of site scale against the zero of the range scale.

The sight, model of 1916, which acts as a support for the panoramic or peep sight, is attached to the

rocker arm, left.



75 MM. GUN CARRIAGE, MODEL OF 1916.
TRAVERSING MECHANISM.

In direct fire, the axle of the bore is brought on the line of site by operating the angle of site handwheel until the cross hairs of the sight are on the target and the range is laid off independently by bringing the desired range graduation opposite 300 on the angle of site scale. Line of site may be set independent of

the range, as there are two angle of site handwheels.

Traversing Mechanism. The total traverse of the gun on the carriage is 800 mils. The traversing handwheel is located on the left side of the carriage and turns in a clockwise direction for left traverse.

The traversing handwheel shaft is mounted in the angle of site bracket, left, and the angle of site bracket cover, left. A bevel pinion on upper end of the shaft meshes with bevel gear on traversing shaft, which bears in angle of site bracket, cover, left and intermediate shaft bearing bolted to top carriage. A bevel pinion at lower end of the intermediate shaft meshes with bevel gear on end of traversing-worm shaft, which is mounted in bearing in top carriage. Traversing worm meshes with traversing rack which is screwed to pintle bearing. Traversing stops are filister head screws between end teeth of traversing racks to limit movement of worm in rack.

The movement of handwheel is transmitted through shafts and bevel gears to worm and rack. Rack is mounted in pintle bearing, which remains stationary, and top carriage moves about its bearing in center of pintle bearing and bronze-lined slides around the outside of pintle bearing. Traversing scale is screwed to pintle bearing above rack, and pointer is formed on traversing worm-shaft bearing.

DISMOUNTING AND ASSEMBLING CARRIAGE.

Note.—The first and most important precaution to be observed in assembling guns and carriages is that all parts must be clean.

Where dismounting but not assembling operation

is described, assembling is approximately the reverse of dismounting.

I. To remove recoil cylinder.
II. To disassemble recoil cylinder.
III. To assemble recoil cylinder.
IV. To dismount gun.
V. To remove counter-recoil spring.
VI. To remove breechblock.
VII. To replace piston rod, gland pkg.
VIII. To remove wheel.
IX. To remove shields.
X. To remove spring cylinder.
XI. To remove sight.
XII. To remove rocker and rocker arms.
XIII. To remove top carriage.
XIV. To remove equalizing gear and pinions.
XV. To remove brake mechanism.
XVI. To remove trails.

I. To Remove Recoil Cylinder.

1. Remove valve turning gear cover (take out four ⅜" bolts attaching it to the piston rod bracket).

2. Remove valve turning gear, valve turning arm and connecting-rod as a unit by removing split pin, nut, and connecting rod pin from trunnion cap, right.

3. Remove piston rod (remove lash wire and two $^{3}/_{16}$" split pins) slide piston rod gear forward and

remove.

4. Remove ¼” locking screw from top of piston rod bracket.

5. Remove $^{3}/_{16}$” cylinder retainer screw and loosen cylinder retainer, but do not remove retainer.

6. Remove brass spring-rod plugs from rear ends of both spring rods.

7. Screw spring compressor eye into rear of left spring rod. Make loop in compressor and attach double sheave close to cradle. Attach single sheave to lunette by means of loose cord of sheave rope.

8. Man pulling rope with from four to six men, retract gun not less than 10”, and secure rope to lunette.

9. Remove cylinder retainer, slide cylinder forward until free of groove in gun and remove cylinder. Handle carefully.

10. Allow gun to return to battery slowly by slacking off on pull rope.

II. To Disassemble Recoil Cylinder.

Note.—The interior parts of recoil cylinder are made with great accuracy to insure proper operation and must be handled with care to avoid injury.

1. Remove recoil cylinder from carriage. (See I.)

2. Drain recoil cylinder by resting on blocks at front and rear, removing both filling plugs and drain plug, and tipping rear end up to allow all oil to flow out of drain-plug hole.

3. Unscrew buffer-rod nut from rear cylinder head,

draw out buffer rod until wrench can be applied on flats, and remove nut. Push rod back into cylinder.

4. Remove lower split pin from gland lock, swing gland lock back until free of notches in gland, and loosen gland with gland wrench. Unscrew front cylinder head with special wrench. Threads may be started by striking handle of wrench with soft hammer. Do not hold cylinder in a vise.

5. Draw out piston rod slowly, supporting it at both ends as it leaves cylinder. Hold recoil valve in cylinder with ends of fingers. Keep receptacle under front of cylinder to catch surplus oil.

6. Drain surplus oil from piston rod by holding vertically over receptacle with piston down and holding buffer rod in place.

7. Rest piston rod on blocks, remove buffer-bushing locking screw, and unscrew buffer bushing, holding piston rod by wrench on flats at front end of rod. Have supporting blocks under both ends of rod so that rod will not be strained.

8. Draw out buffer rod carefully.

9. Draw out recoil valve with fingers. Remaining parts can now be easily disassembled. Buffer head is locked in place with bronze pin, which must be driven out before head can be unscrewed.

III. To Assemble Recoil Cylinder.

This operation is the reverse of II. Be sure that all gaskets and locking screws and pins are replaced and are in good condition. Be sure that all parts of mechanism are perfectly clean and dry, and that oil is clean. Oil must be strained through double

thickness of clean cloth and if clean oil is not available use new oil. Do not make piston-rod gland too tight. Tighten with hand and screw up with wrench one additional notch to lock gland. Fill recoil cylinder before replacing on carriage, as follows:

(a) With drain plug in place and filling plugs out, pour hydroline oil into filling hole slowly to avoid the formation of air bubbles.

(b) When oil is level in filling-plug openings, tilt cylinder slightly to allow escape of air and replenish oil.

(c) Loosen filling plug in front end of piston rod enough to allow oil to drip, and tighten plug.

(d) Replace rear filling plug, raise front of cylinder about 6 inches, and tap cylinder lightly with wood block or lead hammer to remove air. Level cylinder, fill, and replace front filling plug. Be sure that all gaskets are in place and properly centered.

Note.—After recoil mechanism has been disassembled and replaced on carriage gun should be retracted 46 inches and eased back into battery slowly to be sure that it is properly reassembled.

IV. To Dismount Gun.

1. Remove recoil cylinder (see I) and breechblock (see VI).

2. Raise and block up trails in horizontal position, elevate gun until axis of bore is parallel with trails, and attach retracting mechanism (see I-7) to left spring rod, retract gun about 6 inches, remove 3-16-inch split pin in left spring-rod key, and drive out key with bronze drift. Ease gun into battery slowly

and permit further forward movement of spring rod until rope is slack and front end of spring-rod rests against spring cylinder cover.

3. Transfer retracting apparatus to right spring-rod, retract gun about ¼ inch, remove split pin and spring-rod key, ease gun into battery until spring-rod rests against spring-cylinder cover, and detach retracting mechanism.

Note.—In this position full pressure of springs is against cylinder cover and gun is free to slide in ways. Men should be kept from in front of spring-cylinder and care must be exercised to prevent tipping of cradle to the rear, which may cause gun to slide off.

4. Bring gun to maximum depression.

5. Lower trails to ground, spread trails against wheels, set brake, and bring gun to zero elevation.

6. Requires seven men and four pick handles or implements of almost the same length and strength. Slide gun about 36 inches to the rear by hand, place one pick handle in bore of gun at breech with one man, one pick handle with a man on each side under gun slides at front of cradle, and four men with two pick handles under gun as gun is drawn out.

7. Push gun out of ways, supported by men, and remove.

Note.—In using pick handles do not place them under dust guards at gun lugs. Care must be taken to keep gun properly supported at same level as cradle guides at all points until free of guides.

In remounting gun on cradle be sure that ways are well oiled and ways and slides thoroughly clean. Mounting gun is the reverse of IV.

V. To Remove Counter-recoil Springs.

1. Close and latch trails. (Open spring-cylinder cover.)

2. Set brake and drive one spade (to secure carriage).

3. Remove breechblock (see VI.)

4. Attach spring-compressor to right spring rod (see I-7).

5. Secure single block of retracting apparatus to fixed point, such as “dead man,” driven spade, or tree. The holding power of this fixed point must be at least equivalent to a driven spade and attaching point of rope should not be higher than center of spring rod.

Note.—Sufficient slack of rope must be allowed to permit spring compressor to travel full length of spring cylinder and be detached from spring rod at front end.

6. Retract gun about 6 inches, remove split pin in spring-rod key and drive out spring-rod key with bronze drift.

7. Release retracting mechanism gradually until spring compressor rope is slack, draw spring rod out of front end of spring cylinder, and detach spring compressor.

8. Attach retracting mechanism to spring rod, right.

9. Retract spring rod about ½ inch, remove split pin, and drive out spring-rod key.

10. Release retracting mechanism gradually until spring compressor rope is slack, draw spring rod out

of front end of spring-cylinder and detach spring compressor.

Note.—Assembly of counter-recoil springs is reverse of removal. The following precautions must be observed in assembling:

(a) If tension-spring compressor brings spring rod up solid against spring cylinder bushing in rear of spring cylinder, ease off rope slightly and pry up rod with bronze drift until it will enter the bushing.

(b) Before key slot enters gun lug see that keyways in spring-rods and keyways in gun lugs are in line. If not, turn spring-rod by means of drift until keyways are in line.

VI. To Remove Breechblock.

1. Remove operating-shaft detent, slide operating handle to the right as far as the chain will permit, remove 1-16 inch split pin from studlink pin.

2. Remove chain, piston rod, spring piston, piston-rod nut, and locknut as a unit by drawing out of closing-spring case.

3. Remove closing spring from case.

Note.—For complete instructions regarding disassembly of the breech mechanism see page 19.

4. Remove trigger-shaft detent split pin and trigger-shaft detent by drawing it out of the breechblock to the right.

5. Remove trigger shaft by prying gently straight down with screw driver or similar tool. Keep breechblock supported for all succeeding operations.

6. Remove operating handle by sliding to the right

and off operating shaft.

7. Remove operating shaft by sliding to the left.

8. Raise breechblock as far as possible (about 3-8 inch), move bottom part of operating arm to the rear, and remove operating arm.

9. Remove breechblock by sliding down free of breech ring.

10. Remove extractors by sliding toward center line of gun.

VII. To Replace Piston Rod Gland Packing.

(Packing, 4 rings, 5-16-inch square Garlock hydraulic packing.)

(Gun in battery or cylinder removed.)

1. Remove lower split pin from gland lock, swing gland lock up out of notch in gland.

2. Unscrew gland with special wrench and slide forward on rod.

3. Remove packing with bent wire.

4. Insert five rings of new packing, one ring at a time, and push each ring home with packing tool of copper or hardwood to fit into gland recess. Break joints in rings and tap packing tool lightly with hammer to drive each ring of packing home.

5. Screw up gland by hand and not more than three additional notches with wrench so that gland lock will catch and replace split pin.

Note.—For the first few rounds after inserting new packing there will be some leakage at gland and occasional tightening will be necessary. Gland should

not be screwed up tight with a wrench, as it can be made sufficiently tight by hand to prevent leakage if properly packed.

VIII. To Remove Wheel.

1. Raise and support carriage under equalizing gear near each end (about 12” each side of center.)

2. Disengage hubcap latch; unscrew and remove hubcap.

3. Disengage wheel fastening plunger and remove wheel fastening.

4. Remove wheel.

IX. To Remove Shields.

A. Top shield.—1. Remove four ⅜” pins, two ⅜” locking pins, and lift off shield.

B. Apron.—1. Remove four ⅜” hinge pins and remove apron.

C. Cradle Shield.—1. Remove two $^{3}/_{32}$” split pins, nuts and bolts. On carriages number 625 to number 678 inclusive, remove two cradle shield extensions.

D. Main Shield, left.—1. Remove six ½” bolts from shield bracket outer left. 2. Remove three ⅜” bolts from shield socket, inner left. 3. Lift off shield.

Main Shield, right—1. Remove right wheel (see VII). 2. Remove ½” pin from brake band end, remove adjusting nut and force (by hand) brake band out of position, to clear main shield, right. 3. Remove four ½” bolts from shield bracket, outer right, and two ½” bolts from brake lever bracket. Remove two $^{2}/_{16}$” bolts from tool and remove tool carrier. Remove

three ⅜” bolts from shield bracket, inner right. 4. Lift out shield.

X. To Remove Spring Cylinder.

1. Remove recoil cylinder (I), gun (IV), counter recoil springs (V), sight (XI) and shields (IX).

2. Remove trunnion caps (right and left) by raking out four split pins, loosening swing bolt nuts, and withdrawing ½” trunnion cap pins.

3. Remove rocker stops (right and left) by taking out four split pins and ⅜” bolts.

4. Unlatch and spread trails.

Note.—Seven men and four pick handles (or similar implements) are required for succeeding operations.

5. Post two men with one pick handle at rear, two men with one pick handle immediately in front of elevating arc, and two men with one pick handle at front end of spring cylinder.

6. Raise cradle slowly, slightly to the rear until rocker clears top carriage. Carry to the rear sufficiently to rest middle pick handle in trunnions and transfer two men with handle to rear of carriage. Continue to the rear sufficiently to rest front pick handle in trunnions, transfer men to rear, and remove spring cylinder.

XI. To Remove Sight.

1. Remove three ⅜” bolts from rocker arm, left.

2. Remove one ⅜” pin from sight lever in left trunnion.

3. Remove sight and sight link.

XII. To Remove Rocker and Rocker Arms.

1. Remove spring cylinder (see X).

2. Remove two $^{3}/_{32}$" split pins, with ⅜" nuts and bolts, two ⅜" cap screws with lock washers, four ⅛" screws, driving out four O.247" by O.34" by O.872" keys from rocker arms, right and left.

3. Remove rocker arm, left, by sliding up and out of rocker.

4. Remove cross-shaft bearing cover by taking out three $^{3}/_{32}$" split pins and removing three $^{3}/_{16}$" nuts.

5. Drive out ⅛" pin from intermediate shaft pinion, remove two ⅛" split pins, two ½" nuts, one ⅛" split pin, and one ½" cap screw from rocker-arm cap and remove rocker-arm cap.

6. Lift out elevating handwheel and handwheel shaft as a unit.

7. Draw intermediate shaft up and out of rocker-arm brace, draw rocker down from trunnions (keeping in line with rocker-arm bearings) and remove. Swing rocker arm, right, up and around trunnions until free of range-scale bracket and remove.

XIII. To Remove Top Carriage.

1. Remove spring cylinder (see X) rocker and rocker arms (see XII).

2. Remove angle of site bracket, left, by removing three split pins and nuts from ⅜" bolts in angle of site bracket cover, left, taking off cover, removing

nut and split pin from traversing handwheel shaft, removing handwheel and drawing shaft out to the left.

3. Remove two split pins and ¼" nuts from cross shaft pinion case (left) bolts, extract bolts, and remove case.

4. Remove cross shaft pinion case, right, as in XIII-3.

5. Remove split pins and two nuts from cross shafts, right and left.

6. Remove split pins and nuts from four ½" studs securing angle of site bracket, left, and remove bracket with attached parts as a unit.

7. Remove angle of site bracket, right, as in XII-5.

8. Draw out cross shafts, right and left, and remove cross shaft pinions, right and left.

9. Traverse top carriage to the right (by turning intermediate shaft gear by hand) sufficiently to allow traversing stop, rear to be removed. Extract split pin, remove nut, and take off traversing stop, rear.

10. Traverse top carriage to the left until traversing worm is disengaged from rack, remove split pins and nuts from four studs securing traversing worm shaft bearing to top carriage, and remove bearing and attached parts as a unit.

11. Lift out traversing worm with attached parts as a unit.

12. Turn top carriage to the right 90 degrees from zero azimuth, remove three screws that attach traversing rack to pintle bearing and remove traversing rack.

13. Turn top carriage to the right 90 degrees (180 degrees from zero azimuth), remove four screws that attach dust guard to pintle bearing and remove dust guard.

14. Remove two screws that secure clip to pintle bearing and take off clip.

15. Raise top carriage from pintle bearing.

XIV. To Remove Equalizing Gear and Pinions.

1. Remove top carriage (see XIII), wheels (see VIII), brake mechanism (see XV) and trails (see XVI).

2. Turn pintle bearing bottom side up, remove 29 screws which attach washers and binders and remove equalizing-gear cover.

3. Remove split pins and nuts from both locking ring-clamp bolts, unscrew and remove rings (one right, one left).

4. Slide equalizing pinion off axle arms.

5. Remove split pins from right equalizing-gear bolts, hold nuts tight, unscrew and remove bolt, remove nut and washer, remove left equalizing-gear bolt, nut, and washer in the same manner.

6. Remove locking screw and equalizing-gear support (using special wrench). Lift up and remove equalizing gear.

XV. To Remove Brake Mechanism.

1. Remove wheels (see VIII).

2. Remove brake bands, right and left, by

extracting four split pins and removing four brake pins from ends of brake shaft.

3. Remove one split pin from each type “A” pin securing brake lever, foot to brake lever bracket and to sleeve extension. Remove type “A” pins and brake lever.

4. Extract two split pins from brake lever sleeve near center of carriage, draw out and remove brake shaft, left.

5. Remove shield bracket, outer right, brake shaft, right and brake lever sleeve with all permanent parts attached, by removing main shield (see IX, D and E), removing split pin and nut from brakehanger bolt, taking out bolt, and sliding parts off axle arm.

6. Remove shield bracket, outer left, by removing split-pin, nut, and brake hanger bolt and sliding brake hanger with permanent parts attached, off axle arm.

XVI. To Remove Trails.

1. Support carriage at front of pintle bearing.

2. Remove two split pins and nuts from connection bolts, drive out bolts with copper drift, slide trails to the rear and remove.

GENERAL INSTRUCTIONS.

Filling Recoil Cylinder (Cylinder Mounted on Carriage.)

If the recoil cylinder is not completely filled, loss of stability will occur and there is danger of serious

damage to material. Before firing, a commissioned officer should always verify the filling of cylinder by removing one filling plug (with gun level) in which case oil should be visible above recoil valve.

To fill recoil cylinder when assembled to carriage, elevate the gun about five degrees, remove both filling plugs and pour Hydroline oil in slowly with funnel until oil appears at rear filling plug hole. Level gun and again fill until oil appears at both filling holes. Shake carriage gently and continue to refill slowly until air ceases to come out of cylinder. Replace rear plug, elevate gun about five degrees, remove valve turn-gear cover, and loosen plug in end of piston rod sufficiently to allow oil to drip out. As soon as oil starts to drip, tighten plug; be sure that gasket is centered. Replace rear filling plug, rock carriage to permit air to escape from filling hole and fill with oil. Replace plug, level gun, and perform same operation with rear filling hole. When air is all out of cylinder, tighten both plugs and elevate to five degrees, allow to stand for about five minutes, then remove front plug and again refill. Loosen drain plug and drain out about ¼-gill of oil into receptacle. Do not allow oil to run down into gun slides.

About four quarts of Hydroline oil is required to fill recoil cylinder. Oil must be clean and free from dirt and should be strained through clean linen or muslin cloth before using.

In emergencies glycerin and water, or any buffer or engine oils may be used in recoil cylinders, but should be replaced by Hydroline as soon as possible. Where the above liquids are used, all interior parts of recoil mechanism must be emptied, disassembled, thoroughly cleaned and dried before refilling.

CHAPTER VIII
75-MM FIELD GUN MODEL 1917 (BRITISH).

Weights and Dimensions.

Weight	995 lbs.
Caliber	2.95 in.
Total length	88.21 in.
Length of bore	83.915 in.
Length of rifled portion	72.72 in.

Rifling 24 grooves, right hand twist, zero turns at the origin to 1 turn in 75 in. (25.4 calibers) at 9.72 in. from the muzzle thence uniform.

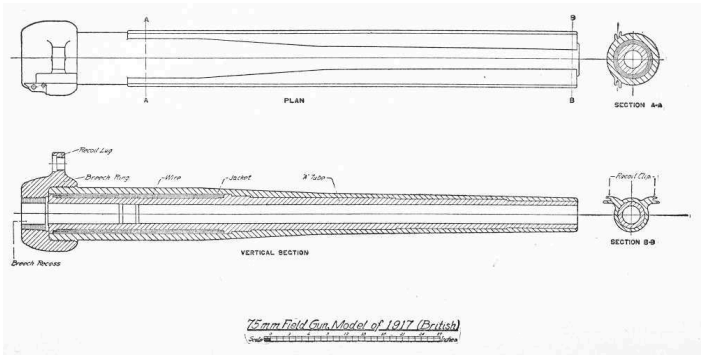
The Carriage.

Weight of carriage, complete	1950 lbs.
Weight of gun and carriage complete	2945 lbs.
Weight at end of trail carriage limbered	96 lbs.
Diameter of wheels	56 in.
Width of track	60 in.
Length of recoil	49 in.
Maximum angle of elevation	16 degrees
Maximum angle of depression	5 degrees

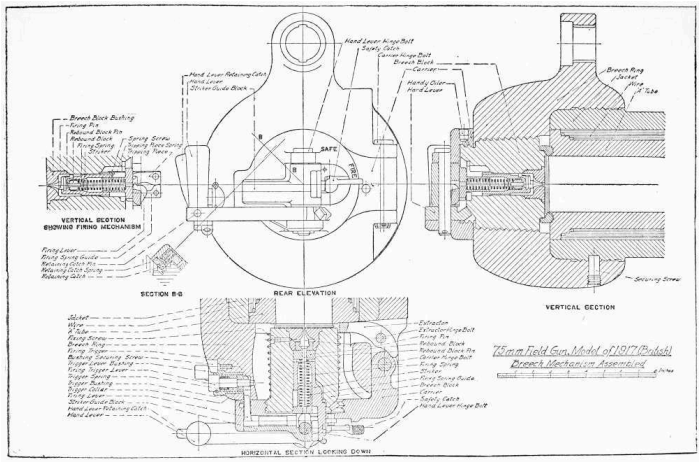
Maximum amount of traverse of gun on the carriage 142 mils

DESCRIPTION.

The gun is a combination of a built up and a wire wrapped gun. It consists of a tube, a series of layers of steel wire, jacket and breech ring. The tube extends from the rear end of the chamber to the muzzle. Over the rear portion of the tube are wound 15 layers of O.04 by O.25" steel wire. The jacket is fitted over the wire and the tube, and is secured longitudinally by corresponding shoulders and the breech ring, which is screwed over the jacket at the rear, and secured by a set screw. The breech ring is prepared for the reception of the breech mechanism, and is provided on the upper side with a lug for the attachment of the hydraulic buffer.



75 mm. Field Gun, Model of 1917 (British).



75 mm Field Gun, Model of 1917 (*British*)
Breech Mechanism Assembled

The breechblock is of the swinging type, interrupted screw with two threaded and two slotted sectors instead of the four we are familiar with in the 3”. The firing mechanism is of the continuous pull type.

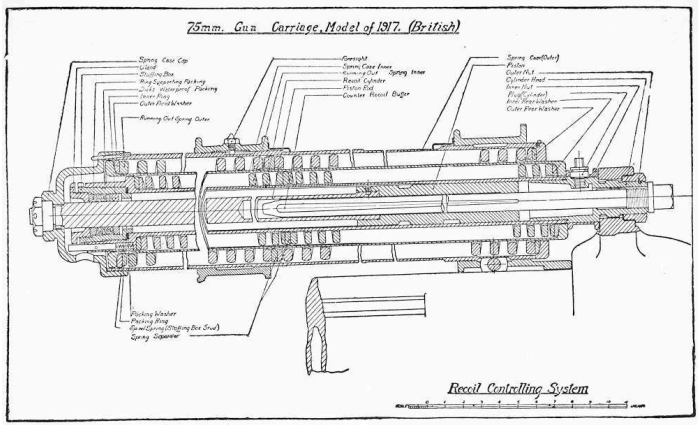
The ammunition used is similar to that used with the American and French types of 75s.

The Principal Parts of the Carriage are:
Trail
Top Carriage
Cradle
Recoil cylinder
Springs
Elevating gear
Range gear
Traversing gear
Firing Mechanism
Brakes
Shield

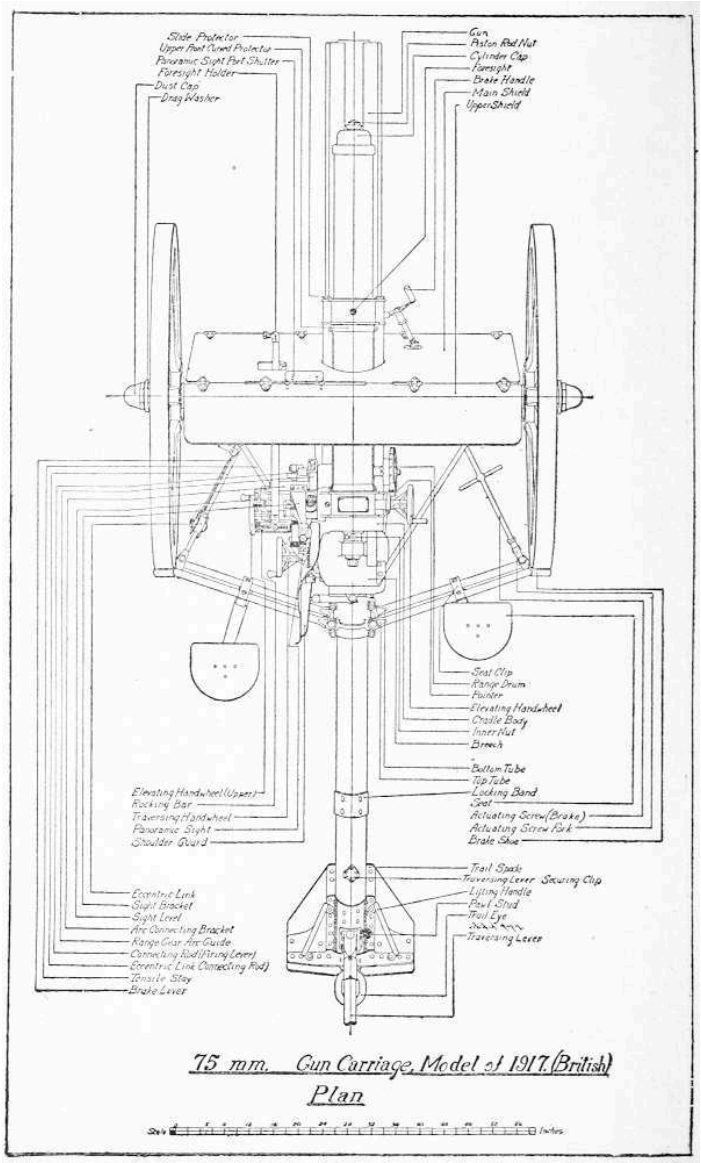
Axle and wheels
Sights
Gravity tank

The trail is tubular. The top carriage houses bearings to receive the cradle trunnions and in travel it is locked to the trail. The bronze cradle pivots on the top carriage. The cradle trunnions support the sight.

The recoil system is of the hydraulic-spring type. The recoil cylinder is surrounded by the counter-recoil springs which in turn are enclosed by a steel case—all of which is screwed on top of the cradle above the gun. The system operates in the same manner as the 3” materiel with the exception that it possesses the additional feature of a gravity tank which replaces oil lost during firing.



75-mm. Gun Carriage, Model of 1917. (British)
Recoil Controlling System



75 mm. Gun Carriage, Model of 1917. (British)
Plan

The elevating mechanism is of the doubled-ended screw type with the independent angle of site. The gears are so arranged that the elevation for range can be made without disturbing the laying for difference in elevation of the gun and the target, that is, the line of sight. The handwheel on the right is for range to the target while the handwheel on the left is for the angle of site.

The traversing mechanism is of the pintle type, consisting of a crosshead, link nut, and an actuating screw with a handwheel. It permits of a 72 mil. traverse either side of the center. A scale strip and a pointer indicate the angle of traverse.

The firing mechanism like that of the American 75 is located on the left side of the gun instead of the right side as on the 3” and the French 75. The gun can be fired when it is within 2 inches of the “in battery” position, which increases the possible speed of firing.

CHAPTER IX
THE 4.7” RIFLE, MODEL 1906.

GUN.

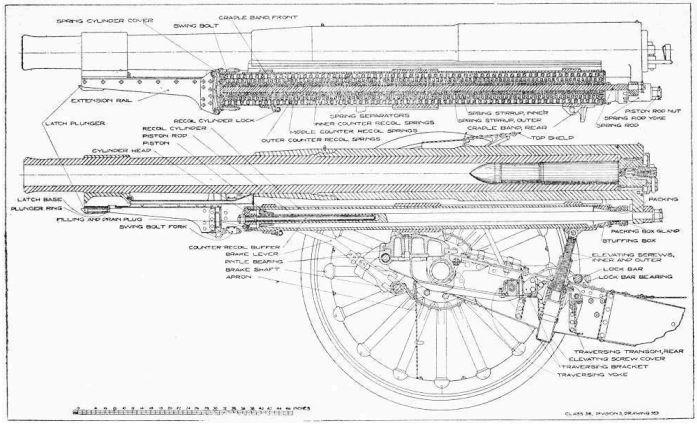
Weights and Dimensions.

Weight	2,688 lb.
Caliber	4.7 in.
Total length	134.92 in.
Length of bore	129.42 in.
Length of rifling	111.9 in.
Number of grooves	42
Twist	Right hand.
Weight of proj. based fuse	60 lb.
Weight of proj. point fuse	45 lb.
Weight of powder charge	95 oz.
Muzzle velocity, 60 lb. proj.	1,700 ft. per second
Muzzle velocity, 45 lb. proj.	2,050 ft. per second
Maximum range	11,000 meters

THE CARRIAGE.

Weight of carriage complete	5,320 pounds
Weight of carriage and gun complete	8,068 pounds
Maximum elevation	15 degrees
Maximum depression	5 degrees
Maximum traverse	140 mils.

The gun is built up and consists of a tube, jacket, locking hoop and clip. The jacket covers the rear half of the tube and projects beyond the tube at the rear to form the breech recess. The jacket also has a recoil lug on the under side for connecting the recoil cylinder. The clip is a short hoop near the muzzle and has guides formed on it to guide the gun in the cradle on recoil. The length of the gun is approximately 11 feet.



4.7” Rifle

The breechblock is of the interrupted screw type having four threaded and four plain sectors. It is operated by a handle which swings from left to right turning and withdrawing the breech with one motion. An extractor is fitted for throwing out the shell case when the breech is opened after firing.

The firing mechanism is of the type known as a continuous pull mechanism, that is, the mechanism is cocked and fired by the pull on the lanyard or by downward pressure on the firing handle located at the right side of the breech.

The recoil system is of the hydro-spring type.

The two parallel steel tubes (the spring cylinders) are fitted into a frame surmounted by heavy steel rails which form the gun slides thus forming the cradle. The recoil cylinder is fitted between these two.

The recoil and counter-recoil piston rods are attached to the gun lug and recoil with the gun, while the spring cylinders and recoil cylinder remain stationary.

The recoil is constant, being 70 inches for all elevations. The recoil cylinder uses hydroline oil as the buffer medium. Throttling is obtained by three throttling bars running lengthwise of the cylinder which are of varying height to give a throttling effect with corresponding slots in the recoil piston. A counter-recoil buffer is fitted in the piston rod to take up the shock when the springs return the gun into battery.

The trunnions on the cradle are mounted in bearings formed by a yoke which swivels in a pintle bearing provided at the front of the trail.

Traverse is obtained by means of a handwheel and screw mounted on the left side of the trail which swings the yoke in traverse carrying the gun with it. A traverse of 70 mils on each side of center is possible.

The piece is elevated by a double screw type of mechanism. The upper end is attached to the cradle and so raises and lowers it. The screw is operated thru gearing by two handwheels one on each side of the trail from 5° elevation dep. to 15° elevation.

The trail is of the solid type made up of flasks of channel section. It has housings for the axle and carries the pintle bearing in which the top carriage or yoke swings. A tool box is provided in the trail. A seat is provided on each side of the trail for the cannoneers. The lunette transom is fitted about 27 inches from the rear of the trail and carries a bearing that fits the limber pintle.

A trail prop is provided for supporting the trail when limbering.

The spade can be released and folded up on the trail when traveling.

A traveling lock is provided on the trail for locking the gun when traveling. The piston rod and spring rods must be disconnected before the gun can be drawn back far enough to lock.

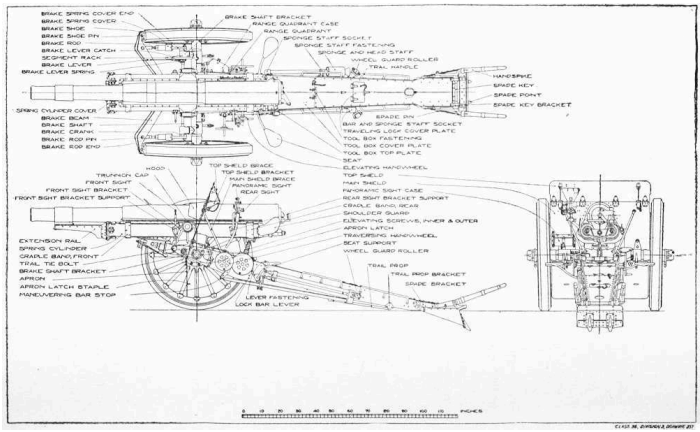
The wheels are 61 × 6 inch with rubber tires and band brakes. Some older vehicles have steel tires and are fitted with tire brakes.

An armor plate *shield* is fitted to the carriage for the protection of the personnel.

The instruments for sighting and laying the piece included a line sight, a rear sight, a front sight, a

panoramic sight and a range quadrant.

The line sight consists of a conical point as a front sight and a V notch as a rear sight. These are located on the Jacket of the gun, and are useful for giving a general direction to the gun.



4.7” Rifle

The sighting is similar to the 3”, 1902.

The rear sight and front sight are used for direct aiming. The rear sight is a peep sight mounted on a range scale quadrant by a bracket on right side of the cradle. The front sight is a pair of cross wires mounted in a ring attached by a bracket on the cradle about 3 ft. ahead of the rear sight.

The range scale quadrant has a socket in which the Standard U. S. Panoramic sight may be mounted.

For indirect fire the gunner on the left of the carriage lays for direction only.

On the right side of the cradle is mounted the Range Quadrant which has in combination with it the Angle of Site Mechanism. For indirect fire the gunner on the right of the piece lays for range with this instrument.

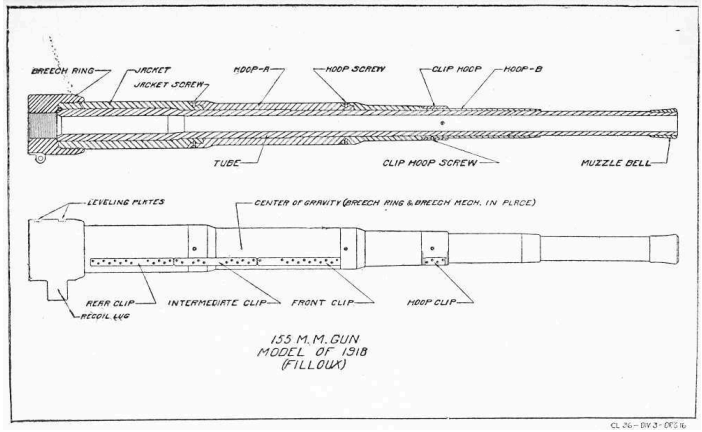
Fixed ammunition is used with this gun. Shrapnel and high explosive shell are used. The base fuzed steel shell and the shrapnel weigh 60 lbs. The point fuzed steel shell weighs 45 lbs. Gas shell are also issued identical with the 45 lb. steel shell.

CHAPTER X
THE 155-MM FILLOUX GUN.

WEIGHTS, DIMENSIONS, ETC.

Weight of Gun including breech mechanism	8,795 lbs.
Length	232.87 inches.
Caliber	155-mm (6.1042 inches.)
Muzzle velocity	2,380 ft.-sec.
Rifling, one turn in 2.989. Caliber, right hand uniform.	
Weight of projectile	95 lbs.
Maximum range	16,200 meters.
Weight of maximum powder charge	25¼ lbs.
Weight of carriage	11,065 lbs.
Weight of gun and carriage, complete	19,860 lbs.
Diameter of wheels	1,160mm.
Width of track	2,250 mm.
Height of axis of gun	1,482 mm.
Elevation	0 to 35 degrees.
Maximum traverse	60 degrees.
Weight of limber complete	3,190 lbs.
Weight of gun carriage and limber	23,050 lbs.

The distance from center line of carriage axle to center line of limber axle, approximately	4,500 mm.



155 M.M. GUN MODEL OF 1918 (FILLOUX)

The gun is of the built-up type and consists of the tube strengthened by the following jackets and hoops beginning at the breech end: The breech ring, the jacket, the hoop A, the hoop B, the clip hoop, the clip hoop set on the hoop B and the muzzle bell. The length of the gun from the muzzle to the breech base is approximately 18½ feet.

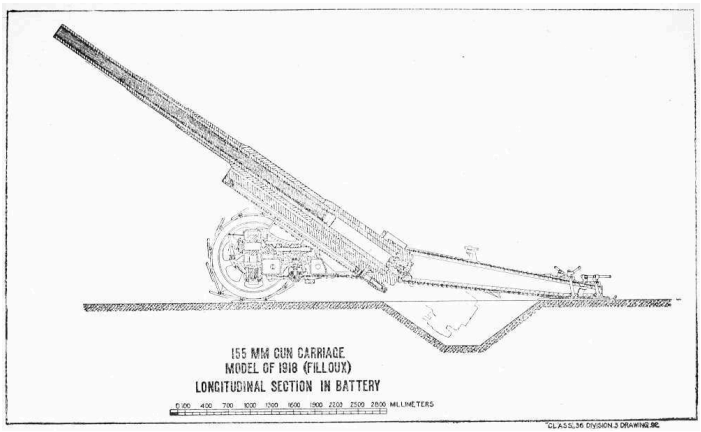
A recoil lug on the underside of the breech ring provides means of attaching the recoil and recuperator rods. Hinge lugs for the breech are also formed on the breech ring. Bronze clips to serve as guides in the cradle are screwed to the sides of the jackets.

The breechblock is of the interrupted screw type, having four plain and four threaded sectors. The breech mechanism is of the plastic obturator type,

having the forward mushroom-shaped head of the breechblock equipped with the asbestos ring, known as the obturator pad. Upon firing, this ring is compressed and acts as a gas check to prevent the leakage of powder gases back through the breech. It has sufficient resiliency to resume its original form after firing. The firing mechanism is of the French percussion primer type which is described under “155-mm Schneider howitzer” and is interchangeable with the guns enumerated therein.

The cradle is a steel forging pivoted by trunnions in the trunnion bearings of the top carriage. It is bored with three parallel cylinders for housing the recoil and recuperator mechanism. On its upper side are slots for the gun slides and the elevating rack is bolted to the lower side.

The recoil mechanism is of the hydro-pneumatic variable recoil type. The larger of the three cylindrical bores in the cradle block contains the recoil mechanism; the two smaller ones, the parts of the recuperator mechanism.



155 MM GUN CARRIAGE MODEL OF 1918 (FILLOUX)

LONGITUDINAL SECTION IN BATTERY

The recoil mechanism consists of a piston and piston rod and a counter rod. The piston rod is connected to the breech lug and, therefore, recoils with the gun. Grooves of variable depth are milled along the length of the counter rod, controlling the flow of oil through the ports of the piston during the recoil. This counter rod assembles within the bore of the piston rod. It does not move longitudinally, but rotates. The amount of this rotation changes the area of the orifices through which the oil can pass. Its rotation is accomplished as the gun is elevated by means of an arm and gear sectors in such a manner as to shorten the recoil as the gun elevates.

A replenisher or gravity tank is provided in connection with the recoil cylinder which assures the recoil cylinder being full at all times and also takes care of any expansion of the oil due to heating. Its capacity is about 17 quarts.

The recuperator mechanism consists of two connected cylinders, one containing the piston and piston rod which are attached to the breech lug, while the other contains a mushroom valve and a diaphragm. The diaphragm separates the oil contained in the first cylinder and part of the second cylinder from the high pressure air which compels the return of the gun into battery after recoil. Normally a small amount of oil must be between the valve and diaphragm. Oleonapth is the liquid used in this recoil mechanism. The amount of oil in the recoil and recuperator mechanism is shown by an indicator so that it can always be seen whether or not they need filling.

The top carriage is a large steel casting mounted on the bottom carriage on which it pivots to traverse the piece.

The handwheels and mechanism for both elevating and traversing, are mounted on the top carriage. The tipping parts are carried on the trunnions of the top carriage.

Belleville Springs carry the weight of the gun when traversing, but on firing the springs compress and the firing stresses are taken on the bearing surfaces between the top and bottom carriages.

The bottom carriage is a large steel casting suspended from the axle (in traveling position) by a heavy multiple leaf spring. It supports the top carriage, houses the axle and provides hinge connections for the trail. When firing the axle is unshackled from the left spring and the bottom carriage bears directly on the axle.

Traversing is accomplished by turning the top carriage which pivots on the bottom carriage. This is done by means of a rack and train of gears which are operated by the handwheel on the left side of the carriage. A traverse of 60 degrees, 30 degrees right and 30 degrees left, is possible.

Elevating is accomplished by a rack on the cradle operated through gears by the handwheel located on the gear box at the left of the top carriage. Elevations from 0 degrees to 35 degrees can be obtained.

The trail is of the split type and consists of steel plate beams of box section. Locks are pivoted at the forward end of the trails for securing them in the open position. When closed together they are clamped and attached to the limber. A traveling lock is provided on the trail for retaining the gun in

retracted position.

Two types of spade are pivoted, one for soft and one for hard ground. When traveling the spades are always removed from the trail.

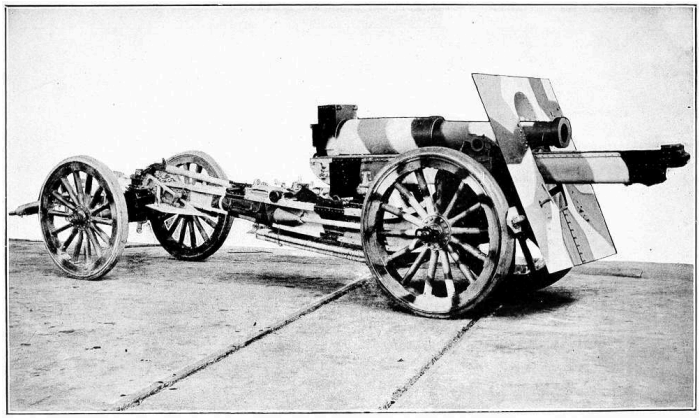
The wheels are of cast steel, each wheel having two solid rubber tires.

Wheel shoes for traveling over soft ground are provided, which assemble over the rubber tires. They consist of twelve plates for each wheel which give a broad bearing surface under the wheel. The wheels are equipped with band brakes.

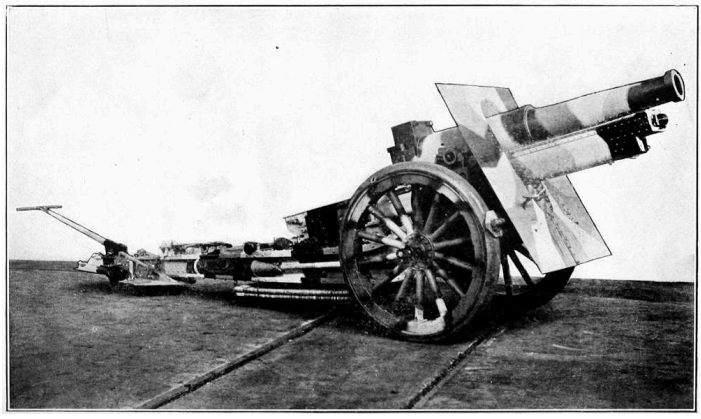
The sighting equipment is exactly the same as that described with the 155-mm Schneider howitzer.

The ammunition used is of the separate loading type. Either shrapnel or high explosive steel shell is used, as well as gas shells and other special ammunition. The projectile weighs 95 lbs. The propelling charge of smokeless powder is a sectionalized charge made up of two sections; a base charge and one smaller increment. The weight of the charge is 25 lbs.

The fuzes commonly used are the 31 sec. combination fuse for use with shrapnel and combining time and percussion elements: the point detonating fuse Mark IV used with the steel high explosive shell and the mark III point detonating fuze used with gas shell.



155-MM. HOWITZER CARRIAGE, MODEL OF 1918 (SCHNEIDER).
TRAVELING POSITION.



155-MM. HOWITZER CARRIAGE, MODEL OF 1918 (SCHNEIDER).
RIGHT SIDE VIEW.

CHAPTER XI
THE 155 HOWITZER, MODEL 1918

THE HOWITZER.

Weights and Dimensions.

Material	Alloy steel.
Weight (including breech mechanism)	1,248 kg.—2,745 lbs.
Caliber	155-mm.—6.1 inch.
Total length	2,332-mm.—91.8 inch.
Length of bore	2,177-mm.—85.7 inch.
Length of rifled portion of bore	737-mm.—68.4 inch.
Rifling	
Number of grooves	48.
Width of grooves	7.145-mm.—0.2813 inch.
Depth of grooves	1-mm.—0.03937 inch.
Width of lands	3-mm.—0.1181 inch.
Twist, right hand, uniform, one turn in 25.586 cal.	

Powder chamber:	
Diameter	158.75-mm.—6.25 inch.
Length	339.85-mm.—13.38 inch.
Volume	6,965.75 cu. in.—425 cu. in.
Obturation	Pad.
Firing mechanism	Percussion.

General Description.

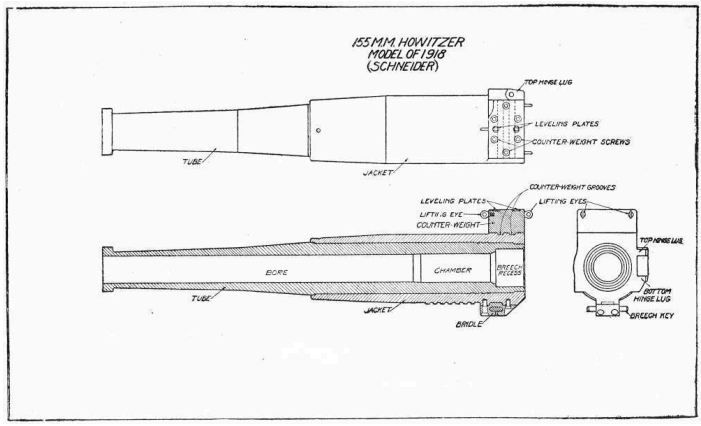
The 155-mm howitzer, Model of 1918 (Schneider) is of the hydro-pneumatic long recoil type, which may be used for direct fire, but was specially designed for siege fire. On account of its high trajectory it is able to direct shells on targets inaccessible to standard 6-inch howitzers of limited elevation.

This howitzer has given satisfactory results in service and has proven to be more superior than guns of similar caliber. It has a muzzle velocity of 1,480 foot-seconds and attains a maximum range of 12,600 yards, the projectile weighing about 95 pounds.

A maximum rate of fire of four or five rounds per minute may be attained, but heating as well as difficulty of preparing and transporting the ammunition by the gun crew renders such rate impossible for more than a few minutes. However, the normal rate of fire is two per minute and may be loaded at any degree of elevation.

The howitzer is mounted on a sleigh and rigidly secured by means of a breech key and the holding down band. The sleigh contains the recoil and recuperator mechanisms which permits long recoil and insures stability at low elevations. When the gun is fired the sleigh recoils on bronze slides on the cradle, which is a U-shaped steel plate and rests in the trunnion bearings of the trail.

This howitzer may be elevated from 0 degrees to 42 degrees by means of the elevating mechanism. The traverse is 52.2 mils right and left, the carriage sliding on the axle and pivoting on the spade, which prevents the carriage recoiling when the gun is fired. The customary shield protects the gunners from flying shrapnel and fragments.



155 M.M. HOWITZER
MODEL OF 1918
(*SCHNEIDER*)

In traveling position the howitzer is retracted and locked to the cradle, the cradle locked to the trail, the spade revolved and secured to the bottom of the

trail. The lower end of trail rests on the carriage limber, which is used to carry the proportionate share of the load of the howitzer and carriage in traveling position. The limber is equipped with a connecting pole for motor traction. The carriage and limber wheels are rubber tired and considered able to negotiate any roads suitable for field artillery.

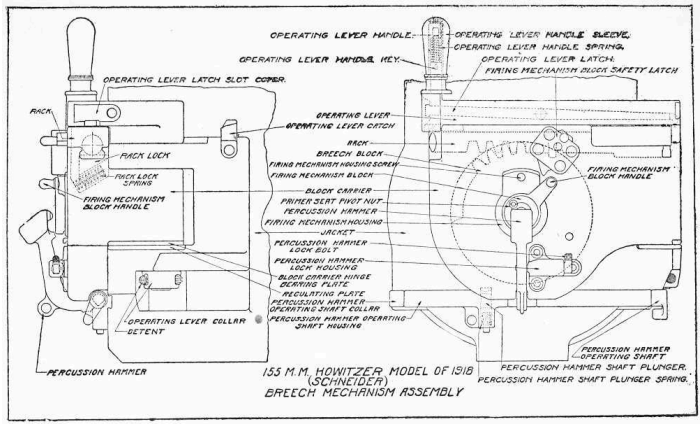
Howitzer Description.

The howitzer, consists of a tube and jacket. **The jacket** is shrunk over, approximately, the rear half of the **tube** and screwed to it by a short thread near the rear end of the tube. The rear end of the tube is prepared for the reception of the breechblock. On the right of the jacket at its rear are two lugs which receive the hinge pintle of the operation lever. A flat seat with two transverse slots is machined on the top of the jacket at the rear end for receiving the counterweight. **The counterweight** is securely fastened to the jacket by six screws, and two lugs which engage the slots in the jacket. **The bridle** is fitted to the underside of the jacket near the rear end and held in place by four screws. The breech key passes through the bridle and holds the howitzer in its seat on the sleigh. On the underside of the jacket just forward of the bridle seat are seven square threads which engage corresponding threads on the sleigh. A holding-down band which encircles the jacket at its forward end also secures the howitzer to the sleigh.

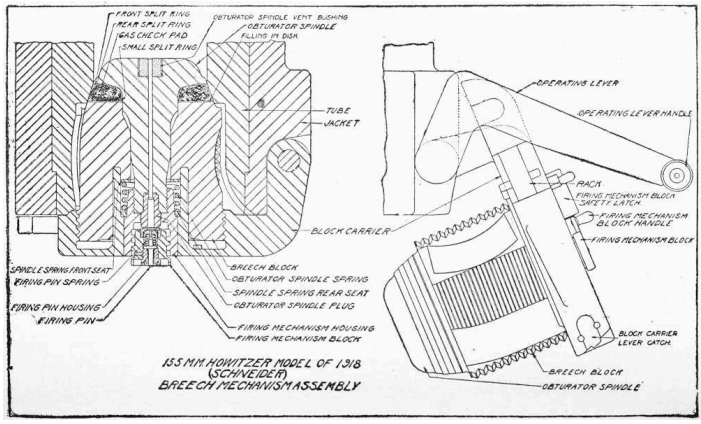
On the top surface of the counterweight are two nickel silver leveling plates.

Vertical and horizontal axis lines are cut on the breech and muzzle faces. A line showing the actual

center of gravity with the breech mechanism in place is cut on the upper side of the jacket marked C. of G. The name and model of the howitzer are stamped on the left side of the jacket just below the counterweight. The name of the manufacturer, year of manufacture, serial number of the howitzer and the weight of the howitzer, including the breech mechanism, are stamped on the muzzle face.



155 M.M. HOWITZER MODEL OF 1918
(SCHNEIDER)
BREECH MECHANISM ASSEMBLY



155 M.M. HOWITZER MODEL OF 1918
(SCHNEIDER)
BREECH MECHANISM ASSEMBLY

The breech mechanism is of the plastic obturator, interrupted screw type having four plain sectors and four threaded sectors. The block can be loaded with one-eighth of a turn. Two of the plain sectors are relieved to permit the breechblock to enter the breech recess. The breechblock is screwed into the block carrier and rides on the hub of the latter.

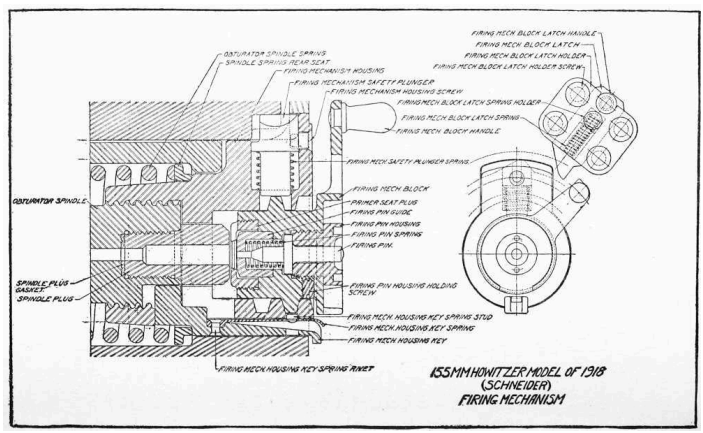
The block carrier is hinged to the right side of the jacket by means of the pintle hinge of the operating lever.

The pintle hinge is fitted at the lower end with an operating lever collar and detent. The dead weight of the breech is carried by the block carrier hinge plate.

The block is rotated by means of a rack which engages teeth cut in the upper surface of the block at its rear end. The rack is actuated by a lug on the under side of the operating lever which engages a slot in the rack. The rack is located in the inside face

of the block carrier. When the breech is tightly closed this lock bears against the breech face of the howitzer and is forced back against the rack lock spring leaving the rack free to move. As the breech starts to open the rack lock is forced up by its spring and locks the rack, preventing further rotary motion of the breechblock.

The operating lever is provided with an operating lever handle which is kept in its raised position by the operating lever handle spring. When the breech is closed and locked the lower portion of the operating lever handle engages the block carrier lever catch. When the breech is fully open the operating lever latch which extends through the operating lever, engages the operating lever catch and holds the breech in that position.



155-MM HOWITZER MODEL OF 1918
(*SCHNEIDER*)
FIRING MECHANISM

The obturator spindle is of the *mushroom head type*. It passes through the center of the breechblock and is

screwed into the front end of the firing mechanism housing, which fits into the hub of the block carrier. The obturator spindle is prevented from turning by the firing mechanism housing key spring. A vent for the passage of the primer flame is drilled through the center of the obturator spindle. The obturator spindle bushing is screwed into the front end of the obturator spindle and the obturator spindle plug into the rear end—the latter forming a chamber for the primer.

The obturator spindle spring bears against the firing mechanism housing and the breechblock, keeping the head of the obturator spindle tightly against the *gas check pad*. The gas check pad or plastic obturator is composed of a mixture of one part asbestos and three parts nonfluid oil, contained in a canvas covering. The pad is protected by the front, rear and small split rings. A steel filling-in disk is placed between the gas check pad and the breechblock.

The firing mechanism housing is provided with a firing mechanism safety plunger which is forced by the firing mechanism safety plunger spring against the inside circumference of a circular boss on the face of the breechblock. When the breechblock is rotated to its locked position, the plunger slips into a notch in the boss and permits the entrance of the firing mechanism block. When the breech is unlocked the lower end of the firing mechanism safety plunger extends into the firing mechanism housing and obstructs the entrance of the firing mechanism block. This safety device makes it impossible to unlock the breech while the firing mechanism block is in place or to insert the firing mechanism block while the breech is unlocked.

The firing mechanism block is provided with a handle, and screws into the firing mechanism housing. The primer seat plug is screwed into the front end of the firing mechanism block and is provided with a notch into which the primer is inserted. The firing pin guide is located just back of the primer seat plug and forms a guide for the firing pin as well as a bearing for the firing pin spring. The firing pin housing is screwed into the rear end of the firing mechanism block and held in place by the firing pin housing holding screw. The firing pin passes through the firing pin housing and the firing pin guide and is forced to the rear by the firing pin spring. The firing mechanism block is provided with a flange at its outer edge in which a slot is cut to receive a projection on the front of the percussion hammer. This prevents the hammer from striking the firing pin when the firing mechanism block is not screwed home. The firing mechanism block latch is located on the outer face of the block carrier and prevents the firing mechanism block from being unscrewed accidentally.

The firing mechanism block is interchangeable with the firing mechanism blocks used on the following cannon:

155-mm. gun, model of 1918 (Filloux).

8-inch howitzer, model of 1917 (Vickers Mark VI and VIII½).

240-mm. howitzer, model of 1918 (Schneider).

The percussion hammer is carried by the percussion hammer operating shaft which is journaled in the percussion hammer operating shaft housing. This housing is secured to the breech face by means of a dove tail projection which fits into a

slot, cut across the entire breech face just below the breech opening. The percussion hammer operating shaft is fitted with a lever at its right end which receives the blow of the firing mechanism striker when the lanyard is pulled. The percussion hammer shaft plunger and spring are located in the percussion hammer operating shaft housing to the left of the hammer. When the breech is open the plunger is forced up by its spring, thereby causing a projection on the plunger to engage in a recess in the operating shaft, locking the shaft so that the hammer cannot be operated. When the breech is closed the underside of the block carrier strikes on the beveled head of the shaft plunger, forcing it down and thus unlocking the mechanism.

The percussion hammer lock bolt is screwed to the face of the carrier to the left of the percussion hammer. Its function is to lock the hammer in the traveling position when the howitzer is not in use.

Operation of the Breech Mechanism. When the breech is closed and locked, the threaded portions of the breechblock mesh with the threads in the breech recess. The operating lever is held by the lower end of the operating lever handle which engages the block carrier lever catch, thus preventing any rotary motion of the breechblock at the instant of firing. The firing pin receives the blow of the percussion hammer and fires the primer. The flame passes through the vent in the obturator spindle, igniting the propelling charge. The gas pressure in the bore forces the mushroom head of the obturator spindle hard against the gas check pad causing the latter to expand and press against the walls of the chamber, forming a gas-tight joint. After the explosion the elasticity of the pad causes it to resume its former

shape, allowing the obturator to be withdrawn freely from its seat when the breech is unlocked.

To Open the Breech. After the piece has been fired, and before unlocking the breech, press back the firing mechanism block safety latch, screw out the firing mechanism block and remove the used primer. The breech can not be unlocked with the firing mechanism block in place. An attempt to do so will result in jamming of the firing mechanism safety plunger. It is therefore important that the firing mechanism block should be removed before attempting to unlock the breech.

Press down on the handle of the operating lever in order to disengage it from the block carrier lever catch. Move the lever toward the rear and then to the right. In the first part of this movement, the operating lever turns freely around the hinge pin and its lug operates the rack which turns the breechblock. The threaded parts of the breechblock are thus disengaged from the threads in the breech recess. As the rack reaches the limit of its travel, the block carrier is swung on its hinge drawing the breechblock out of the breech recess. As the block carrier leaves the breech face of the howitzer the rack lock is forced by its spring into the recess in the rack preventing any further rotary motion of the breechblock in either direction. As the breech reaches its full open position the right end of the operating lever catch engages the operating lever catch, locking the breech in open position.

In loading, care should be taken to ram the projectile home and to enter the propelling charge in such a way that the igniter of the base charge will be in contact with the mushroom head of the obturator spindle when the breech is closed.

To Close the Breech. Press down on the operating lever handle to disengage the operating lever latch from the operating lever catch and move the operating lever to the left and forward. As the block carrier comes in contact with the breech face of the howitzer, the rack lock is pushed back into its seat, freeing the rack. Further movement of the operating lever forces the rack to the left, rotating the breechblock until its threaded portions mesh with the threads in the breech recess. At the end of the movement of the operating lever, the operating lever handle engages the block carrier lever catch and fastens the breech in locked position.

Insert a new primer in the primer seat plug and replace the firing mechanism block. The firing mechanism block can not be entered until the breech is closed and locked. Any attempt to do so may cause damage to the firing mechanism safety plunger or some part of the firing mechanism.

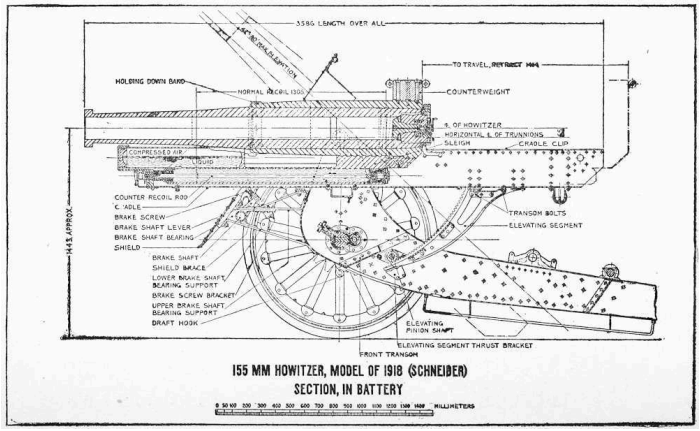
THE CARRIAGE.

For the purpose of description, the carriage is considered as composed of the following groups: *Sleigh (including recoil mechanism), cradle, trail, traveling lock, elevating mechanism, traversing mechanism, wheels, road brake, and shield.*

The sleigh contains the recoil and counter-recoil mechanism and serves as a support for the howitzer, being secured to it by the breech key and the holding-down band. The recoil counter-recoil cylinders, and two air cylinders are bored in the sleigh and form the recoil mechanism. The ends of the recoil and counter-recoil cylinders are attached to the cradle and when the howitzer is fired the

sleigh and howitzer recoil, sliding on the cradle sides.

The holding down band is anchored on either side to the front band clips, which are secured to the sleigh. Grooves are cut underneath the two top edges of the sleigh, and are lined with bronze liners, known as sleigh slides. These liners slide on the cradle clips and guide the howitzer during recoil. Five longitudinal cylinders are bored in the sleigh, the two upper cylinders running about one-third the length of the sleigh, forming air tanks and are closed at the front end by the air tank heads. The left air tank head is provided with an opening in which the gage-cock body is assembled. A pressure gage may be assembled through an adapter to this gage-cock for ascertaining the pressure in the counter recoil system. The gage-cock is also provided with a pointer which registers the quantity of liquid in the system on a scale provided on the air tank head. **The two lower cylinders extending the full length of the sleigh, form a housing for the recoil mechanism, the right cylinder being the counter-recoil cylinder and the left the recoil cylinder.** The small equalizing cylinder in the center of the sleigh, extending only a short distance, is closed at the front end with the filling valve, through which air or liquid is introduced into the system.



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
SECTION, IN BATTERY

The counter recoil cylinder is connected by a passage to the right air tank and also to the small equalizing cylinder, the latter being connected to the left air cylinder, thus maintaining equal pressure in both air cylinders and in the counter-recoil cylinder. The counter-recoil cylinder is closed at the rear end with the counter-recoil cylinder head and at the front end with the stuffing box, through which the counter-recoil rod and its piston moves. **The recoil cylinder** is closed at the rear end with the recoil cylinder head and at the front end with the recoil cylinder stuffing box, through which the recoil piston rod operates. This rod is hollow and serves as a buffer chamber for the buffer rod, which is securely screwed to the recoil cylinder head at one end, the other end carrying the counter-recoil valve. The recoil and counter-recoil rods are fitted with the piston rod nuts on the front end which engage the piston rod lock plate.

The cradle is a steel U-shaped plate reinforced by

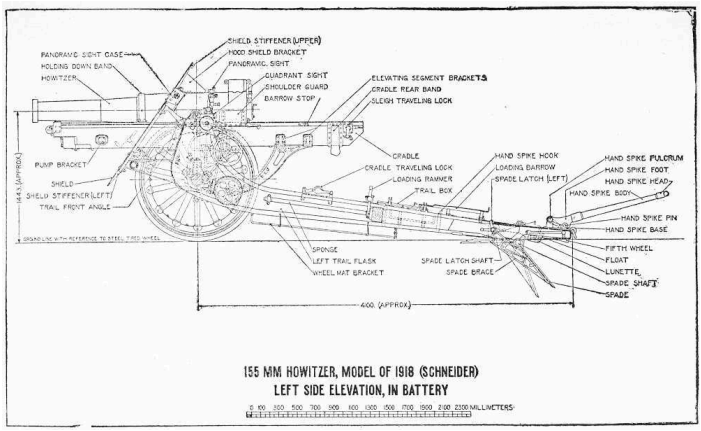
several transoms and supported by the trunnion bracket, elevating segment brackets, and in traveling position by the cradle band which engages the clips on which the howitzer recoils when in action. The sleigh traveling locks are mounted at the extreme ends of the cradle and used to lock the sleigh to cradle when the howitzer is in traveling position.

The cradle is mounted on trunnions on the carriage, and by means of elevating segments geared with the elevating mechanism may be inclined at various firing angles. When carriage is traveling the rear end of the cradle rests on the cradle traveling lock, thereby relieving the elevating mechanism of the weight of the howitzer, sleigh and cradle.

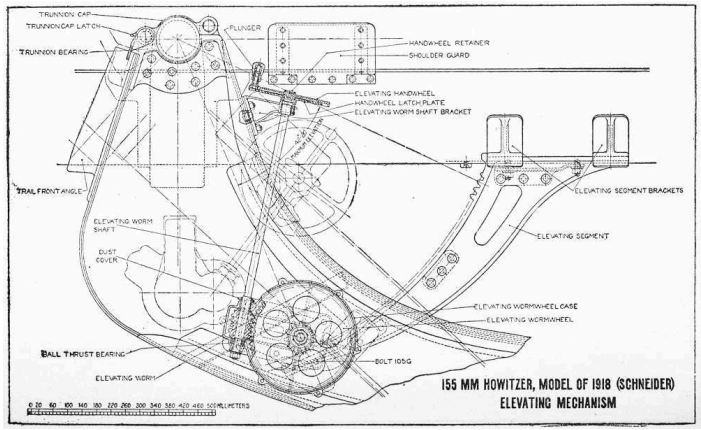
The left trunnion of the cradle is bored out to receive the sight and bracket. The shoulder guard is located on left side of the cradle just back of the trunnion bracket and protects the gunner from the recoiling parts. The firing mechanism is located on the right side of the cradle and provided with a safety device which prevents the piece from being fired when the piston rod nuts are not engaged by piston lock.

The recoil indicator is located just back of the trunnion bracket on the right side of the cradle and consists of a steel spring which is adjusted by means of a nut so that the pointer bears against a scale engraved on the edge of the sleigh indicating the length of recoil. The front end of the cradle is covered by the cradle head and provided with an opening through which the pressure-gauge adapter may be assembled to the gauge-cock body. The lower half of the front end of the cradle is closed by the front transom, forming a guide for the piston-rod lock which is operated by means of a lever. When

this lever is lowered the lock plate moves to the right, releasing the piston-rod nuts. When the lever is raised the lock moves to the left, locking the nuts in firing position. The locking device is protected by the cradle front cover which holds the lever in firing position when closed. The filling valve is accessible through the cradle bottom cover located on the bottom of the cradle to the rear of the front transom. The pump bracket is located on the left side of the cradle near the front.



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
LEFT SIDE ELEVATION, IN BATTERY



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
ELEVATING MECHANISM

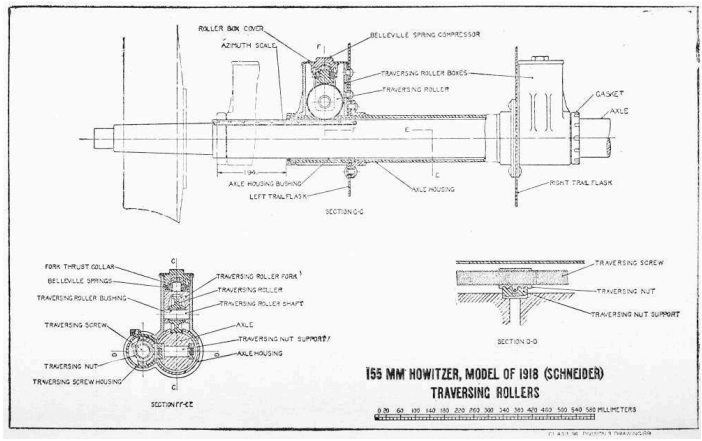
Recoil and Counter-Recoil Mechanisms. When the howitzer is fired the recoil mechanism exercises its retarding influence by means of a liquid which is obliged to pass through an orifice whose size diminishes as the movement proceeds, thus checking the recoiling mass. The recoiling movement of the gun actuates at the same time the counter-recoil mechanism, which acts on the counter-recoil liquid and forces it into two reservoirs, thus further compressing a gas therein contained. When the recoil movement is ended the expansion of gas forces the counter-recoil mechanism back “into battery,” and the recoil cylinder again exercises its retarding influence to prevent a too rapid return and shock. The normal recoil is 51.375 inches (1.305 meters).

When the piece is fired the howitzer and sleigh move to the rear, the recoil and counter-recoil rods, which are held by the piston-rod lock remaining stationary. The liquid in the counter-recoil cylinder is thus forced into the air cylinders, building up a

pressure sufficient to return the howitzer to battery. The liquid in the recoil cylinder is forced through the orifices in the recoil piston rod and then through the throttling ring. The tapered buffer rod, which is attached to the recoil cylinder head, moves through the throttling ring, gradually closing the orifice, thus keeping the pressure constant as the velocity of recoil is reduced. As the buffer rod moves to the rear the counter-recoil valve is opened, allowing the liquid to pass freely into the buffer chamber. As the gun returns to battery the buffer valve closes, forcing the liquid to pass through the small clearance around the valve, thus absorbing the energy of counter recoil.

By means of the **elevating mechanism** the howitzer, sleigh and cradle are inclined at the various firing angles, varying from zero to 42 degrees, by rotation in the trunnions of the cradle.

Two elevating segments attached to the cradle are actuated by the elevating pinion shaft operating in bearings integral with the elevating worm wheel case secured to trail. To lower end of worm shaft is fitted a worm which engages a worm wheel and pinion shaft in the gear case. On upper end of worm shaft is attached the elevating hand wheel fitted with a handle and plunger enabling the operator to lock the howitzer at any desired elevation. The motion of the handwheel is transmitted through the worm gear to the pinion shaft and thence to the elevating segments.



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
TRAVERSING ROLLERS

The handwheel is provided with a handle of a spring locking type, downward pressure on which unlocks it from the handwheel latch plate, permitting the mechanism to be operated.

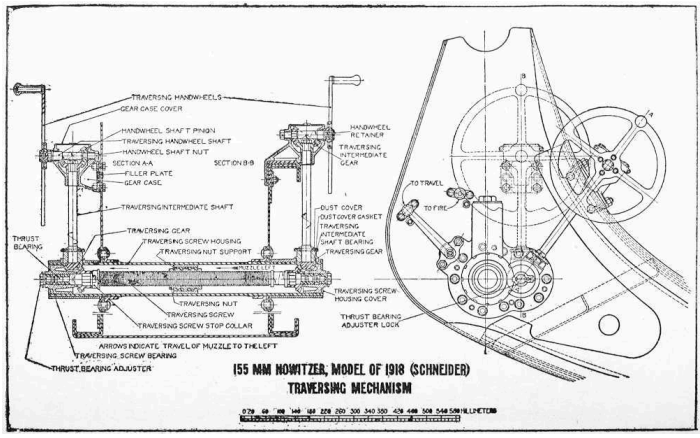
Traversing Mechanism. The traverse of the carriage is obtained by means of the traversing mechanism causing the carriage to slide on the axle, the trail pivoting on the spade. The movement is 3 degrees each side of center or a total of 105 mils.

At the center of the axle is rigidly attached a bronze traversing nut through which passes the traversing screw which may be operated from either side of the carriage by means of handwheels connected to the screw through bevel gears and shaft. The traversing screw operates in the travelling housing longitudinally and held in position by thrust bearings and thrust bearing adjusters at both ends of the screw. When either of the handwheels is operated the traversing screw is rotated and moves

to the right or left as the case may be, carrying the entire carriage which moves across the axle on traversing rollers.

In order to reduce friction during the traversing operation the carriage rests on the axle through Belleville springs and two concave faced traversing rollers mounted on roller shafts in the axle housing. When gun is fired the Belleville springs are compressed and the carriage rests on the axle through the bronze traversing roller boxes.

On top of axle projecting to the left of carriage is riveted an azimuth scale graduated in mils so that the position of the carriage on the axle may easily be seen at any time. When in traveling position the carriage should be locked to the axles by the axle traveling lock, thus relieving the traversing mechanism from unnecessary stress.



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
TRAVERSING MECHANISM

The **axle traveling lock** is a device employed to

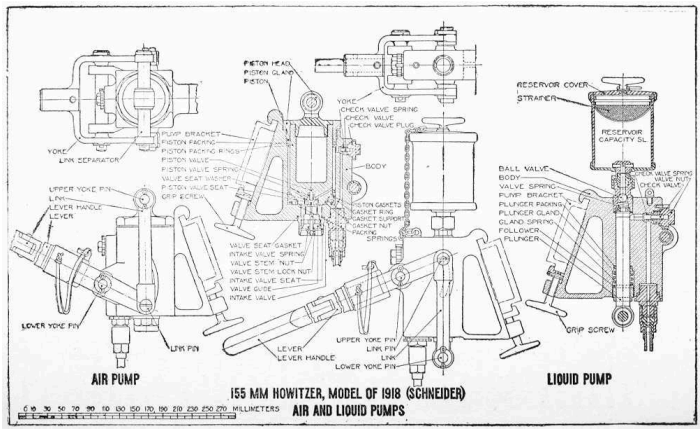
relieve the traversing mechanism from unnecessary stress when the carriage is in traveling position. When the carriage is prepared for traveling the traveling lock engages a series of square grooves cut in the center of the axle. The lock is operated by an eccentric on the end of the traveling lock shaft which is controlled by the lock lever fixed on outer end. The lock lever may be placed in two positions marked “to travel” and “to fire,” by means of its handle which is provided with a spring plunger engaging the traveling lock catch. In order to properly lock the carriage in traveling position it is necessary to traverse the carriage to the center position on the axle, thus permitting the locking device to engage the grooves cut in the center of the axle.

The air pump is furnished for the purpose of charging and maintaining the necessary pressure in the counter recoil reservoirs. When in operation it is attached to a bracket on the carriage by means of a screw clamp and connected to the reservoir by the filling pipe. The pump will operate against a pressure of 400 to 600 pounds per square inch.

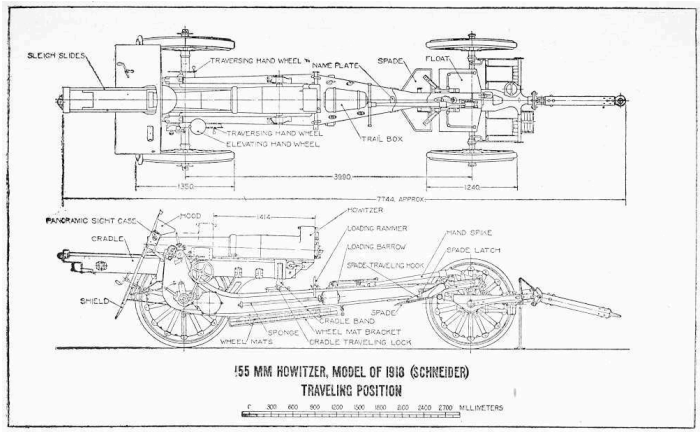
The liquid pump is a single-acting-plunger used for charging the counter-recoil system and for the purpose of replenishing losses of liquid from the cylinders. Power is applied through a hand lever connected by parallel links and a cross-beam at the lower end of the piston. The hand lever is detachable and also used in connection with the air pump. When in operation the pump is attached to a bracket on the carriage by means of a screw clamp. The filling pipe is employed to connect the liquid pump with the recuperator cylinder.

The reservoir for compressed gas is a

commercial seamless cylinder with a capacity of 2,842 cubic inches and is charged with nitrogen gas at a working pressure of 2,000 pounds per square inch (140 kilograms per square centimeter). The reservoir is provided with a needle valve and a connection for the pressure gage or filling pipe. This cylinder is used for charging the counter-recoil system and may be carried on the artillery supply truck furnished with 155-mm organizations.



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
AIR AND LIQUID PUMPS



155 MM HOWITZER, MODEL OF 1918 (SCHNEIDER)
TRAVELING POSITION

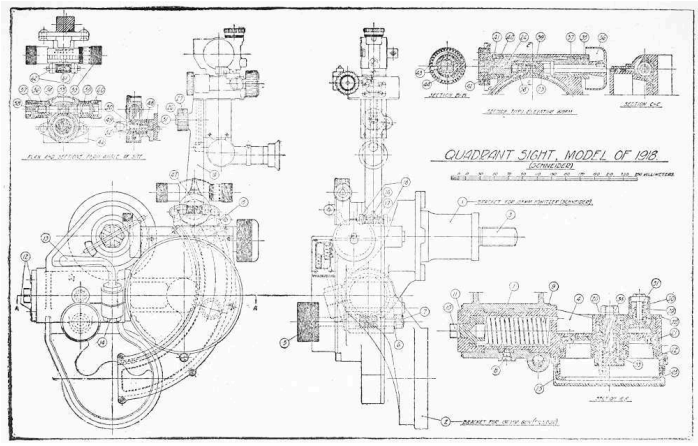
The filling pipe is used to connect the counter-recoil reservoirs with the air or liquid pump or with the compressed gas reservoir.

Pressure Gage. The gage for the compressed gas reservoir is calibrated from 0 to 150 kilograms per square centimeter. It is used to ascertain the pressure of gas in the reservoir and must be attached before screwing on the filling pipe. The gage for the pressure-gage adapter is calibrated from 0 to 60 kilograms per square centimeter, is screwed into the side of the adapter and used to test the pressure in the counter-recoil system.

The quadrant sight, model of 1918 (Schneider), is mounted on the left trunnion of the carriage, both in traveling and in action, and should not be removed by the battery mechanics. The principal features of the quadrant sight are: The cross-leveling mechanism, the elevating mechanism, and the angle of site mechanism.

The cross-leveling mechanism principally consists of the leveling worm, leveling stop, antibacklash spring, leveling clamp, and cross levels. By means of the cross-leveling mechanism the quadrant sight is adjusted to proper alignment with the bore of the howitzer.

The bracket fits into the trunnion on the left side of the carriage and is provided with four tennons which engage slots in the face of the trunnions keeping the sight in proper alignment with the bore of the howitzer. The bracket is screwed in place by the bracket bolt; the front end of the body of the quadrant sight fits into the cylindrical part of the bracket and is held in place longitudinally by four lugs.



QUADRANT SIGHT, MODEL OF 1918.
(*SCHNEIDER*)

The body of the sight is rotated by the *leveling worm* engaging the worm segment cut on the under

side of the body. The outer end of the worm is provided with a knurled hand wheel by means of which the leveling mechanism is operated. The leveling stop, secured to bracket, engages slot in the body, thus limiting the angular motion of the body in either direction. The rear end of the cylindrical part of the bracket is split and provided with a leveling clamp by means of which the body may be locked in position after it has been leveled.

The cross level is located on the rear edge of the sight shank and serves the gunner in determining the level position of the instrument. The level vial is a glass tube, closed at both ends, and partially filled with a liquid consisting of 4 per cent alcohol and 60 per cent ether, a small bubble remaining in the tube. Graduations are etched on the circumference of the tube to indicate the central position of the bubble. The vial is held in a level-vial tube, the ends being wrapped in paper and set in plaster of paris. The knurled cross-level cover fits over the holder and, together with the level-vial tube, are held in place by the cross-level caps, which close the ends of the holder. When closed, the cover serves as a protection for the vial.

The elevating mechanism consists principally of a sight shank, elevating worm wheel, antibacklash pinion, elevating worm, elevating worm eccentric, elevating scale drum, and scale drum housing.

NOTES ON CARE OF THE 155 HOWITZER.

The executive should be perfectly familiar with the working of the recoil and know when to put a gun out of action due to faulty recoil. *The length of the recoil should be such that the end of the gun slides do*

not recoil over the end of the cradle rails. In counter-recoil, the sleigh should be perceptibly slowed down at a point about 10 centimeters from the front of the cradle, and from there on should ease gently into battery without a sound or shock. Strict watch should be kept to see that no excessive leakage takes place through the stuffing boxes, the valve in the gauge adapter, or the oil hole in the cylinder end nut. Slight leakage can hardly be helped, as one of the stuffing boxes is under more than four hundred pounds of pressure per square inch when the gun is at rest, and three or four times that amount when the gun is in full recoil. However, if a pool of liquid is found after the gun has been standing all night, it is time to report the matter and have the packings replaced. The gun must be dismounted, the stuffing-box repacked, and the dermatine inspected. The dermatine packing is a compound resembling rubber, but it has the quality of resisting any chemical action that the liquid may set up in the recuperator. A worn dermatine packing may be replaced by the simple expedient of turning it wrong side out and then using it again as before. This has actually been tried and found to give good results. Another temporary repair was effected by cutting a ring from a solid truck tire and using it in the place of the dermatine, until a packing of the latter could be obtained.

The French obtain a very tight fit in their stuffing boxes by the peculiar design that allows the liquid pressure to actuate a strong spring which in turn expands the packing against the rod or cylinder wall. Leakage through the recuperator stuffing box will be noticed by the liquid coming out of the oil hole in the right-hand cylinder end nut.

In dismounting French materiel, care must be used

to replace the same nuts on the bolts from which they were taken. Threads are not standardized as to diameter; hence, trouble is likely to occur when remounting.

To dismount the tube from the recoil mechanism, or sleigh as it is denoted, a suitably strong overhead beam is selected and the carriage run beneath it. Mount two one-ton duplex blocks on the beam over either end of the tube and thread the bore with a half-inch wire cable sling, in such a manner as to leave a bight at both muzzle and breech ends. Into these loops the hooks of the block catch. Gunny sacks form a suitable packing at the muzzle and breech to prevent the cable damaging these parts of the tube. Provide several blocks of two by four or four by four stuff, to block up the sleigh as it is moved to the rear—as we shall soon see that it does. Remove the locking hoop by knocking out the retaining bolts, and also remove the cradle bolts from their housing on the cradle. This will allow the sleigh to move to the rear of the cradle. Take a strain on the blocks and carefully move the sleigh back over the trail until the recoil-lug key (locking the recoil lug to the sleigh) clears the end of the cradle. Remove the set screw from the bottom of the sleigh which locks the tapered key in place, and proceed to drive the key out with a sledge hammer and a block of wood. During this operation the rear of the sleigh must be blocked up on the trail in order to take the strain off the cradle rails. After the key is cleared, the tube may be raised by means of the two blocks, care being taken to make the lift vertical, otherwise the slots and grooves just in front of the breech will jam and be damaged. Remove the carriage and lower the tube onto blocks. The process of mounting is just the reverse of the above.

The elevating and traversing mechanisms give little trouble, if all gear cases are kept packed in grease. It is extremely important that, in laying for elevation with this piece, the final turns of the handwheel should bring the gun into correct position by raising the breech and not by lowering it. In this way all backlash is taken out of the gearing and the howitzer rests solidly for firing. The gunner may easily be taught to remember this by always having him bring the range bubble to the front of the glass and then slowly elevate the breech, bringing the bubble to him.

The traversing mechanism moves the whole carriage, including gun, along the axle, about the spade as the center of rotation. The traversing screw moves the carriage by being rotated through nut set solidly in the axle. The axle and nut are stationary and the screw moves laterally by means of the traversing handwheel. Hence, the carriage being attached to the screw, must move when the screw moves. Inasmuch as the axle is straight, it must accommodate itself to the arc of the circle described about the spade as the center. It does so by moving tangent to the arc, and consequently one end moves to the front and the other end moves to the rear, carrying the wheels with them. From this it will be seen that before attempting to traverse the piece, the brake must be “off.” The movement of the wheels may be easily seen, if a pencil line be drawn across the tire just above the brake shoe and then the piece traversed. The line will be seen either to raise or lower according to whether the piece be traversed to the right or left.

In filling the “brake” or recoil cylinder, good results have been obtained by merely leveling the

gun and filling the brake cylinder until full. Trying to pour out one hundred cubic centimeters of the liquid after the brake is full, as the French drill regulations lay down, is almost impossible; and no bad effects will be noticed provided the gun does not become excessively warm during the firing. If it should become warmed up sufficiently to affect the recoil, level the gun, unscrew filling plug to release the pressure, rescrew, and continue the fire. In using the manometer gauge, to measure the pressure and the height of the liquid in the recuperator, it will be found that the valve in gauge adapter will sometimes stick open to the extent of letting out all the air in the recuperator tanks. The only sure remedy for this is entirely to dismount the gun, remove the adapter, and replace its valve packing, which no doubt will be found to be worn and frayed, or else some foreign substance will be found to be lying between it and its seat. The gauges should be tested about once in three months by means of a standard steam gauge testing apparatus, making the appropriate transformations if the tester be graduated to pounds per square inch as most steam testers are. It will be found that the maximum steam pressures used are rather lower than these gauges read, hence only the lower readings may ordinarily be tested.

To set the pointer to the correct pressure reading, pull the pointer loose and apply a known pressure to the gauge. Set the pointer at the corresponding reading on the manometer and press it on tightly. In general, this is sufficient for practical work.

After each firing the breechblock should be entirely dismounted and each part washed in caustic soda solution and then stippled with oil before reassembling.

The wheels are made of smaller members than those that we are accustomed to see in our own materiel. It must be remembered, however, that the French designed their wheels for much better roads than ours; and, in comparison with our materiel throughout, this fact must be borne in mind. The wheels must be carefully watched, especially through the dry weather, for they tend to check and crack. Remedies are tire shrinking and soaking in water over night, followed by a thorough and careful application of linseed oil. Fast travel, as when the piece is coupled to a truck, must be avoided if the life of the carriage is to be assured.

According to the French drill of the gun squads, in going into action, the piece is first unlimbered and the trail is then laid on the ground, and the cannoneers change posts to the extent of the gunner going to his position by his sight; while the remaining cannoneers lift the trail again and set the spade. This is slow and cumbersome work. Much better results may be obtained by setting the spade at the time that the piece is unlimbered, without moving the cannoneers from their posts.

CHAPTER XII
EXPLOSIVES, AMMUNITION AND FUSES.

EXPLOSIVES.

As a matter of practical interest, explosives may be divided into three classes, namely:

(1) Progressive or **propelling explosives** called **low explosives**.

(2) Detonating or **disruptive explosives**, termed **high explosives**.

(3) **Detonators** or exploders, known as **fulminates**.

The first includes all classes of gun powders used in firearms of all kinds; the second, explosives used in shell, torpedoes, and for demolitions; the third, those explosives used to originate explosive reactions in the two first classes. Corresponding names are given to the phenomena characteristic of each class of explosives, (1) explosions proper, of low order, progressive, or combustions, (2) detonations, of high order, (3) fulminations, this last possessing exceptional brusqueness.

The explosion of low order is marked by more or less progression; the time element is involved as a controlling factor, the time required to complete the explosive reaction being large compared with that of the other forms of explosion.

The second class of explosion is of a different

nature. The explosive reaction is not limited or confined to the surfaces exposed but appears to progress in all directions throughout the mass radially from the point of initial explosion. It has been determined experimentally that the velocity of propagation of the explosive wave throughout a mass of guncotton is from 17,000 to 21,000 feet per second.

Fulmination is a class of explosion still more brusque than the last. The abruptness of their explosion and the consequent sharpness of the blow and the concentration of heat on the point of ignition constituting their efficiency as originators of explosions of the first two classes.

Methods of Exploding. Explosives may be exploded by three methods; in reality but two, by heat and by application of energy as by a blow. The heat may be applied directly by friction, by electricity and detonating cap, these two methods of applying the heat giving rise to the three practical methods above mentioned. As it is not practical to apply heat directly to the charge, small charges of special explosives are made up into primers and these are exploded in one of the ways above mentioned and so communicate the explosion to the main charge. Fulminate of mercury is one of the high explosives fulfilling the requirements and it is readily exploded by any one of the methods mentioned. It is used in all detonating caps. Primers for cannon also contain an additional charge of black powder to increase the flame. For this purpose also igniting charges of black powder are attached to the smokeless powder charges for the larger calibers.

Uses. The chief use of low or progressive explosives is as a propelling charge in guns and for

blasting where it is desired to exert a pushing effect rather than a blow. High explosives are used when it is desired to exert a high pressure and shatter the container, as in a shell, mine, etc. This class is not satisfactory as a propelling charge for the reason that its rapidity of action is so great that the pressure exerted would burst the gun before the projectile could start. Low explosives are not satisfactory shell fillers for the reason that their action is so low that the shell would break at its weakest point before all the explosives had exploded and what remained would be wasted. With a high explosive, all or most of the charge explodes before the shell can break up. The greater the rapidity of action of an explosive the finer the fragmentation of the projectile. With too rapid action the pieces are too small; with too slow action they are too large. Experience teaches the proper rapidity of action to attain the fragmentation most efficient against animate and material targets.

Propelling Charges. Up to the present time nitrocellulose powder has complied better with the requirements of a suitable, smokeless powder than any other that has been proposed and is used in our service for propelling charges in guns. The danger of manufacture is also less than that of nitroglycerine powders. Moreover the latter, which was formerly used in our service and still is in the British and some others, causes too much erosion of the tubes due to the greater heat of explosion. It has the advantage of requiring a smaller charge for the same muzzle velocity and therefore a smaller powder space and consequent lighter weight of gun.

Shell Fillers. High explosives for shell fillers. Up to the present explosive “D,” trinitrotoluol and picric acid are the principal high explosives which fulfill

the requirements as shell fillers. Explosive “D” on account of its great insensitiveness to shock is used in armor piercing projectiles and also in field gun and howitzer shell. It is detonated by a fuze. Trinitrotoluol is used in submarine mines and in general demolition work as it is much easier to explode than explosive “D.”

Table of Explosives. The following table gives a good idea of the principal explosives in use in our service and the characteristics of each:

Purpose.	High or Low.	Name.
Propelling charge in guns.	L	Nitrocellulose, smokeless powder.
Bursting charge, projectiles.	H	Picric acid, explosive “D” (powder form) Trinitrotoluol.
Blank, saluting charges.	L	Black Powder.
Re-inforce charges, primers.	L	Black Powder.
Base charge, shrapnel.	L	Black Powder.
Time trains, fuzes.	L	Black Powder.
Igniting charges, cannon.	L	Black Powder.
Charges, submarine mines.	H	Trinitrotoluol wet guncotton.
Igniting elements, fuzes and primers.	H	Fulminate of mercury, chlorate of potash (potassium chlorate).

High Explosives. The principal high explosives used as shell fillers in our service are: picric acid, explosive "D" and trinitrotoluol, or more popularly known at TNT. The picric acid and picrates used as shell fillers are secret compositions. Mellinite, essentially picric acid alone or with some other substance is used as a shell filler by the French. It is poured into the shell in a fused state and allowed to harden, thus giving a very compact charge and one easily handled. It has the disadvantage however of forming unstable compounds with the metal of the shell and great care must be exercised in coating the interior of the shell with a protective coat before pouring in the fused mellinite. Lyddite is the English equivalent of mellinite. Picric acid was also used by the Japanese or it may be a mixture of picric acid and some nitro compound. The most successful explosive of this type is explosive "D" invented by Colonel Dunn of our Ordnance Department and sometimes known as "Dunnite." It is not fusible and must be compressed for use as a shell filler, being forced into the shell by compression. This is a disadvantage as compared to mellinite as the density of loading is less and weight for weight therefore less efficient. It is little sensitive to shock and therefore not very dangerous to load even under great pressure. Trinitrotoluol is also used as a shell filler but its chief use is in demolition work and as the charge for submarine mines.

Nitrogen Compounds. It may be interesting to note that all of the principal explosives with which we have been dealing are compounds containing nitrogen. In fact the war has been fought with fixed nitrogen which explains the great interest taken in the various attempts to fix the free nitrogen of the air which is the world's great storehouse of free

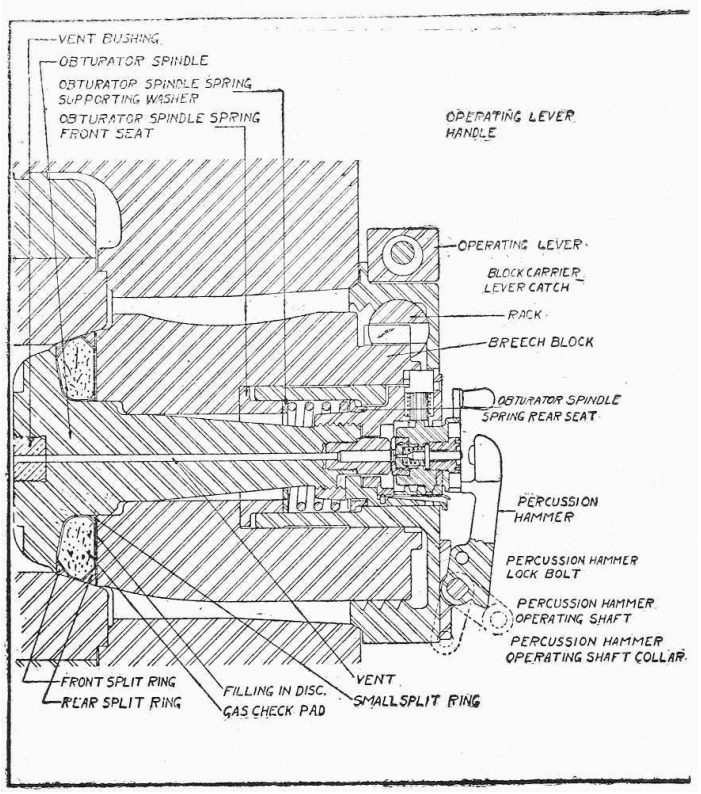
nitrogen. As nitrogen is also a necessary ingredient in the various fertilizers, the result to the world of a commercial process for speeding up the cycle of changes through which nitrogen passes in its life giving mission from free nitrogen in the air to its various compounds in the nitrogeneous animal and vegetable tissues is almost limitless and as usual war has been the incentive to speed up a process which will result in incalculable value to mankind.

Classification. Guns are loaded with three kinds of ammunition: fixed, semi-fixed and separate loading ammunition. In fixed ammunition the round is complete and projectile and powder loaded into the chamber at the same time. In semi-fixed the projectile is separate from the powder charge, which however is put up and loaded into the chamber in a container. In separate loading ammunition the powder is loaded into the chamber in bags. In the first two cases the cartridge case furnishes the means for sealing the rear of the powder chamber against escape to the rear of the powder gases. In the last case some form of obturating device is made a part of the breechblock furnishing a gas check to seal the rear of the powder chamber.

Fixed Ammunition. All of our field guns below 5 inches in calibre use fixed ammunition. The powder is placed loose in the cartridge case, the space not filled with powder being stuffed with packing paper, excelsior, or felt wadding next to the projectile so as to hold the powder in contact with the primer, in some fixed ammunition a brass diaphragm is soldered to the inside of the case for the same purpose and to keep out moisture, (4.7” Gun). An igniting charge of black powder is a part of the primer and in some cases an additional charge is

placed at the forward end of the powder space in the cartridge case to insure rapid ignition of the smokeless powder. In this case it is held in place between two quilted disks of crinoline.

Semi-fixed ammunition is employed in our 6” and 4.7” field howitzers. The cartridge case contains three weights of propelling charge for firing in the three zones designed to give a high angle of all with these weapons. Access to the charge is had by tearing off the brass diaphragm closing the forward end of the cartridge case. By removing the first charge the remaining charge is that prescribed for the second zone, and by removing the top two charges the remaining charge is that of the first zone. The three charges are tied together and the middle charge has an igniting charge of black powder attached. The removal of charges is facilitated by the separate container for the powder charge and the round is more easily handled in the two parts especially in the case of the six-inch howitzer, where the projectile weighs 120 lbs. The same primer is used as in fixed ammunition, the cartridge case performing the function of an obturator.



BREECH MECHANISM OF 155 GUN SHOWING
DE BANGE OBTURATOR.

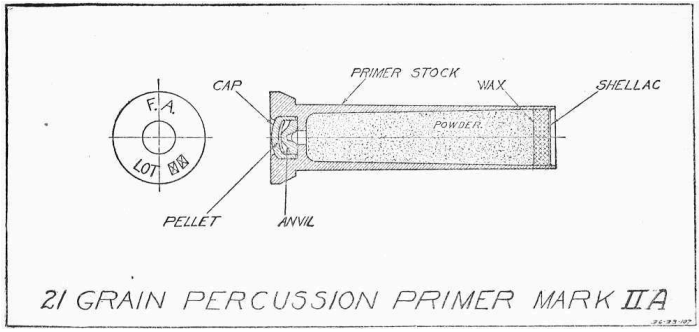
Separate Ammunition.—Obturation. The 155-mm Filloux gun and 155-mm howitzer use separate ammunition. In such guns there must be provided some form of a gas check which will prevent the powder gases from rushing to the rear into the threaded portion of the breechblock, as this would soon erode the thread sectors and render the gun useless beside losing a large amount of pressure in the bore. The device used as a gas check is called an obturator. There are two systems of obturation in

use, named after their inventors:

The DeBange and the Freyre. The former is used in the 155's. It consists of a steel mushroom head closing the rear of the powder chamber, the spindle of which passes through a central hole in the breechblock. Between the mushroom head and the face of the breechblock is a pad of asbestos, paraffine and tallow, pressed into shape by a hydraulic press and covered by canvas or asbestos wirecloth. Split rings having hardened outer surfaces are fitted, one just behind the mushroom head and one just in front of the face of the breechblock. Their diameter is slightly greater in the free state than the conical surface of the bore where they bear when the breech is closed so that they always close the rear of the powder chamber. The pressure of the powder gases forces the mushroom head to the rear and this compresses the asbestos pad which in turn forces the split rings to bear with greater force against the walls of the powder chamber thus securely closing the rear opening of the powder chamber. For more details of this device see pages 302 to 306 Tschappat's O & G.

Powder Bags. Cartridge bags for separate loading are made of raw silk, and are sewed with silk thread. Other materials are apt to produce flare-backs or premature explosions because they are not entirely consumed in the bore or continue to burn if not consumed. The raw silk however either is entirely consumed or if not, the parts ignited immediately go out as soon as the flame is removed and do not smoulder. Specially treated cotton fibre bags have been tried but so far as I know have not as yet superseded the raw silk for the purpose. The gases remaining in the bore after the discharge of a charge of smokeless powder are explosive and with air form

an explosive mixture, hence the danger upon opening the breech if any smouldering particles remain in the bore.



21 GRAIN PERCUSSION PRIMER MARK II-A

Primers. The devices for initiating explosions of propelling charges in military guns are called primers. With fixed and semi-fixed ammunition the primers are seated in the base of the cartridge case. In the case of separate loading ammunition the primers are inserted separately in the breechblock, the expanding gases of the detonated primer forcing the walls of the primer case tightly against the bore through the breechblock and thus sealing this channel of escape for the gases from the powder chamber. This necessitates a much larger and stronger case for separate loading primers than for those inserted in the base of a cartridge case.

Classes of primers. Primers are divided into three classes according to the method by which they are fired: (a) *friction primers*, (2) *electric primers*, (3) *percussion primers*. Combination primers are made which may be fired by any two of these methods, usually electric and one of the others. The

characteristics of a good primer are, certainty of action, safety in handling, no deterioration in storage, simplicity in construction and be cheap to manufacture. They are also divided into obturating and non-obturating depending upon whether they close the vent during discharge or not.

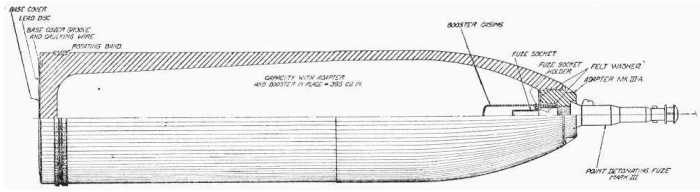
Primer pressing. Primers for fixed ammunition are inserted in the base of the cartridge cases by means of a special press for this purpose. The primer body is a trifle larger than the seat in the cartridge case provided. This seat is rough bored to a diameter less than the finished size and then mandreled to finished dimensions with a steel tapered plug. This process toughens the material of the case around the primer seat and prevents the expansion of the primer seat under pressure of the expanding gases.

Percussion primers. Except for very heavy siege guns and railroad artillery the guns handled by the Field Artillery use percussion primers. The 110-grain percussion primer is the one in use in our service and as typical will be described. The charge consisting of 110 grains of compressed black powder makes the charge burn like a torch rather than explode, which facilitates the ignition of the charge of smokeless powder, with which the flame comes in contact. The diametral holes spray the flame in several directions thus insuring ignition at many points simultaneously. The percussion element consists of a percussion primer cup, the percussion composition and an anvil, all of which are assembled together in a cup in the rear face of the primer case. The percussion composition is made up of chlorate of potash, sulphide of antimony, ground glass and sulphur. A blow upon the cap by the firing pin detonates the percussion composition and the flame from this

detonation ignites the black powder which in turn explodes the charge of smokeless powder.

The General Shape and Nomenclature of Projectiles.

The reason for the particular shape of shells may not be clear to all. In the first place all matter has the property known as inertia, which we may define as that tendency of matter to remain in a state of rest or to continue at a uniform velocity if in motion. It offers a resistance to any change in the state of either rest or motion whether of amount or direction. Consequently when we apply a sudden and tremendous force to the base of a projectile by means of the expansive force of exploding powder gases, there will be set up in the metal a resistance to this force in which every particle of the projectile will resist by an amount proportional to the mass of particles beyond the point of application of the force to itself. The actual force will be proportional to the weight and acceleration produced by the applied force in the projectile. This explains the reason why the *walls of the projectile are thicker near the base*. It also explains the method of calculating the thickness of walls, for if we know the weight at any cross section and the co-efficient of strength of the metal we may calculate the thickness of walls necessary to withstand the pressure for any given muzzle velocity which is fixed by other considerations. It explains also the preference for steel in projectiles as for the same weight the steel is much stronger making it possible to throw a greater amount of shrapnel or high explosives in shell.

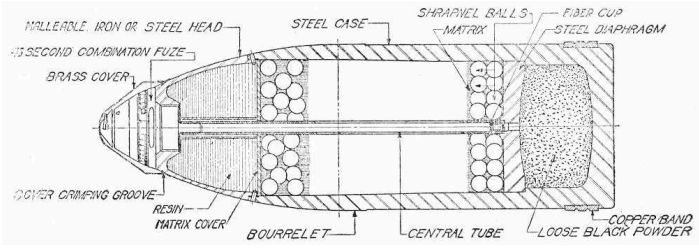


155-MM COMMON STEEL SHELL MK IV

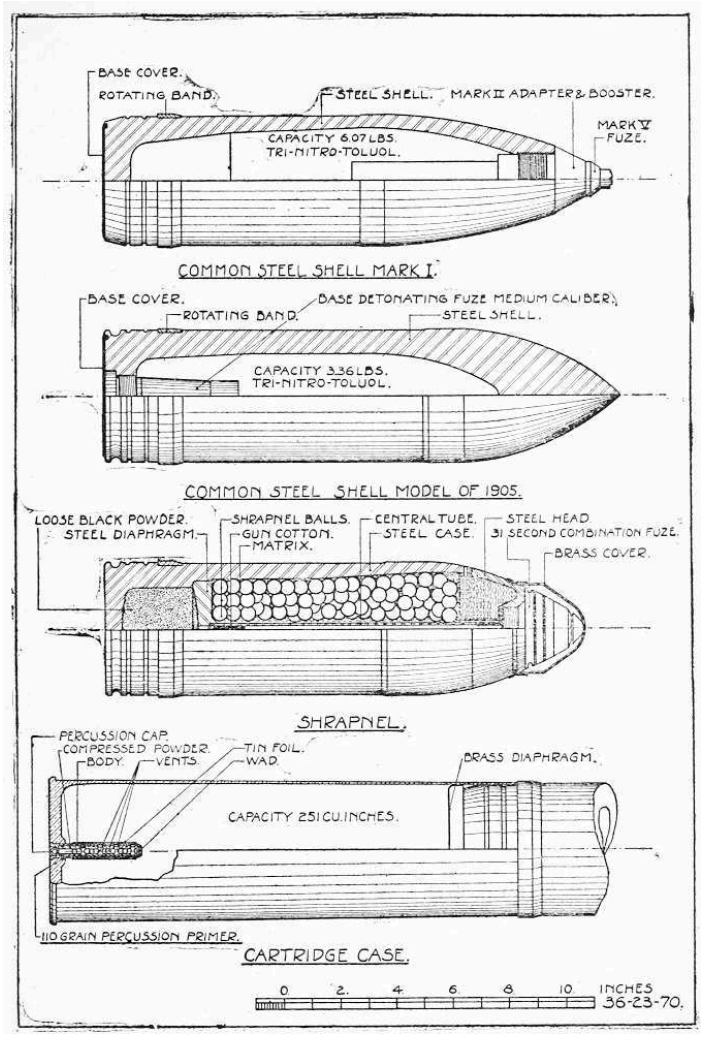
The necessity for compact loading, especially in the case of high explosive shell is also noted as otherwise the shock due to inertia would break up the charge and perhaps cause a premature explosion. Hence it is very necessary to guard against airholes in filling shell cavities.

In order to secure regular and uninterrupted movement of the projectile through the bore it is necessary that the projectile and bore have the same geometric axis. Also the projectile must be seated exactly and uniformly for succeeding rounds in its seating in the bore. This latter is necessary in order that the powder chamber may not vary as this would give irregular pressures. The liability of *strapping the rotating bands* or setting off the fuze in certain kinds of fuzes are also explained by inertia. It might even cause sufficient shock to detonate the charge in the shell. The remedy is accurate seating of each projectile by reason of trained gun crews using the same amount of force at each ramming. The first condition, coincidence of axes, is obtained by means of the ogival head which has a diameter some tenths of a millimeter smaller than the diameter of the bore, and serves as a front support for the projectile while the rotating bands center it in rear. Were it not for the bell the projectile, held only by the soft material of the rotating band, would wabble in its travel through the bore and tumble soon after leaving it. It

is also necessary that the center of gravity of the projectile be on its geometric axis. Otherwise it will travel on a spiral of the same pitch as the grooves and knock the tube walls as it travels through the bore and without the support of the bell might cause a premature explosion by actuating the fuze.



155M/M SHRAPNEL—95 LBS.—MARK-I.



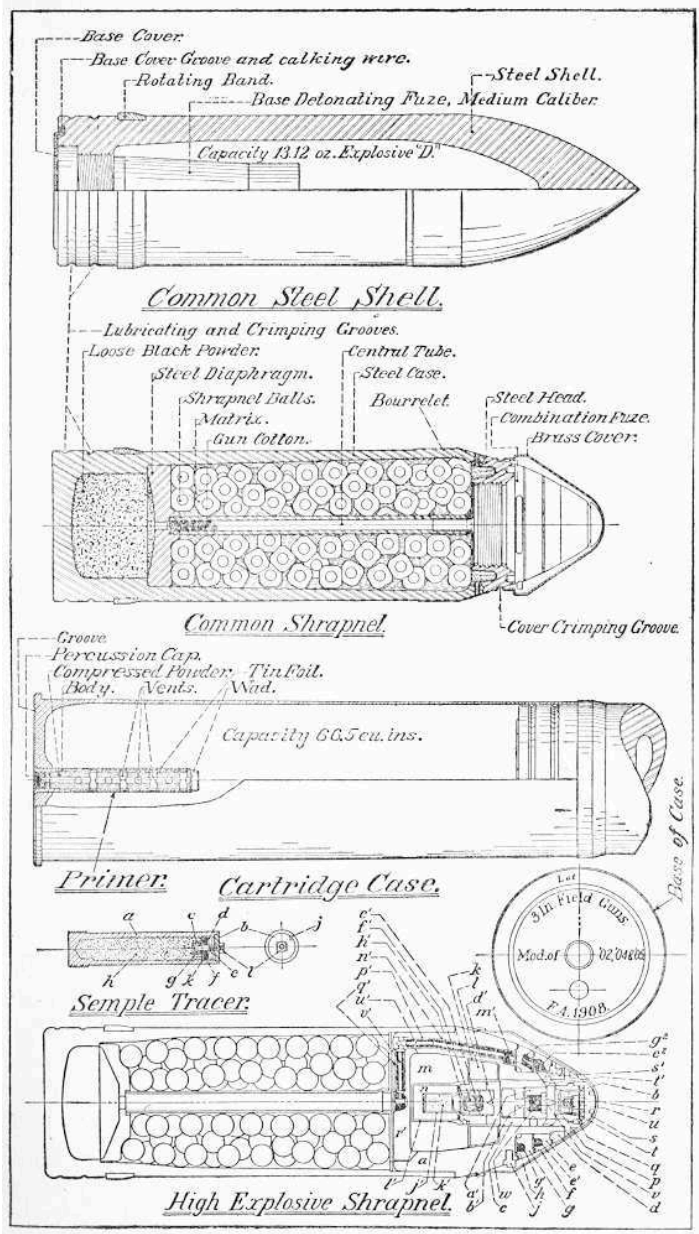
COMMON STEEL SHELL MARK I.
COMMON STEEL SHELL MODEL OF 1905.
SHRAPNEL.
CARTRIDGE CASE.
4.7” Gun Ammunition.

Three-inch Ammunition.

Fixed ammunition is used in the 3" field guns, and is made up with either common shrapnel, high explosive shrapnel, or common steel shell. The rounds as made up vary in length with the type of projectile used. The ammunition chests of the battery are of sufficient size to take any one of the rounds furnished, so that the number of each kind to be carried is a matter for regulation by proper authority. Each round is issued with projectile filled and fused. The weight of the projectile is 15 pounds, and the total weight of one round is 18.75 pounds. The components of one round are *the cartridge case with primer, the powder charge, igniter, projectile and fuze*.

The cartridge case.—The cartridge case is a solid drawn-brass case 10.8 inches long; it has a capacity of 66.5 cubic inches, and weighs, with primer, 2.25 pounds. A circular groove is cut in the base of the cartridge case and *the groove is painted red for high explosive shrapnel, yellow for common shrapnel, and black for high explosive shell.*

The primer.—The percussion primer, known as the "110-grain percussion primer," contains an igniting charge of 110 grains of black powder in addition to the essential elements of a percussion primer. The purpose of the black powder is to insure the ignition of the smokeless powder charge in cartridge case.



Common Steel Shell.

Common Shrapnel.
Cartridge Case.
Semple Tracer.
High Explosive Shrapnel.
3" AMMUNITION

The powder charge.—The powder is a nitrocellulose powder composed of multiperforated (7 perforations) cylindrical grains, each 0.35" long and 0.195" in diameter. The charge varies slightly for different lots of powder, but is approximately 24 ounces. The charge gives a muzzle velocity for shrapnel of 1,700 feet per second (1600 f/s for shell) with a maximum pressure in the bore not exceeding 33,000 pounds per square inch. At the front end of the cartridge case there is an igniter of black powder weighing about ¼ oz. which assists in the uniform ignition of the smokeless powder charge.

The projectiles.—All projectiles have a copper rotating band 1.2" from the base. This band engages in the rifling of the bore of the piece, and gives the projectile a rapid rotation about its long axis during flight. This causes it to travel straight, point on, without tumbling.

Common shrapnel.—The common shrapnel is a base-charged shrapnel fitted with a combination fuze. The case is of steel with solid base. The shrapnel filling is composed of 252 balls, each approximately 167 grains in weight (42 to the pound). The balls are approximately 0.5" in diameter. The balls are poured around a central tube and rest upon a steel diaphragm, the interstices containing a smoke-producing matrix. The bursting charge consisting of 2¾ oz. of black powder is in the base and is covered by the diaphragm which supports the central tube, affording a conduit to the

flame leading from the fuze to the bursting charge.

In action the case is not ruptured upon the explosion of the bursting charge; the head is stripped and the balls are shot out of the case with an increase of velocity of about 274 feet per second. The remaining velocity of the shrapnel at 6,500 yards is approximately 724 feet per second and the time of flight 22 seconds, so that at that extreme range, with the increase of velocity due to the bursting charge, this shrapnel with 21-second fuze will be effective. The weight of the shrapnel with fuze is 15 pounds.

Shrapnel is a projectile containing a great number of hardened steel balls, each approximately ½" diameter, which may be projected from a point in the air (called the *point of burst*) close to but short of the target. Each ball is capable of killing a man or horse at a distance up to 250 or 300 yards from the point of burst. Taken collectively, the paths of these balls form a cone, called the *cone of dispersion*. The ground section of this cone is elliptical in shape with its longer axis approximately in the plane of fire. At mid-range when burst at *normal height of burst* (H. B. = 3 mils), the dimensions of this area are approximately 20 yards wide by 250 yards deep. These dimensions will however vary with the *angle of fall*, *the height of burst*, the *slope of the ground* at the target, and the relation between the *linear* and the *rotational velocities* of the shrapnel at instant of burst in the air. A 3-mil H. B. is chosen because this gives an average density of 1 hit per square yard of vertical target area. An infantry skirmisher (standing) with his interval occupies approximately 1 square yard.

Shrapnel has very little effect upon material objects. It is very effective against personnel not

protected by cover, or to search an area which is known to be occupied, or which must be traversed, by hostile troops.

Ehrhardt High-explosive shrapnel.—The Ehrhardt high-explosive shrapnel is fitted with a combination fuze and a high explosive head. The case is drawn steel with solid base. The shrapnel filling is composed of 285 balls, each approximately 138 grains in weight (50 to the pound). The balls are poured around the central tube and rest upon the steel diaphragm, the interstices containing a matrix of high explosive.

In time action (burst in air), the case is not ruptured upon the explosion of the bursting charge, but the head is forced out and the balls are shot out of the case with an increase of velocity of from 250 to 300 feet per second. In the meantime the head continues its flight, detonating on impact.

If the fuze be set at “safety” or for a time greater than the actual time of flight, this shrapnel may be used in lieu of high-explosive shell. Upon impact a high-explosive shrapnel is detonated by means of the percussion element of the combination fuze, the head being detonated first, which detonation causes the sympathetic detonation of high-explosive matrix surrounding the balls.

Common steel shell.—This steel shell is high-explosive and fitted with a base detonating fuze. The case is hollow and made of drawn steel. It is provided with an ogival head. The steel shell contains a bursting charge of 13.12 ounces of Explosive D. The weight of the shell with bursting charge and fuze is 15 pounds. The shell is always issued filled and fuzed.

This shell bursts on impact and with great force exerted in all directions. It is a powerful instrument for the destruction of material objects such as guns, intrenchments, houses, stone walls, etc. The effect, however, is very local.

Frankford Arsenal combination fuzes.—These fuzes are point fuzes with combination time and percussion elements for use with common shrapnel. They are of the type known as the ring or "dial" fuze, in which the time train is set by turning a graduated ring which carries part of the train. These fuzes may be reset as often as desired.

Ehrhardt combination fuze for high explosive shrapnel.—This fuze is similar to the Frankford Arsenal Combination time and percussion fuze but in addition contains a high explosive head and detonating element. Due to this arrangement, both the projectile and the high explosive head have a high-explosive shell effect when striking on impact.

The service base detonating fuze.—The details of the detonating fuze and the composition of the detonator are kept secret. A detonating fuze is necessary in order to produce a higher order of explosion by causing an instantaneous conversion of the high explosive compound called "Explosive D" with which the shell is charged. If an ordinary percussion fuze were used only an ordinary explosion would be produced as in the explosion of black powder.

Preparation of blank metallic ammunition.—Blank metallic ammunition will always be assembled under the personal supervision of a commissioned officer, who will be held responsible that it is prepared in the manner prescribed. (G. O. 9, War

Dept., Jan. 11, 1908.)

For this purpose there are issued blank-cartridge cases, black powder in bulk, tight-fitting felt wads, rubberine, or other quick-drying paint, primers, etc.

Before assembling, the cartridge cases should be carefully inspected to see that they are in sound condition and thoroughly clean and dry. They should also be tested by trying them in the gun, to determine whether they have become deformed. Any cases that do not readily enter the chamber in the gun or that are otherwise seriously deformed should be laid aside for resizing. After inspecting the cartridge cases the blank ammunition should be prepared as follows:

(a) Insert the primers with the primer-inserting press.

(b) Pour into the cartridge case the proper weight of black powder and shake it down well.

(c) Insert the felt wad and press it down hard until it rests squarely on the powder charge.

(d) Give the upper surface of the felt wad and the inside of the cartridge case just above the wad a good coat of the rubberine or other quick-drying paint furnished for the purpose, using a brush, and allow the case to stand until this coat is dry. Then apply another coat of rubberine paint in a similar manner. The object of using rubberine paint, which is strongly adhesive, is to thoroughly seal the joint between the wad and the case to prevent any powder grains from leaking out, and at the same time to firmly hold the wad in place.

The reloading and cleaning outfit.—This outfit consists of the following parts, and is furnished to

each battery:

Primer-inserting press, small
Bushing
Powder measure, saluting
Decapping tool, with guide
Cleaning brush
Hammer
Case holder
Case-holder stand
Storage chest

The bushing is used in the primer-inserting press for the insertion of new primers.

The decapping tool and case holder and stand are used for removing exploded primers from the cartridge cases. A light blow on the rod with a piece of wood or the bronze hammer generally removes the primer.

A powder measure to suit the saluting charge for the gun is furnished, and when level full holds the required charge.

The cleaning brush is furnished for cleaning the cartridge cases after they have been used and should be ordered to suit the size of case for which intended.

Care of Cartridge Cases.—As soon after firing as practicable the exploded primers should be removed from the cartridge case by means of the decapping tools furnished with the reloading outfit. The case should then be thoroughly washed in a strong solution of soft soap and soda to remove all powder residue. It should then be thoroughly dried.

If the cartridge cases are carefully cleaned and washed immediately after firing, not only will less labor be required but the life of the cartridge case

will be greatly prolonged.

A good solution for washing cartridge cases may be prepared by using ingredients in the following proportions: 1 gallon of water, 2½ ounces of soft soap, 5½ ounces soda. The mixture should be boiled and stirred until the ingredients are entirely dissolved.

In washing cartridge cases this solution should be used hot and in sufficient quantity to completely immerse the cases.

Neither acids nor solutions of acids will be used for cleaning cartridge cases.

Precautions to be Observed with Fixed Ammunition.

(a) Do not unnecessarily expose ammunition to the sun or load it into a warm gun before time for firing; if this is done, erratic shooting will result.

(b) Handle carefully, otherwise cartridges may become deformed and cause jams.

(c) Never use force or any implements on the base of the cartridge in loading.

(d) See that fuzes set at safety or are provided with waterproof brass cover for transport.

(e) Do not fire ammunition which has been under water with the waterproof brass cover removed.

(f) Both service and blank ammunition should never be carried in the battery at the same time. If conditions are such that both may be used in exercises, only one kind should be in the firing battery; the other should be under lock and key

outside the firing position.

(g) Misfires and hangfires are of exceedingly rare occurrence. In case of a failure to fire, the firing handle should be pulled again in order to snap the trigger. If this fails to fire, the breech should *not be opened* until after the expiration of at least one minute, when the round or cartridge should be removed and placed to one side. Defective ammunition, cartridges and primers should be reported.

With Blank Ammunition.

Firing with blank ammunition will be greatly facilitated by a careful observance of the following:

(a) Before firing, a careful examination should be made of the assembled rounds to see that the felt wads have not become displaced or the cartridge cases dented or deformed by careless handling. If the cartridge cases have been properly resized and are clean, no difficulty should be experienced in inserting them in the gun, provided the chamber of the latter is clean. The continued insertion of cartridge cases that are not clean causes an accumulation in the gun chamber which may make the insertion of subsequent rounds difficult or impossible.

(b) In firing blank ammunition the gun chamber will be sponged after each round with a damp sponge, to extinguish sparks and remove powder residue resulting from the previous round, before the insertion of another round.

(c) Care will be taken to see that the sponges are not worn and that they thoroughly fit the chamber.

The interval between rounds in firing blank ammunition should be sufficient to allow thorough sponging of the chamber and examination to ascertain that all sparks have been extinguished.

(d) Wads for the preparation of blank metallic ammunition are made to tightly fit in the cartridge case. No wads should be used that are not a tight fit in the case.

FUZES.

Principle of operation.—We have just learned something of the force of inertia in connection with a projectile. Most fuzes are actuated by this force. From our knowledge of the trajectory we know that usually a projectile does not strike on its nose. Therefore we cannot devise our fuzes to work like the driving of a nail into a board. The striking element is the anvil and is a fixed pointed spur against which a sliding element containing a fulminate strikes. The sliding block carries a small charge of black powder which is set off by the fulminate, thus igniting the train which leads to the high explosive charge detonator. Were this sliding block left free to slide back and forth at all times it would be unsafe to transport the fuze, as it might be set off by accident. There must be therefore some means of holding it safely away from the anvil until it is desired to detonate the charge. There are thus two conflicting conditions to be met: safety during transportation and sensitiveness at the point of departure. It may not be understood at first why sensitiveness at the point of departure should be a condition to be met. Suffice it to say that all fuzes are designed to arm at discharge or soon after leaving the bore for they must be ready to act at any time

after leaving the muzzle. Were they to be safe during flight they might be so safe that the remaining velocity would not be sufficient to set them off. All fuzes are designed to arm as we say either during travel through the bore or immediately after.

Methods of Arming.

Spring method.—Let us suppose that after our projectile has started on its way the sliding block is free to move within a cavity at the forward end of which is the anvil. If the projectile comes to a sudden drop or even sudden reduction of velocity the block if unrestrained will, according to the principle of inertia, keep on going till something stops it. The something in this case is the anvil and the fulminate cap is set off. But it is not so simple. For while the projectile is in flight it is acted upon by the air resistance and slows down but the block in the cavity of the head is not subjected to this resistance. It therefore gains on the projectile or creeps forward in the cavity unless restrained as it is by a spring. Now one more point and this type of fuze is complete. We supposed that our block was free to slide. For safety's sake it is pinned to the cavity. Again we call upon inertia to bread the pin so as to leave the block free to slide. The strength of the pin is calculated so that the force of inertia of the mass of the block is greater than the resistance of the safety pin and when the projectile starts the pin breaks and the spring forces the block to the rear of the cavity until the sudden stop of the projectile permits the block to slide forward as explained. Such a fuze requires a comparatively high initial velocity and is not adapted to howitzers using low muzzle velocities.

There are three other methods in use to arm the

fuze. They are **inertia of a sleeve**; **centrifugal force** and **powder pellet system**, that is, combustion of a grain of powder holding the sliding block from the anvil by means of an arm resting against the unburned powder grain. These are more sensitive than the type described.

In the first system, a sleeve fitting around the plunger carrying the cap slides to the rear by inertia when the projectile starts and two clips engage in notches on the plunger body making the sleeve and plunger thereafter move as one body, they are thus held together by a plunger spring which before arming held the plunger away from the anvil. The safety spring held the sleeve and plunger away from the anvil and after arming prevents forward creeping by the plunger and sleeve now locked together. Upon striking, the plunger and sleeve move forward as one body and the cap strikes the anvil.

In centrifugal systems the primer plunger is kept safely away from the anvil by a lock which is kept in place by springs. When the rotational velocity reaches a certain point the force of the springs is overcome by the centrifugal force and the locks are thrown aside or opened and the plunger is free to move forward on impact.

In the powder pellet system (the one largely used by the Germans) there is a well or channel filled with compressed powder, this is set off by a fulminate cap which is fired by inertia, a small plunger-anvil striking the cap. When the powder is consumed it leaves a channel into which an arm attached to the sliding block carrying the igniting fulminate for the charge may slide, thus permitting the block to slide forward to the anvil fixed in the forward part of the cavity. It is held from creeping

forward after the compressed powder is burned by a safety spring, thus insuring sufficiently hard an impact to set off the cap.

Heretofore in our service the fulminating cap has been fixed and the plunger carried the anvil or as we call it the firing pin. Such is now the system in our base detonating fuzes, and in our combination fuze.

The new point detonating fuzes are patterned after the French and are practically French fuzes.

Fuzes Classification.

Fuses are classified as:

(a) Percussion if it acts on impact, producing a low order of explosion.

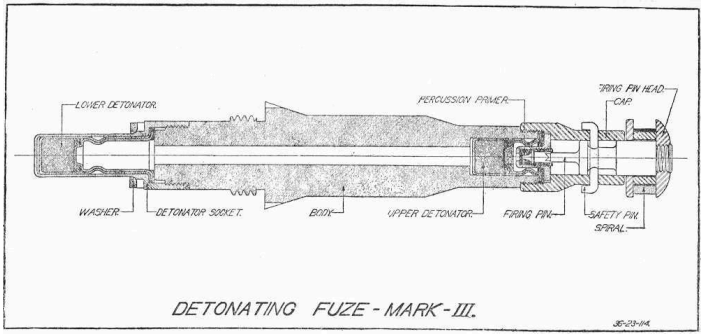
(b) Time when it acts in the air at a certain point of the trajectory.

(c) Combination if it is able to act in the air or upon impact.

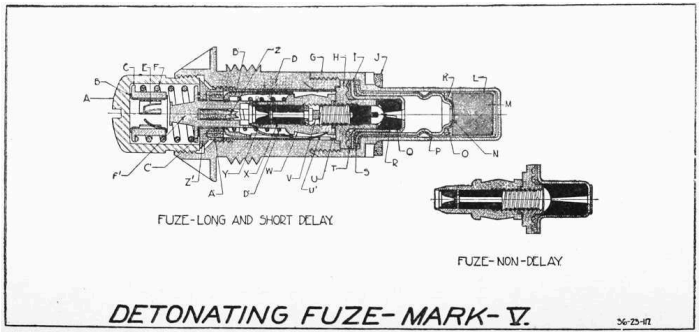
(d) Detonating when it contains a fulminate which will bring about detonation upon impact.

The detonator may be separate or incorporated in the fuse. For the 75-mm gun and the 155-mm howitzer it forms a part of the fuze.

Many fuzes are armed on set-back. An exception to this is the long detonating fuse, MK 111, which is armed by the unrolling of a brass spiral holding together two half rings made of steel so fitted as to prevent the anvil and the head of the fuse from getting close together. The spiral unrolls when the rotational velocity of the projectile reaches a certain speed, thus drawing away the two steel rings and arming the fuse.



DETONATING FUZE—MARK-III.



DETONATING FUZE—MARK-V.

It is of great importance that the spiral spring be not unrolled during transportation or storage. This is prevented by winding a tape of tarred canvas around the spirals, the head being covered by a thin band of tinfoil. Just before loading the projectile the head and tape are removed by pulling the free end of the tape.

The following precautions concerning fuses must be rigidly observed to prevent grave accidents:

1. All detonators and detonating point fuses must

be fitted with a felt washer underneath, thus insuring proper seating in the central tube.

2. Never disassemble a fuse by unscrewing.

3. Any fuse, the parts of which have become accidentally unscrewed, must be destroyed at once. If fired it may cause a premature burst; if handled a grave accident may result.

4. Any fuse or projectile which has been fired is dangerous, because it may then be able to detonate by a very slight shock. It is forbidden to touch it.

5. Never remove the tin hood from the long fuse before having screwed the fuse in the central tube.

6. After having removed the tin hood, be sure that the spiral is in its proper position. Never use a long fuse without the spiral.

7. Be sure the men understand that this spiral must not be removed. It has happened that men have removed this spiral, thinking that it was a device similar to the safety ring in trench mortar fuzes, MK VII E.

8. See that the ring of the long fuze which connects the powder train to the fuze body cannot be unscrewed. If it can be unscrewed the fuze should be sent back to the depot.

9. If it is necessary to remove a shell with a long fuze by means of the rammer, be sure to have a special rammer cup in the shape of a hollow cylinder of wood which will fit between the shell and the rammer.

10. Time and combination fuzes cannot be made absolutely water-tight; the cover must therefore not be removed until the projectile is about to be loaded.

Fuse Tables.

Tables showing American and French fuses to be used by our Field Artillery, with information concerning markings, color, time of delay, size of fuse, etc.

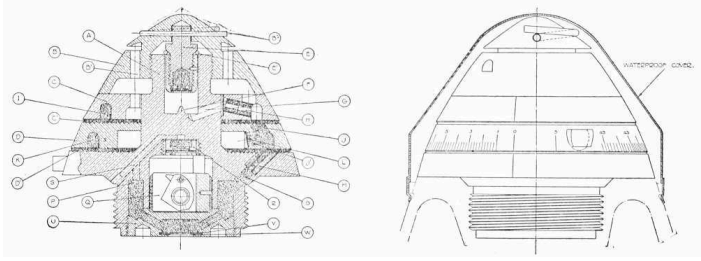
DETONATING FUSES.

Time of delay.		Color.	Size of Fuse.	Corresponding to.	
MK I	2-100	White head.	Short.	Russian 3GT.	3”
M II (non delay)	2-100				8”,
MK II (non delay)	2-100	White top.	Short.		20·
MK II (short delay)	5-100	Black top.	Short.	Modified.	Gu
M II (long delay)	15-100	Black head.	Short.		Ru
MK III (Supersensitive)	zero	No color.	Long.	French IAL.	75
MK IV (non-delay)	2-100	White top.	Short.	French 24/31 SR (99-15).	Ho
MK IV (short delay)	5-100	Black top.	Short.	French 24/31 AR (99-15).	Ho
MK IV (long delay)	15-100	Black top violet detonator socket.	Short.	French 24/31 SR (99-15).	Ho
MK V (non-delay)	2-100	White top.	Short.	French 24/31 SR (99-08).	All

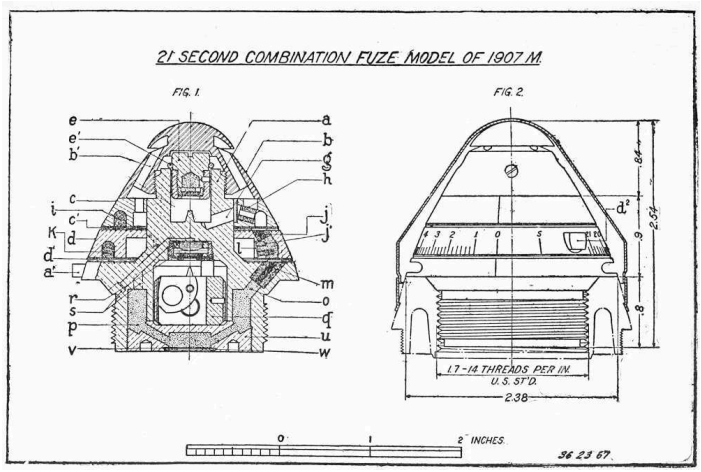
MK V (short delay)	5-100	Black top.	Short.	French 24/31 AR (99-08).	All
Mark—VII (non delay)	2-100	White.	Short		6”
Mark VII (long delay)	20-100	Black top with violet detonator socket	Short		6”

Letter “E” after mark VII indicates safety device.

Note:—All American point detonating fuses are stamped on head cap in letters and figures, .125 in high, with name of use, amount of delay, initials of loader, lot and number; thus: PDF. MIV, xx Delay, FA, Lot No. xx.



45-SECOND COMBINATION FUZE MARK I.



21 SECOND COMBINATION FUZE MODEL OF 1907 M.

COMBINATION FUSES.

Fuse.	Total time burning Sec.	Corresponding French Type.	On what projectile used.	By what cannon fired.	Wt. of fuse.
21 s/ comb. F. A., 1907 M.	21	22/31M 1897, 24 sec.	Com. Shrapnel. MKi.	All 3” and 75-mm guns	1¼ lbs.
21 s/ comb. F.A., 1915	21	22/31M 1916, 24 sec. AA.	Com. Shrapnel. MKi.	All 3” and 75-mm guns	1¼ lbs.
31 s/ comb. F. A. 1915	31	30/55M 1889, 40 sec.	Com. Shrapnel.	4.7” gun.	2 lbs.
45 s/ comb. F. A. 1907 M.	45	Same as above.			

		30/55M 1889, 40 sec.	Com. Shrapnel, MKi.	155 How.	
		30/55M 1913, 40 sec. AA.	C. S. Shell AA MKiii AA. Shrapnel.	4.7” gun Anti-aircraft.	

ACTION OF AMERICAN AND FRENCH DETONATING FUSES.

Time	zero	$^{1}/_{100}$	$^{2}/_{100}$	$^{5}/_{100}$	$^{15}/_{100}$
Color	No color.	Red.	White.	Black.	Black with violet socket.
American	MKii	None being made.	MK i	MK ii (SD)	MK ii (LD)
Detonating		Fuse is considered	MK ii (ND)	MK ii (SD)	MK iv (LD)
		unsafe	MK iV (ND)	MK V (SD)	
		safe	MK iV (ND)	MK V (SD)	
Fuses		Will be abandoned by French	MK V (ND)		
French detonating fuses	iAL.	1	SR.	AR.	LR.

Notes on Ammunition Marking.

Marks on H. E. Shell. These are of two kinds.

(a) Stamped marks made with a steel punch on the body of the projectile just above the rotating band. These refer to the manufacture of the projectile.

(b) Painted marks or bands which are clearly visible. They refer to the loading, to the weight of the projectile and to the special purposes for which the projectile is to be used.

Painted marks referring to loading are found on the ogive.

H. E. shells are usually painted red.

Marks referring to weight are painted in black just above the rotating band, as follows:

L.— very light.

+— light.

++— normal.

+++— heavy.

++++— very heavy.

A white cross above these marks means that a plate has been welded on the base. These marks are also painted on the boxes.

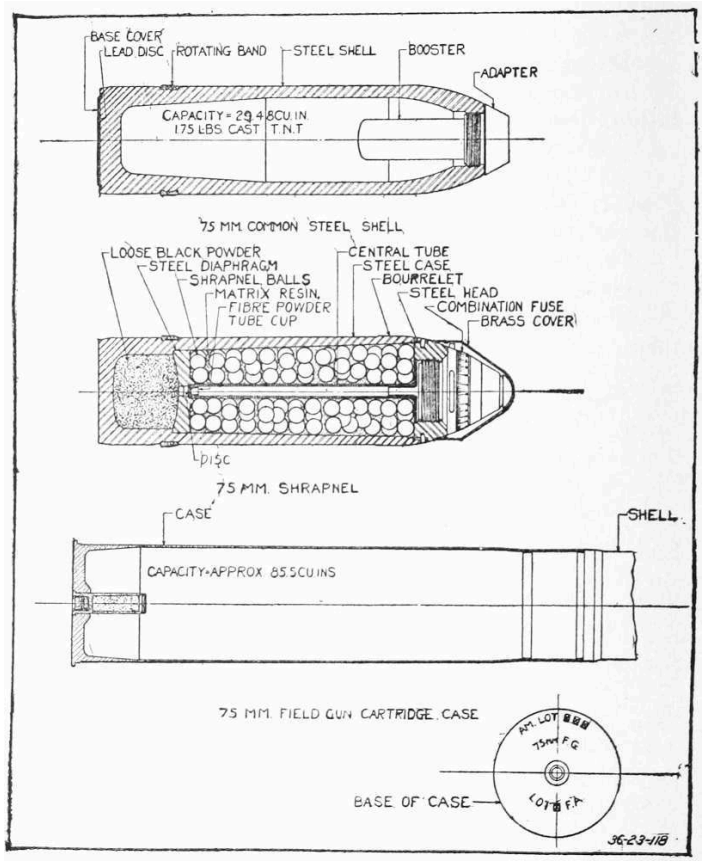
Shells fitted with cartridge cases (fixed ammunition) are not painted below the rotating bands.

Special Shell.

Incendiary shells.—These incendiary shells are filled with some flame-producing liquid, alumino thermic charge or incendiary cylinder composed of slow burning linstock and string strongly impregnated with saltpeter.

Markings.—Green with red ogive.

All shells containing black powder are more or less incendiary. Percussion shrapnel is incendiary.



75-mm Ammunition.

Star Shells.—For 155 howitzer. Upon bursting, they liberate eight white stars fitted with silken parachutes. The stars are projected backward through the base of the projectile at the point of burst. The parachutes open, the stars descending very slowly, illuminating the surrounding objects for about 45 sec. The best height of burst is about 300 m.; the burst interval should not be over 300. These shells are also incendiary. Markings: a blue star and

an “E.”

Gas shells are either toxic or tear-producing.

(a) Toxic shells are numbered either 4 or 5. The liquids 4 and 5 volatize, immediately upon contact with the air. The gases are quickly diffused and easily carried by the wind.

Effect.—Liquid 4 acts immediately and is felt instantly.

Liquid 5, on the contrary, works more slowly and its effects are apparent only after several hours. Markings: Green with white bands, and numbers 4 or 5 on the ogive.

(b) Tear shells.—These shells are numbered 11, 12 and 13. They are filled with two liquids, either mixed or separated, one liquid being tear producing, the other smoke producing. When the shell bursts, a greater part of the liquid is volatilized, the remainder being projected to the ground in small drops which volatize with variable speed. Markings: Green with numbers 11, 12 or 13 on the ogive.

Tracer shell.—This shell is fitted with a time fuse which ignites the inside charge, the flames of which pass through the holes in the ogive thus tracing the trajectory. Tracer shells are used in fire for adjustment on aircraft. They are also incendiary. Markings: White with blue ogive. Letter “T” painted on body.

PRECAUTIONS IN SEPARATE LOADING PROJECTILES.

All projectiles must be seated accurately and carefully in loading, otherwise not only inaccurate

fire will result but also premature detonations may occur.

Rotating bands should be smoothed and lightly greased just before loading. In transport and in storage the bands should be protected by rope bands, straw tithes, etc., to prevent deformation.

CHAPTER XIII
CARE AND PRESERVATION.

OILS AND CLEANING MATERIAL, TOOLS AND ACCESSORIES FOR ARTILLERY MATERIEL WITH THEIR USE.

In order that all parts of the materiel may function easily, it is necessary that all the working and bearing surfaces may be properly cleaned and lubricated with the appropriate lubricant. Where such surfaces are not directly accessible, oil holes are provided; these holes should be kept free from grit and dirt. Except during oiling, they should be kept fully closed by the means provided.

For use in service, for the cleaning and preservation of this materiel, the ordnance department issues hydroline oil, lubricating oil, clock oil, vaseline, sperm oil, coal oil, neat's-foot oil and light slushing oil. Each of these oils are suited for the particular purpose for which it is issued, as stated below, and care should be taken that it is not used for other purposes.

Hydroline oil.—Used in the recoil cylinders of the carriage *and for no other purpose*. Never used as a lubricant. It is characterized by its low freezing point and its non-corrosive action on metals.

Lubricating oil (*Engine oil Number 1*).—A light

petroleum oil used exclusively in all oil holes of the materiel, and in lubricating such parts as wheels and axles, guns and cradle slides, cradle pintle and socket elevating and traversing mechanisms, exterior of cylinders, brake bearings, hinges, different surfaces of breechblocks, threads, breech recess, et cetera.

Clock oil.—Used on the spindle and all gearings of the Battery Commander's telescope, bearings of the panoramic sight, range quadrants and fuze setters. In all cases clock oil should be used only when the instruments mentioned are disassembled for cleaning. It should be applied by dropping from the end of the dropper attached to the end of the cork. In case of emergency, use as a substitute either sperm oil or Engine oil No. 1, in the order mentioned.

Vaseline (**Petrolatum**).—The heavy petroleum oil free from rosin. Used on the worm gears and the worm racks of the panoramic sight, the hand and bracket fuze setter, B. C. telescope, and on the micrometer screw and bushing of the quadrant. The spare parts of the breech mechanism should also be coated with vaseline and each piece then wrapped in paper to prevent the oil from being rubbed off.

Sperm oil.—A lighter lubricant than the lubricating oils, and may be used on the gears of sights, fuze setters, ranges, quadrants, parts of revolvers, et cetera; lubricating oil may also be used on such parts. It is also used as a temporary rust preventive. Its low viscosity and light body make it unsuitable for this purpose for more than a few days.

Coal oil.—Used for cleaning purposes. In the field it may be used for lanterns. Coal oil for general illuminating purposes is furnished by the quartermaster department.

Neat's-foot Oil.—An animal oil used for softening and preserving leather. Applied with a moistened cloth to the flesh side of moistened leather.

Light slushing oil.—The heavy petroleum oil similar to cosmic. Used as a rust preventive. Essentially a mineral oil containing a large per cent of rosin. Prescribed for use in the protection and preservation of all bright or unpainted of steel or iron on all parts of the equipment when the materiel is to remain unused for an appreciable length of time. Its use as a lubricant for mobile artillery is forbidden. Before applying the slushing oil to any surface, the parts should be thoroughly cleaned so as to be free from rust, coal oil, lubricating oil, et cetera, as their presence will cause rusting under the slushing oil. The slushing oil should then be applied in a thin, uniform coat, since this is all that is necessary to give good protection. Except in very cold weather it can be applied by using a paint brush as when painting, in cold weather it should be applied by stippling—that is, by holding the brush perpendicular to the surface to be coated and then tapping the surface with the point of the brush. It can be applied through the bore of the gun by a slush brush issued for that purpose. In cold weather it should be warmed before used in the bore of the gun. It may be readily removed by burlap or waste dipped coal oil.

Borax.—Issued for use as a flux in welding.

Lavaline.—A metal polish issued interchangeable with Gibson's soap polish. Used on bits and collars.

Lye, powdered.—When dissolved in water, one pound to six quarts with sufficient lime to give a consistence of paint, is used to remove old and blistered paint.

Napthaline.—A moth preventive, effective only after eggs and grubs already present have been removed. Used in the storage of blankets, et cetera.

Polish, Gibson's Soap.—A metal polish issued interchangeably with lavaline. Used on bits and collars.

Paint, rubberine.—Used in connection with loading ammunition in accordance with instructions regarding the same.

Primer, brown enamel.—A hard, quick drying enamel used for painting parts of horse collars, draft springs, et cetera.

Sal Soda, Bicarbonate of Soda.—A saturated solution of soda and water makes an alkaline solution that will not rust. The solution must be saturated, that is, at least 20% or one-fourth pound of soda (6 heaping spoonfuls to one cup of water). This solution is an effective solvent of powder fouling and should always be used after firing, whether metal fouling solution is to be used or not. It reduces the labor of cleaning with oil alone by more than half. Used also in a weaker solution (one-half pound to 8 quarts of water) in washing surfaces to be painted and to remove dirt and grease.

Soap, H. & H.—A neutral naphtha soap used in washing blankets, web and cloth equipment. Applied in the form of a solution (one cake to 9 cups of hot water). If for any cause this soap is not obtainable, a good laundry soap (ivory or equal) may be used, but in no case should yellow soap containing a large percentage of alkali be used.

Soap, castile.—An alkaline soap used in cleaning leather equipment. Applied on a moistened sponge.

Soap, saddle (Hollingshead).—A soap used as a dressing for leather equipment. Applied with a thick lather on a moistened sponge.

Swabbing solution, contains.—Ammonium persulphate, 60 grains or one half spoonful smoothed off. Ammonia 28%, 6 oz. or ⅜ of a pint or 12 spoonfuls. Water, 4 oz. or ¼ pint or 8 spoonfuls. Dissolve the ammonium persulphate in the water and add the ammonia. Keep in a tightly corked bottle. Pour out only what is necessary at a time and keep the bottle corked.

TOOLS AND ACCESSORIES.

In the repair of all equipment, it is literally true that "a stitch in time saves nine," and that a timely repair will save the entire article.

Tool Kits will be kept complete and serviceable; edges of cold chisels free from nicks; drifts and punches properly shaped immediately after using; and files kept clean.

To prevent unscrewing, *copper wire* is used to lash nuts and other threaded parts which are not secured by split pins.

Contents of Leather Pouch for Spare Parts (carried in Trail Boxes of 3-inch Guns):—

For Breechblock—

50 Split pins

1 Block latch and spring

1 Firing pin and spring

1 Firing pin sleeve

2 Handy oilers, 5-16 inch

1 Hinge pin catch
1 Lever latch spring
1 Locking bolt, nut and pin
1 Locking bolt spring
2 Oil hole covers with screws
1 Pallet pin
1 Sear
2 Trigger shaft detent

For Hand Fuze Setter—

2 Corrector scale screws
1 Guide plate lock screw
2 Index bar screws
1 Index plunger and spring
2 Oil hole screws
1 Range index
3 Range ring screws
1 Stop pin screw

For Bracket Fuze Setter—

1 Corrector scale screw
3 Guide screws
4 Housing screws & split washers
1 Knob washer
1 Range worm crank & knob taper pin
1 Range worm crank handle
2 Range ring screws
3 Split pins (0.125)
1 Spring and spring cover with screw
2 Stop pins with rivets

For Cylinder—

1 Drain-plug, cylinder
1 Elevating & traversing lock spring
1 Filling plug (piston rod)
5 Rings Garlock packing, ¾ in

Special Wrenches, **Spanners**, other tools and accessories will be used only for the purposes for which they are intended. This purpose is usually stamped upon the tool.

In assembling or disassembling parts of the materiel, no part will be struck directly with a **hammer**. If force is necessary, a piece of *wood* or *copper* should be interposed between the hammer and the part struck. All nuts are provided with *split pins* as keepers.

A pair of **wire cutting pliers** is provided for use in pulling split pins, cutting wire lashings, etc. When a nut is assembled the split pin should always be inserted and properly opened.

Axes, hatchets, picks, pick mattocks and shovels are carried on the carriage for use in the field and will not be put to other uses. The working edges will be kept bright and lightly oiled, the edges being sharpened if intended for cutting, or smooth if intended for digging. *Deformed blades*, *edges* or *points* should be straightened at the anvil and forge or in a vise. *Shovel points* are straightened with a hammer on a block of wood.

The *side edges* of *shovel blades* should not be used as a mattock, as such treatment will deform the blade. In the field, *split handles* should be wrapped with a cord until they can be replaced by new handles.

Canvas Buckets are used for watering animals, for washing carriages and equipment. Whenever possible, they should be dried before folding and replacing in the holders on the carriages.

A rip or hole may be patched and made practically water-tight by a coat of shellac.

Lanterns are used for illuminating purposes in the field only.

Paulins are used to cover the harness and guns when in the field or in park. On the march they are carried on the carriages, being folded to serve as seat cushions. Holes and tears should always be properly sewed, stitched or darned as soon as practicable.

Picket Ropes are used in the field as drag ropes for the carriages or as picket lines for the animals. The ropes must be in a serviceable condition and free from knots. To keep them in a serviceable condition, splicing may often be necessary.

CARE AND CLEANING OF THE DIFFERENT PARTS OF THE CARRIAGES.

To disassemble and to clean the cylinder.—For cleaning, the cylinder is dismounted and emptied and the cylinder head, counter recoil buffer, and piston rod removed. The interior of the cylinder, the piston, the counter recoil buffer and the stuffing box should then be thoroughly cleaned by the use of cotton waste. The removal of the packing is not necessary in cleaning. The cylinder bore should be carefully inspected, and if any rust has formed it should be removed with coal oil, using if necessary, fine emery cloth. The latter must be used with great care to prevent any increase in the clearance

between the piston and the cylinder. If rubbing, burring, or scoring of the parts is noted, the rough spots should be carefully smoothed down by a skilled workman with a dead smooth file or with emery cloth, and the cause of the roughness ascertained and removed. Where unusual rubbing or scoring has occurred, the facts will be reported to the Officer of the Ordnance Department charged with the duty of keeping the battery in repair, for his information and action. The exterior of the cylinder should be kept well oiled and free from rust and dirt, and an inspection made at least once a month to ascertain its condition. Where rust has formed it should be removed with coal oil, and, if necessary, emery cloth. For shipment or storage, or where the carriage is to stand without firing for extended periods, the cylinder should be coated with the light slushing oil used for the bore of guns.

To fill the recoil cylinder.—If the cylinder is not completely filled, loss of stability will occur and higher stresses than normal will be developed in the carriage. For this reason the cylinder should be filled with the greatest care, a commissioned should, himself, verify that the cylinder is full and that no air is left in it, exception of the void noted below. It is far easier to fill the cylinder when it is disassembled from the cradle. If assembled in the cradle, bring the gun to its maximum elevation and remove both filling and drain plugs. It is necessary that the drain plug holes should be lubricated on top of the cylinder. Fill through the hole in the piston rod. Allow a few minutes for the air to escape and the oil to settle.

Refill and repeat two or three times. When satisfied that the cylinder is entirely full of oil, insert

both plugs, and depress the gun to its maximum depression. After a few moments elevate again to its maximum elevation and unscrew both plugs. Now refill as described above. When entirely full, allow not more than two cubic inches (about one-fourth of a gill) of the oil to escape, insert both plugs and lash them with copper wire. It may happen that after firing a few rounds the gun will not return to battery. This may be due to, first, weakness of springs, second, stuffing box gland being screwed up too tight, or third, the oil having expanded, due to heat. It any case the cause must be ascertained and remedied, if due to expansion of oil, it is proven by the fact that the gun cannot be pushed into battery by force exerted on the breech of the gun. In that case elevate the gun to its maximum elevation and remove the filling plug. The oil will now escape permitting the gun to return to battery. In emergencies, water may be used in the cylinder. This should be done only when absolutely necessary, and never in freezing weather, and as soon as practicable the cylinder should be emptied, cleaned, and thoroughly dried and filled with hydroline oil. About 9 pints of hydroline oil are required for filling the recoil cylinder.

To empty the recoil cylinder.—The cylinder may be emptied either when assembled or disassembled from the cradle. In either case, remove both the filling and drain plugs, depress the forward end of the cylinder and drain the contents into a clean can or other receptacle over which a piece of linen or muslin has been stretched, for straining the oil.

To clean the recoil cylinder oil.—The hydroline oil used in the cylinder should be cleaned and free from grit and dirt. The oil should be stored in the

closed cans provided for the purpose, and be carefully protected from dirt, sand, or water. Oil withdrawn from the cylinders and containing any sediment must not be used again until it has been allowed to settle for not less than 24 hours. When sediment has thus been permitted to settle great care must be taken not to disturb it in removing the oil. To insure the cleanliness of all cylinder oil it should be strained through a clean piece of linen or muslin before using.

To clean the bore of the gun.—After firing and at other times when necessary, the bore of the gun should be cleaned to remove the residue of smokeless powder, and then oiled. In cleaning, wash the bore with a solution made by dissolving one-half pound of Sal Soda in one gallon of boiling water. After washing with the soda solution, wipe perfectly dry and then oil the bore with a thin coating of the light slushing oil furnished for that purpose. Briefly stated, the care of the bore consists of removing the fouling resulting from firing, in obtaining a chemically clean surface and in coating this surface with a film of oil to prevent rusting. The fouling which results from firing of two kinds—one, the production of combustion of powder, the other, copper scraped off the rotating band. Powder fouling because of its acid reaction, is highly corrosive, that is, it will induce rust and must be removed. Metal fouling of itself is unactive, but its presence prevents the action of cleaning agents. It should be removed if it accumulates. At every opportunity in the intermission of fire, the bore of the gun should be cleaned and lubricated.

To clean the breech mechanism.—The breech mechanism should be kept clean and well lubricated.

It should be dismounted for examination and oiled when assembled.

To clean the recoil springs.—Dismount to clean. All rust should be removed and the springs well oiled before assembling. When the springs are dismounted the interior of the cradle should be cleaned and examined for defective riveting, missing rivet heads and scoring. The condition of the spring support guide should be noted and all burrs or scores carefully smoothed off.

To clean, lubricate and care for the elevating and traversing mechanism.—The contact surfaces between the cradle and the rocker should be kept clean, thoroughly oiled, and free from rust. If indications of rusting, cutting, or scoring of these surfaces appear, the cradle should be dismounted, the rust removed, and rough spots smoothed away. The elevating and traversing mechanisms should be dismounted for thorough cleaning and overhauling. They should be kept well oiled and should work easily. If at any time either mechanism works harder than usual, it should be immediately overhauled and the cause discovered and removed. In traveling, the cradle should be locked to the trail by means of the elevating and traversing lock, so as to relieve the pointing mechanism of all travel stresses.

To clean, lubricate and care for the wheels.—The wheel and wheel fastenings should be dismounted periodically and the fastenings, hub boxes, axle arms, and axle bore cleaned and examined. All roughness due to scoring or cutting should be smoothed off. The hollow part of the axle acts as a reservoir for the oil to lubricate the wheel bearings. Experience will show how much oil is needed, but enough should be used to insure that the

oil will pass through the axle arms to the hub caps. The nuts on the hub bolts should be tightened monthly during the first year of service and twice a year thereafter. The ends of the bolts should be lightly riveted over to prevent the nut from unscrewing. When the hub bolts are tightened, the hub band should be screwed up as tightly as possible against the lock washer at the outer end of the hub ring.

GENERAL INSTRUCTIONS FOR THE CARE AND MAINTENANCE OF MATERIEL

Assembling and Disassembling.

(a) Cradle mechanism, cylinder, springs et cetera.

All work upon recoil cylinders, sights, and other optical equipment should be done in the presence of a commissioned officer. The recoil cylinder should never be clamped in a vise, but when necessary to hold it from turning, a spanner applied to the front end of cylinder should be used. Never remove the cylinder end stud nut when the piece is at an elevation. See that proper kind of oil is used in cylinders and for lubrication. Strain the oil used in filling the cylinders through a fine clean cloth and be sure that the receptacles used in handling the oil are clean. Take every precaution to keep the interior of the cylinders clean and to prevent the entrance of foreign particles. In assembling the gland be sure that at least four threads of the gland are engaged with the threads of the cylinder head. Lash parts with copper wire to prevent unscrewing. Close down the ends of the recoil-indicator guide to avoid loss of

the indicator. Prevent possible injury to cannoneers by causing them to stand clear of the counter-recoil spring column in assembling or dismounting. Remove cylinder end stud screw before trying to unscrew cylinder end stud.

(b) Gun

In moving the gun on or off the cradle, provide ample support for the breech end, so that the gun clips are in prolongation of the cradle guides; if this is not done the cradle guides may be ruined.

(c) Elevating and traversing mechanism.

If the gun will not remain at the elevation at which set, the crank shafts are probably not correctly assembled. If the elevating screw do not house in traveling, they are incorrectly assembled.

(d) Sights and quadrant.

Frequently verify the adjustments of sights and quadrant. Require special care in handling sights. Do not permit cannoneers to use front sight as a handle in mounting. Be sure that the range disk of the quadrant and range strip of the rear sight shank are graduated for the particular type of ammunition used by the battery. This also applies to the fuze setter.

Care of Materiel.

(a) Parts of the Carriages.

All nuts are secured by split pins, which should be replaced and properly opened when nuts are screwed home. Do not strike any metal part directly with a hammer; interpose a buffer of wood or copper. All working and bearing surfaces of the carriage require oiling; those not directly accessible for this purpose

are provided with oil holes closed by spring covers or handy oilers. Do not permit brake levers to be released with a kick or blow. It has been found that the apron hinges occasionally become broken, and that the apron hinge pins are frequently lost. Whenever this happens the hinge or hinge-pins should be immediately replaced. For if this is not done the apron, which is very expensive is apt to become cracked or broken. When the lunette becomes loosened the lunette nuts should at once be tightened.

(b) Wheels.

Keep hub bolts and hub bands properly tightened. To tighten the hub bands screw them as tightly as possible with a wrench and then force them farther by striking the end of the wrench with a hammer. All wheels and pintle bearings should be frequently oiled.

(c) Inspections.

Battery commander should frequently make a detailed inspection of all the vehicles in the battery, to see if any parts of them are broken or if any screws, nuts, split-pins, et cetera are missing. If any such defects are found they should immediately take steps to replace missing or broken parts. At these inspections the material should also be examined to ascertain whether the cleaning schedules have been properly carried out. Compliance with these instructions will do much toward prolonging the life of the carriage.

Firing, Precautions and Preparations for.

Before firing, inspect to see that cylinders are

properly closed and that the cylinder end stud nut and piston rod-nut are in place. If time permits, oil slides before firing. Note length of recoil for the first few shots to be sure that the recoil mechanism is working properly. There is no danger as long as the recoil does not exceed 48 inches. Therefore, for first shot always set recoil indicator for about 42 inches. If the gun fails to return fully into battery, it is probably due (1) to dirt on slides and guides, (2) to cutting of slide surfaces on account of lack of oil, (3) to gland being screwed up too tightly, (4) to dirt or foreign particles in the cylinder, and especially in the counter recoil buffer recess, (5) to weakness of springs, 90% of such cases will be found to be due to 1, 2 or 3. Lock the cradle to the trail at drill and at traveling to avoid unnecessary strain upon the pointing mechanism. After unlimbering, release elevating and traversing lock before attempting to elevate or traverse gun.

Cleaning and Care of Leather.

All leather contains more or less oil. When the amount of oil decreases the leather becomes harder, less pliable, and shows a tendency to crack. It loses its elasticity and breaks more readily under sudden strains. Exposure to the sun evaporates the oil and exposure to the rain washes it out, both conditions tending in the long run to bring the same result, namely, hardening and stiffening of the leather. Accumulations of foreign substances are very injurious for they tend to absorb the oil from the leather underneath, leaving it dry and hard, or they retain moisture on the surface, prevent the air from getting to it and rot the leather. Also many substances such as perspiration and excretion from

the horse contain chemicals which are very injurious. For these reasons all leather must be kept clean. The cleaning agent used is castile soap with water. All pieces should be taken apart and as much dirt and dust as possible removed with a damp sponge or cloth. All remaining dirt is then removed by washing with castile soap and water. In doing this always use as little water as possible. Wring the sponge out nearly dry, rub it on the soap and work it with the hands until a thick, creamy lather is formed. Then scrub the leather thoroughly until all dirt is removed. Special care should be taken around spots that have been in contact with metal perspiration or excreta. If there is an old accumulation of dirt a soft stick may be used to scrape this off. Never allow a knife or a piece of glass to be used or any sharp edged instrument. After all dirt is removed run the sponge in one direction, all the way along the leather to remove all remaining dirt and extra lather. Never allow the pieces to be rinsed off in a bucket of water. Metal parts should be washed thoroughly and dried and if necessary any rust removed with a crocus cloth. Although as little water as possible is used some of the oil in the leather will certainly be washed out, and, to keep the leather in proper condition, it must be replaced. After an ordinary cleaning this is normally done by an application of saddle soap. Saddle soap is not a cleaning agent—only a dressing for leather. It contains enough oil to replace, if properly applied, all loss through ordinary use. It is used in the same manner as castile soap, in the form of a thick, creamy lather, rubbed well into the leather and allowed to dry. The leather should be well rubbed with the hands while drying, to keep it soft and pliable, and to work the oil in. Always allow it to dry in the shade, preferably for several hours,

and never assemble pieces, especially fastening straps into buckles until thoroughly dry. Oil is never applied directly to leather unless it has become so hard and dry that saddle soap is not sufficient to soften it. There is only one oil issued for that purpose. That is “Neat’s Foot Oil.” This should only be applied to the flesh side of the leather and very lightly. Several light applications give much better results than a few heavy ones. The oil should be well rubbed in with the hands and should be preferably applied after cleaning the leather with castile soap and water, as the pores of the leather are then more open and the oil penetrates much better. Never oil leather until it becomes greasy, for, besides wasteful, it makes the leather too spongy. In emergencies, where Neat’s Foot Oil cannot be procured any good vegetable oil may be used, preferably olive oil. This is only for emergencies and is not to be used unless Neat’s Foot Oil or saddle soap cannot be had. All new leather equipment should be cleaned with castile soap and water as soon as unpacked as leather very often becomes covered with mold after being packed in boxes for some time. Ordnance leather as it comes to the battery is very dry and should be thoroughly oiled before being used. New equipment after being washed thoroughly, should be given, in several light applications as much oil as it will absorb without becoming greasy. Each application should be allowed to dry thoroughly and should be given frequent rubbings to soften the leather. With the proper kind of preparation for use there is no excuse for the large amount of broken new leather equipment which is so common. In packing harness for shipment, especially into harness sacks the harness should be cleaned and oiled and then dried for at least twenty-four hours before putting into the sacks. After removing from

the sacks at the destination, cleaning and dressing with saddle soap is sufficient. When the leather is dirty, clean it—not to improve its looks but to preserve it. When wet allow it to dry in a warm (not hot) place, in cold weather; or in the shade in summer. When it is dry apply saddle soap or oil. Never hang any piece of equipment over a nail or sharp edge as cracks always develop where the leather has been folded over sharply. Ordinary oils and greases rot leather, so all such equipment must be kept away from contact with them. Never leave any piece of leather where it will chafe against any sharp edge or corner and never leave it exposed to the sun longer than necessary.

Care of Cloth Equipment.

All cloth equipment should be kept as clean as possible by continual brushing. The fewer times necessary to wash it, the longer its life. Canvas goods such as paulins, webbing, etc., when it becomes necessary to wash them should be scrubbed with Paco, or H. & H. soap and water. Make a solution of one cake of either soap in nine cups of hot water. Brush the article to be cleaned thoroughly and spread it on a clean table. Scrub with the above solution and scrubbing brush until a good lather appears. Rinse in clean water and hang in the shade to dry. Woolen articles may be cleaned in the same manner or with ordinary laundry soap. The first method being always the best. It is preferable to wash these in cool or warm water, as hot water shrinks them. Never wring woolens out, but after washing, rinse in clean water and hang immediately up to dry. Saddle blankets should be kept well brushed and should be frequently unfolded, hung in

the sun and beaten with a whip. When removed from the horse they should be doubled over with the wet side out and put in the shade to dry. If no shade is available, and they must be exposed to the sun, always fold the wet side inward. With these precautions, saddle blankets should not need washing oftener than twice a year. In washing immerse the blanket in tepid soap suds repeatedly until clean, rinse in clean water, and hang in the sun to dry. Do not scrub the blanket.

Care of Metal.

All metal equipment should be kept clean and free from rust. Coal oil is used to remove rust, but it must always be removed as it will rust the metal if allowed to remain. The coal oil should be applied to the metal and if possible allowed to remain for a short time. This will loosen and partially dissolve the rust so that it can be rubbed off with a rag or a sponge. Continued applications may be necessary if there is much rust. A solution of Sal Soda is also a good rust remover. The articles must be washed thoroughly after using this to remove all traces of the soda as it is a very active corrosive. Never scour metals to remove rust if it can be avoided as this leaves a roughened surface which will rust again much more easily. Polished surfaces such as brass fittings should be cleaned and polished with Lavaline. This may also be used on the bearing surfaces of steel collars. All surfaces after cleaning should be dried thoroughly and if not painted should be greased with cosmis or cosmoline. These form an air-proof coating over the metal surface so that no moisture may reach it and cause rusting. If the metal is not dried thoroughly, some moisture may be held

between the grease and the metal surface which will in time cause rust to appear. Care must be taken that the grease covers the surface completely. All surfaces against which there is no friction should be painted and kept so. Ordinary olive drab or collar paint is very satisfactory for this purpose.

Care of Guns During and After Firing.

Always while firing keep the bore as clean as possible. If there is time to swab out between shots, do so. During continued firing a bucket of water should be kept near the gun, and the sponge on the rammers staff kept wet while swabbing. Watch the recoil indicator and occasionally push it ahead so as to be sure you are getting a correct reading. Be sure that the gun returns fully into battery after each shot. Keep the ammunition, and especially the rotating bands, free from dust and dirt.

The rotating band should be greased very lightly with cosmis just before inserting the projectile into the breech. In continued firing, oil the slides frequently. Keep the fuze setter clean and be careful that no dirt gets down around the stop pin. Examine the breech recess frequently and wipe out all dirt and brass filing that may accumulate. The gun should be cleaned thoroughly immediately after firing. Make a solution of one pound of sal soda in one gallon of boiling water. Remove the breechblock and carrier, and let one man clean and oil it thoroughly while the rest of the gun is being cleaned. Remove the sponge from the rammer staff, and over the brass rammer, fit a piece of folded burlap. Fold this burlap as many times as you can and still force it through the bore. Soak the burlap in the sal soda solution and swab the bore out thoroughly. Be careful to remove all copper

filing, and the bore should be as bright as a piece of glass when finished. After cleaning it is best though not absolutely necessary to swab out with clean water. Then dry thoroughly with a dry swab, and grease every exposed surface. In cleaning the breechblock and firing mechanism always dismantle it completely. Clean and oil the slides, fuze setters and all parts of the carriage. Decap the empty cartridge cases and wash them out thoroughly with the sal soda solution. There is a decapping set with every battery. Rinse out in clean water and set them in the sun to dry.

A CLEANING SCHEDULE FOR MATERIEL.

Daily.

Before leaving the park:

1. Unlock boxes and chests and secure them with snaps.

2. See that all tools, paulins, etc., are secure.

After returning to the park:

1. Remove from carriages all dust, excess oil and mud. Examine for missing nuts, split pins, broken parts and parts that need adjustment. Make necessary repairs.

2. Clean and oil breech recess and breechblock; after firing, clean bore with salsoda solution, wipe perfectly dry and oil.

3. Oil wheels, elevating and traversing mechanism, tools if necessary.

4. See that all oil holes are properly closed and

that carriages are ready for immediate use.

5. Clean and oil without dismounting; rear sight, quadrant and fuze setter.

6. Lock all boxes and chests.

7. Signal detail: clean all instruments, oil all exposed bearing surfaces. Test telephones and go over all wire used that day and repair same by covering exposed parts. Have all instruments, wire etc., ready for immediate use.

8. Clean all collars and bits and dry the blankets; wipe dirt from the harness.

9. Clean and oil all pistols and revolvers that have been used that day.

Weekly.

1. Wash and clean entire carriage.

2. Disassemble and clear all oil breech mechanism. Always do so immediately after firing.

3. Clean out and fill with oil, all oil holes of gun clips and cradle pintle.

4. Clean all leather straps as you would clean harness.

5. Take apart and thoroughly clean all parts of harness.

6. Take apart and clean and oil all pistols and revolvers.

7. Clean with castile soap and harness soap all leather of the personal equipment.

Monthly.

1. Disassemble the following and clean and oil: elevating mechanism, traversing mechanism.

2. Pull from battery and clean and oil guide rails and clips. Trip gun and test recoil.

3. Tighten all hub nuts and inspect wheels for dish.

4. Take off wheels, clean and oil axles and hubs. Replace hub liner when necessary.

5. Dismount poles, double trees and spare pole, clean and oil.

6. Dismount rear sight bracket from support, clean and oil. Do the same for the front sight.

Every Three Months.

1. Dismount, clean, oil and assemble the recoil mechanism.

2. Inspect the surplus kits and replace all articles that are not in proper condition.

3. Unpack, clean, oil and repack the battery and store wagons, forge limber.

Every Six Months.

1. Inspect all articles of the permanent camp equipment, dry, oil and repair when needed. Pitch tentage for examination and drying.

2. Examine all articles in store such as leather, harness and spare metal parts. Clean the harness, dub the leather, oil all metal parts.

PRECAUTIONS AND GENERAL INSTRUCTIONS.

1. Never allow steel parts to be struck with a steel hammer. Always use a copper drift between the hammer and the steel part.

2. Never try to force a delicate part if stuck. The sticking is probably due to rust and the parts can be loosened by soaking in coal oil or by heating the exterior surfaces with a torch.

3. Be careful in using screw drivers or wrenches not to let them slip and thus ruin the heads of the screw or nut.

4. Insist upon the rule that any part needing repairs be repaired immediately upon arrival in garrison or camp.

5. Never allow a broken part to be stored except for the action of an inspector or survey.

6. Before any article is put away for storage, have it thoroughly inspected and make necessary repairs.

7. See that all articles of your equipment are always marked or stamped with the insignia and the battery number.

8. Hold all members of your organization responsible for any carelessness or negligence in the care of the equipment.

CHAPTER XIV
FIRE CONTROL EQUIPMENT.

SIGHTS.

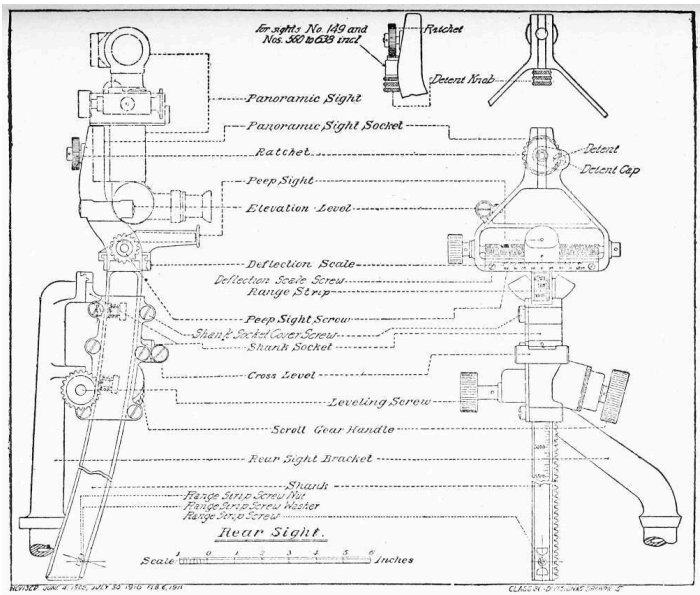
The instruments provided for sighting and laying the gun include a line sight, a rear sight, a front sight, a panoramic sight, and a range quadrant.

Line sights.—The line sight consists of a conical point as a front sight and a V notch as a rear sight, located on the top element of the gun. They determine a line of sight parallel to the axis of the bore, useful in giving general direction to the gun.

Front and rear sights.—The front and rear sights are for general use in direct aiming. The front sight carries cross wires. The rear sight is of the peep variety, constructed as follows: To the sight bracket is attached the shank socket upon which a spirit level is mounted for the necessary correction due to difference in level of wheels. The sight shank consists of a steel arc, the center of which is the front sight. It slides up and down in the shank socket and is operated by a scroll gear. A range strip is attached to the face of the shank and is graduated up to 6500 yards, least reading 50 yards. To the left side of the shank is an elevation spirit level, permitting approximate quadrant elevations to be given with the sight shank when the quadrant is out of order.

The peep sight and its deflection scale are mounted above the shank. This peep traverses along

a screw operated by a knurled head. A socket and ratchet are also provided for the attachment of the panoramic sight.



Rear Sight.

Nomenclature of the important parts of the Rear Sight:—

Peep sight
Elevation level
Deflection scale
Peep sight screw and head
Range strip
Shank
Shank socket
Cross level
Leveling screw
Scroll gear and handle

Rear sight bracket
Panoramic sight socket and ratchet

PANORAMIC SIGHT, MODEL 1917.

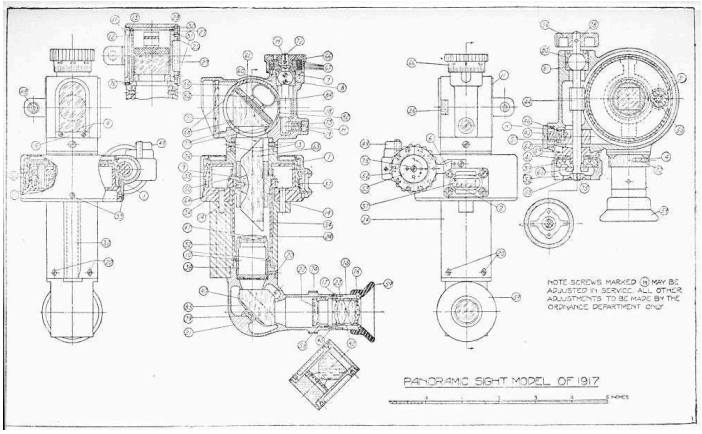
Description.

The panoramic sight is a vertical telescope so fitted with an optical system of reflecting prisms and lenses that the gunner can bring into his field any point in a plane perpendicular to the axis of the telescope. The optical characteristics of the instruments are as follows:

Power = 4.

Field of view = 10°.

The rotating head prism has a movement of 600 mils in a vertical plane; movement is obtained by turning elevation micrometer. The amount and direction of rotation is indicated on a scale in the head by the elevation index and micrometer. The scale is graduated in 100-mil intervals, the micrometer in mils. One complete turn of the micrometer is equivalent to one space on the sale. The head is level when the index is opposite 3 and micrometer at zero.



PANORAMIC SIGHT MODEL OF 1917

Movement in azimuth is obtained by turning **azimuth worm**. The amount of rotation is read from the scale on the azimuth circle and the azimuth micrometer. **The azimuth micrometer** may be turned independently of the azimuth worm to set any desired deflection. Figures in black are for right-hand deflection and in red for left-hand deflection. The scale on the azimuth circle is graduated in 100-mil divisions from 0 to 32 in each half circle. The micrometer is graduated for every mil. For larger angular deflections, by turning the throw-out lever the azimuth worm is disengaged, permitting the head to be turned to any desired position.

The reticule is provided with a horizontal and a vertical cross line. The horizontal line is graduated in mils.

An open sight attached to the side of the rotating head is for approximate setting of the instrument.

No disassembling or adjustment of the panoramic sight, except as described herein, is to be made,

except by ordnance personnel detailed for such work.

The panoramic sight is seated in a T slot in a socket of the sight, model of 1916, in firing, and is carried in a panoramic sight case on the shield when traveling.

Use of the Panoramic Sight for Direct Fire.

Level rocker with zero on range scale opposite 300 on angle-of-site scale and gun at center of traverse. Set azimuth scale at zero, azimuth micrometer knob at zero, micrometer index at zero, elevation scale at 3, and elevation micrometer knob at zero. By means of cross-leveling knob on sight socket bring cross-level bubble level.

Correct for deflection in azimuth by turning azimuth micrometer until required deflection is opposite fixed arrow pointer; bring zero on micrometer index to zero on azimuth micrometer by means of micrometer-index knob.

Elevate gun by means of angle-of-site handwheel and traverse until cross hairs of panoramic sight are on target.

For Indirect Fire.

Level rocker and set scales for zero setting as directed in first paragraph under “direct fire.”

Lay off required deflection in azimuth by means of micrometer index and azimuth worm knob, so that deflection may be read from azimuth index and azimuth micrometer. Traverse gun until vertical cross hair of panoramic sight is on aiming point.

Vertical angles may be read by means of elevation

scale and micrometer scale. Zero point of elevation scale is 3. Each division on elevation scale represents 100 mils.

All scales are graduated in mils.

The open sight on side of rotating head is used to obtain preliminary direction of sight.

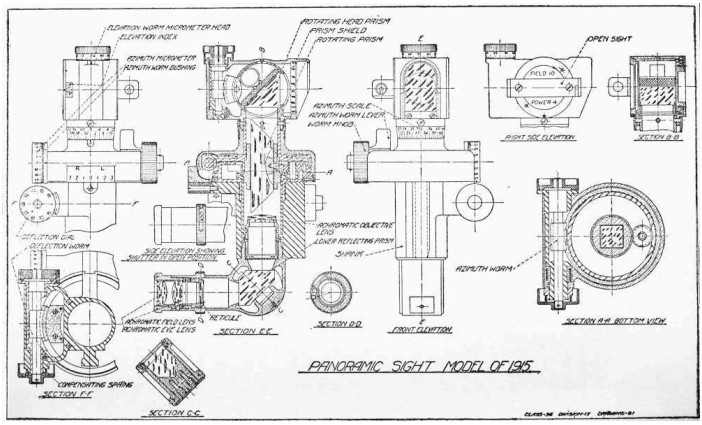
In turning azimuth angles greater than 100 mils the throw-out lever may be pressed and rotating head turned to nearest division in even hundreds desired. Each unit on azimuth scale represents 100 mils.

Panoramic Sight, Model of 1915.

The panoramic sight is a vertical telescope so fitted with an optical system of reflecting prisms and lenses that the gunner with his eye at the fixed eyepiece in a horizontal position can bring into the field of view an object situated at any point in a plane perpendicular to the axis of the telescope.

The rays coming from the object are reflected downward from the rotating head prism into the rotating prism. The rotating prism rectifies the rays; after their passage through the achromatic objective lens, the lower reflecting prism reflects them in such a way that there is presented to the eyepiece a rectified image, which the eyepiece magnifies. A glass reticule marked with graduated cross lines is located in the focal plane of the instrument, with the intersection of the cross lines coincident.

The instrument has a universal focus, **a magnifying power of 4** and **field of view of 180 mils**.



PANORAMIC SIGHT MODEL OF 1915

The principal parts of the panoramic sight are the rotating head, the elevation device and its micrometer, the azimuth mechanism with limb and micrometer, the rotating prism mechanism, the deflection mechanism, R and L scale and micrometer, the shank and the eyepiece.

The limb or azimuth scale is divided into 64 parts, each division representing 100 mils.

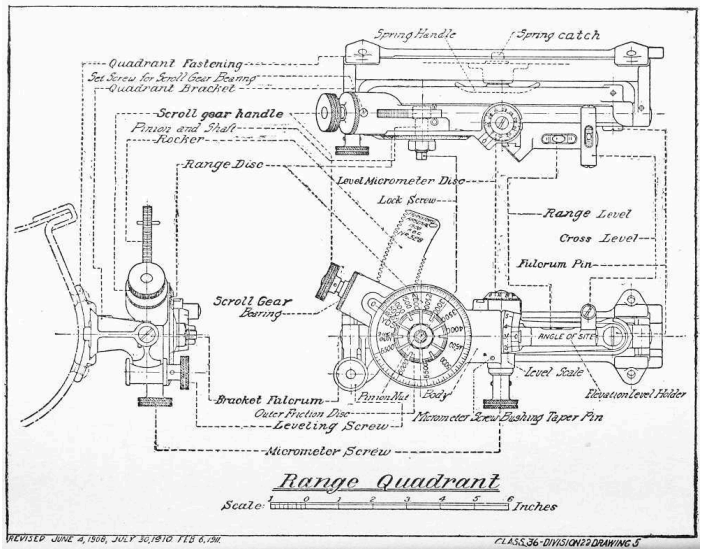
The azimuth micrometer is divided in 100 equal divisions or mils, numbered every 5 mils. One complete revolution of the azimuth micrometer is equal to the distance between divisions on the azimuth scale. The limb of the deflection scale is divided into six divisions; three on each side of the zero, red for right and black for left, each division representing 100 mils. The deflection micrometer, engraved upon the front end, is graduated into 100 equal divisions, numbered every 10 mils, red and black in opposite directions.

THE RANGE QUADRANT

The range quadrant consists of the quadrant spring fastening and bracket, rocker, body, scroll gear, range disk, range and cross levels with suitable leveling screws, and a micrometer to set off the angle of site.

The range disk is graduated to 6500 yards, least reading every 50 yards, scale numbered every 500 yards. This disk is operated by a scroll gear. Large changes in range may be made by pulling out the handwheel, thus disengaging the scroll gear, and moving the body and index to the approximate range, whereupon the handwheel is released, and the range accurately set by again turning the handwheel.

The micrometer has 100 divisions and is operated by a milled head. The limb of the micrometer, called the level scale, is graduated from 2 to 5, each division corresponding to one complete revolution of the micrometer. The arbitrary reference point or mean position of the level holder is 300 which corresponds to a point on the same level as the gun.



RANGE QUADRANT

REVISED JUNE 4, 1908, JULY 30, 1910, FEB 6, 1911.

CLASS 36-DIVISION 22 DRAWING 5

CARE AND INSPECTION OF SIGHTS.

Rear sight Bracket.—Should not be bent, broken or cracked. Must be seated firmly in the bracket support.

Shank Socket Mechanism.—Not bent or burred; interior of shank socket, scroll and worm gears free of scratches, burrs or deformed threads. Sight shank easily inserted and moved up and down in the socket. Scroll gear securely held in mesh with rack of sight shank. For large movements of shank, should be easily disengaged by pulling out scroll gear handle; must be securely held in place by spring when released. Keep interior well lubricated. See that level vials of cross and elevation levels are intact and

bubbles not too large.

Sight Shank.—Rack on right side must engage with scroll gear; keep lightly oiled. Sight shank should remain in fixed position except when disengaged or operated by scroll gear handles. For changes in range of 300 yards or less use only the scroll gear; over 300 yards pull scroll gear handle and slide shank up or down in socket by hand, making accurate setting with the scroll gear.

Panoramic Sight.—Lug must fit snugly in T slot of rear sight and then held fast by clamp screw and ratchet. When making ready for march order, first set the azimuth and R & L deflection scales at zero, and the elevation scale at 300. Release clamp screw and ratchet. In removing panoramic sight, grasp at center below the azimuth gear case, lift vertically out of the socket, lower the top of sight to the left and replace in panoramic sight box.

Quadrant.—Must fit snugly in its bracket, spring catch engaging. Nut on range disk must be tight to prevent slipping. To remove quadrant, press on spring catch before sliding off bracket.

The sights are correctly adjusted when, at zero elevation and deflection, correction having also been made for difference of level of wheels, the line of sight is parallel to the axis of the bore.

The **range quadrant** is correctly adjusted when, with the range disk set at zero, level set at 300, axis of gun horizontal and corrected for difference of level of wheels, the bubble of the range level is centered.

In adjusting sights, the panoramic sight should *first* be corrected. If the rear sight is adjusted first, it will

require readjustment if the subsequent adjustment of the panoramic sight causes a change in position of the rear-sight range strip.

To adjust the panoramic sight.—Select a well defined point at least 2000 yards distant. If the bore sights are not available, stretch two threads or hairs from the tail of a horse across the grooves marked on the face of the muzzle and fasten them by a strap or rubber band. Remove the firing-lock case from the hub of the block-carrier. By sighting through the hole in the vent bushing of the breechblock, adjust the intersection of the cross hairs on the distant point, using the elevating and traversing mechanisms of the gun. Now without moving the gun or disturbing the laying of the cross hairs, bring the cross wires of the panoramic sight on the same distant point by means of the azimuth scale worm-knob and the scroll gear of the rear sight (*on panoramic sights*, M1915, *to the deflection R & L scale should first be made to read 0, and the elevation scale of the objective to read 300*). The cross hairs of the gun and the cross wires of the panoramic sight will thus be laid on the same point. Now adjust the azimuth micrometer scale to read 0 by means of unscrewing and tightening the screw on the milled head. Loosen the nut on the range strip; move it up or down until it reads (0) 100. Tighten the nut again. Verify the laying. For this adjustment, it is not necessary to have the wheels or the carriage on a level platform; cross level should be leveled.

To adjust the rear sight.—Having adjusted the panoramic sight and the rear sight range strip as described above, and without disturbing the laying of the gun, shift the deflection scale of the peep sight and raise or lower the front sight until the cross wires of the latter are laid upon the same distant

point. Now loosen the two screws of the deflection scale and place the 0 of this scale opposite the index of the peep sight. The front sight is raised or lowered by removing the split pins and then turning the front sight in the sight bracket sleeve either up or down.

To adjust the quadrant.—(a) If an adjusted B. C. telescope or another gun with its quadrant in proper adjustment is available, the angle of site of some distinctly visible and distant point is measured by either of these means. The gun to be adjusted is then laid upon this distant point either with the bore sights, or with the tangent sight set at 0 (or some other convenient) range. The measured angle of site is then set off on the level scale of the quadrant and the bubble of the range level is centered by turning the handwheel of the range disk. By using the quadrant wrench, the range disk is then adjusted to read 0 range, (or the convenient range previously set off on the tangent sight).

(b) If no means are at hand to correctly measure the angle of site of a distant point, the quadrants may be adjusted by using two guns as follows: Unlimber two guns at about the same level, first seeing that the sights are in adjustment (par. 75). Lay both guns upon some distant point by means of the panoramic sight set at 0 range. Now set both quadrants for the same angle of site (roughly estimated A. S. of the distant point) and center the bubbles of the range level by turning the handwheel of the range disks. By means of the quadrant wrench, adjust the range disk of one of the quadrants to agree with the other. Whatever error exists will now be the same in each quadrant.

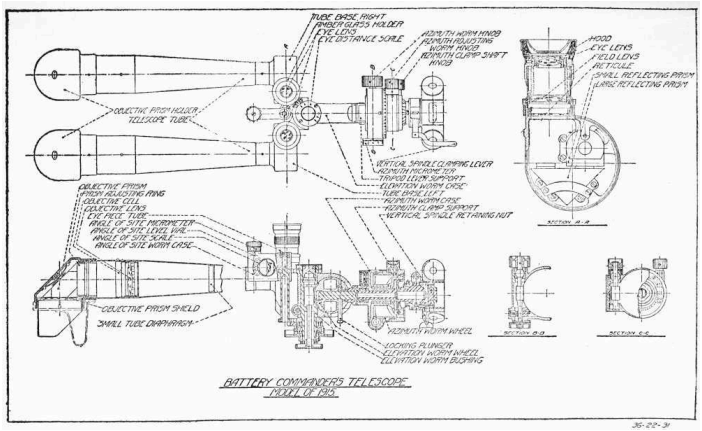
Now move one of the guns about 100 yards away and turn the muzzles toward each other. With the

sights set at 0 range, lay the panoramic sights upon each other and measure the angle of site of each gun. Half the difference of the two readings will be the slope of the line of sight between the two guns. On the level scale of the quadrant which read the greater angle of site, set off 300 plus the half-difference, on the other quadrant set off 300 minus the half-difference. Now center the bubble of the range level by turning the handwheel of the range disk. By using the quadrant wrench, adjust the range disk until it reads 0 range. Having thus adjusted two guns, the others may be adjusted by the first means described.

OBSERVING INSTRUMENTS.

B. C. Telescope, M. 1915.

The B. C. Telescope, M. 1915, is a binocular observing instrument of the scissors type. The two tubes of the telescope may be clamped either in a vertical or a horizontal position. In the former position the objectives are 12 inches above the eyes of the observer, and in the latter position they are 24 inches apart and at the same height as the eyes of the observer. In both cases they permit the observer to take advantage of some shield or other cover and still obtain a full view of the sector of observation. The tubes may be adjusted for the observer's interpupillary distance in either the vertical or the horizontal position. The eyepieces may be adjusted to the eyes of the observer by screwing in or out.



BATTERY COMMANDER'S TELESCOPE MODEL OF 1915.
36-22-31

The principal parts of the telescope are:— Leveling mechanism, azimuth mechanism, elevating mechanism, angle of site mechanism, the telescopes and the tripod. A carrying case is provided separately for the instrument and for the tripod. In garrison a storage case is also provided.

The leveling mechanism consists of a ball and socket joint operated by the vertical spindle clamping screw.

The azimuth mechanism consists of the azimuth worm knob with its lever, operating the azimuth worm and worm wheel; the adjusting or slow motion knob and the azimuth clamp. The azimuth limb is divided into 64 parts, each division representing 100 mils. The azimuth micrometer is divided into 100 equal parts or mils, numbered every 10 mils. One complete revolution of the micrometer is equal to one division of the limb. The scales therefore correspond to those on the panoramic sight, 6400 mils to the circumference.

The leveling mechanism is operated by the small elevation worm knob.

The angle of site mechanism consists of the level, the angle of site scale and micrometer with its worm knob.

The telescopes consist of the eyepieces, telescopic tubes with their optical systems. In the right eyepiece is a graduated cross wire which can be rotated for either the horizontal or the vertical position.

The tripod is similar to the usual telescopic instrument tripod.

The optical characteristics of the instrument are as follows:—Power 10; field of view 75 mils; focal length of objectives 11½ inches; the field is flat, free from chromatic and spherical aberration, coma and distortion.

Care and Instructions.

To set up the telescope.—First set up the tripod, clamping and propping the legs so as to obtain the desired cover and view. By means of the vertical spindle clamping lever, approximately center level on azimuth worm case and clamp tightly. Carefully take out B. C. telescope from case and while pressing on locker plunger, place telescope on vertical spindle so that the projection on the azimuth worm case will fit into the corresponding slotted segment of the telescope. Release the locking plunger.

To focus the eye pieces.—Adjust each eye piece separately by turning the same until the image of a distant object appears sharply defined. Read the diopter scale, plus or minus, and note for future use.

To adjust the interpupillary distance.—The eye

pieces having been focussed, loosen the large friction clamp knob in front. Grasp both tubes with the hands and separate or close them in (either in the vertical or horizontal position) until the fields of view of the two eye pieces are exactly coincident and present a single image to the eyes. This can be tested by alternately closing one eye and then the other, noting any movement in the image. Tighten the large friction clamp knob. Read the interpupillary scale and note for future use.

To lay 0 on any point.—Level the instrument by means of the vertical spindle clamping screw. Bubble must remain approximately centered while instrument is turned 1600 mils. Set both the azimuth index and the micrometer to read zero. Release the azimuth clamp shaft knob; turn the telescope toward the point and tighten the azimuth clamp shaft knob. Bring the vertical wire accurately on the point by turning the azimuth adjusting worm knob.

To measure the deflection and site of a target.—Lay the zero on the aiming point as above. If the line of sight must be moved through a large angle, press down the azimuth worm lever as far as it will go and while holding it down move the azimuth mechanism until the line of sight is approximately directed upon the target; then release the worm lever and bring the cross wires accurately on the target by turning the azimuth worm knob (for deflection) and the elevation worm knob (for elevation). Center the site level. Read the deflection and site.

For carrying the B. C. telescope assembled on the tripod, clamp tightly the vertical spindle clamping lever; close in and clamp the tubes of the telescope; slide up and clamp the lower tripod legs; then carry the telescope over the shoulder by grasping the

tripod legs, tube bases of telescope resting on the shoulder.

To dismount the B. C. Telescope and to pack in carrying case.—Screw in both eye pieces. Press on the locking plunger and lift the telescope vertically off the spindle. Unclamp the large friction clamp knob, bringing the tubes together and insert in the carrying case; close and lock the lid. In dismounting the tripod the leg separators of the upper sections should first be unclamped. After the lower legs have been assembled, they should be clamped. To set up the tripod the operation is reversed.

Aiming Circle, M, 1916.

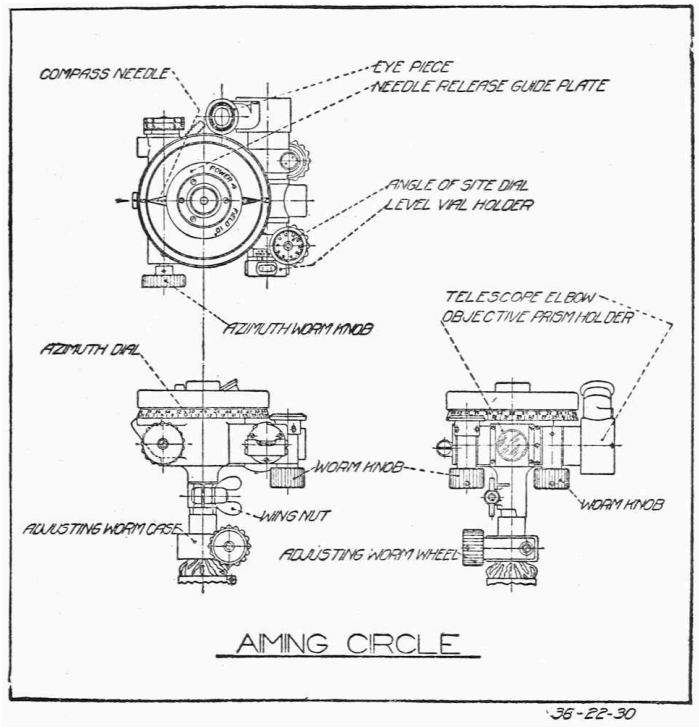
The Aiming Circle is an angle measuring instrument only and consists of a telescope, leveling mechanism, angle of site device, elevating mechanism, azimuth circle and compass, mounted on a tripod.

Its leveling, azimuth and angle of site mechanisms are similar to those in the B. C. Telescope, as is also the tripod. The elevating mechanism consists of elevating worm knob and gear connecting it with the telescope. The telescope has a universal focus, magnifying power of 4, and a field of 180 mils. The cross wires are illuminated by a window. The compass is secured by the needle release button.

Care and Instructions.

Glass compass cover should fit tightly. Compass needle when clamped should not rotate while instrument is revolved or tipped. When release button is pressed, compass must swing freely on

pivot and again remain clamped when button is released. *Compass should be released only when aiming circle is set up and horizontal.*



AIMING CIRCLE
36-22-30

Bubble must remain approximately centered while instrument is turned 1600 mils.

To lay 0 on any point.—Set both the azimuth index and the micrometer to read zero. Release the wing nut; turn the telescope toward the point and again tighten the wing nut. Bring the vertical wire accurately on the point by turning the adjusting

worm wheel.

To measure the deflection and site of a target.—Lay 0 on the aiming point as above. If the line of sight must be moved through a large angle, press down on the azimuth worm lever as far as it will go and while holding it down, move the azimuth mechanism until the line of sight is approximately directed upon the target; then release the worm knob (for deflection) and the elevation worm knob (for elevation). Center the site level. Read the deflection and site.

To measure the compass deflection of a target.—Set both the azimuth index micrometer to read 40. Release the wing nut; turn the telescope until the N and S poles of the compass are respectively near the N and S points marked on the compass box. Make the coincidence accurately with the adjusting worm wheel. Now proceed to measure the deflection and site of the target as described above.

The Tripod and Azimuth Gear Case.—The leather cover protecting the ball and socket joint must fit snugly both above and below, and be free of rips or holes. The ball and socket joint and the tripod legs should be easily adjusted and moved, but should remain fixed when clamped by the clamping levers.

For carrying the aiming circle assembled on the tripod, the wing nut and the vertical spindle clamping lever should be clamped tightly and the instrument carried over the shoulder by grasping the tripod legs, head of tripod resting on the shoulder.

Adjustments B. C. Telescope and Aiming Circle.

The B. C. Telescope and the Aiming Circle are correctly adjusted when the following conditions prevail: Telescope properly focussed; plane of level perpendicular to the vertical axis of the instrument; angle of site scale reading 300 when the line of sight is horizontal; lost motion on worm gears eliminated. In principle, the adjustments of the B. C. Telescope and of the Aiming Circle are exactly the same. The leveling and focusing have already been described. Detailed instructions of the operations in eliminating lost motion in the worm gears will be found in the *Handbook for F. A. Fire Control Equipment*, 1916.

To make the site scale read 300 when the line of sight is horizontal.—Set up the telescope or aiming circle. Level the instrument so that the bubble on the azimuth worm case will remain centered while the instrument is turned 1600 mils. Lay on some point of a stake or other vertical linear object which is at a convenient distance but not closer than 100 yards to the instrument. The point selected should be at such a height that the telescope can later be set up close to it, with the objective at the same height as the selected point. Read the angle of site. This reading will be equal to (300 + S + E), in which S is the angle of slope of the line of sight, and E is the error in the site adjustment. Before leaving this station, set up a second stake near the telescope and mark on it a point which is at the height of the objective.

Now move the telescope to the first stake; set up and level the instrument with the objective at the height of the point marked on this stake. Lay on the marked point of the second stake and read the site. This angle will be equal to (300 - S × E). Subtracting one reading from the other we have:—(300 × S ×

E) - (300 - S × E) = 2S; or one-half the difference of the two readings is equal to the angle of slope of the line of sight. Therefore with the cross wires directed upon the marked point of the second stake, center the bubble of the site level. Now loosen the angle of site locking screw and turn the micrometer to read (300 - S), being careful to keep the bubble centered. Screw up the locking screw. The instrument is now in adjustment.

After one telescope has been adjusted, other telescopes, aiming circles and quadrants may be adjusted by merely measuring the site of some distant point. The other telescopes and guns, being in position near the adjusted telescope, are then made to read the proper site when laid upon the distant point.

FIELD ARTILLERY RANGE FINDER, 1 METER BASE (Bausch & Lomb.)

The instrument and accessories consist of the range finder proper, the tripod mount, the tripod, the adjusting bar, the carrying-case and the storage box.

The optical parts of the **range finder** are embodied in a seamless, steel tube (A) covered with canvas and asbestos, to minimize the effects of the change of temperature. The eyepiece (B) is located in the center of the instrument and is equipped with a focusing device graduated in diopters. A soft rubber eye cap is furnished to protect the observer's eye from shocks and stray light. A ray filter having two sets of glass is operated by a small lever (C) situated to the lower left of the eyepiece housing.

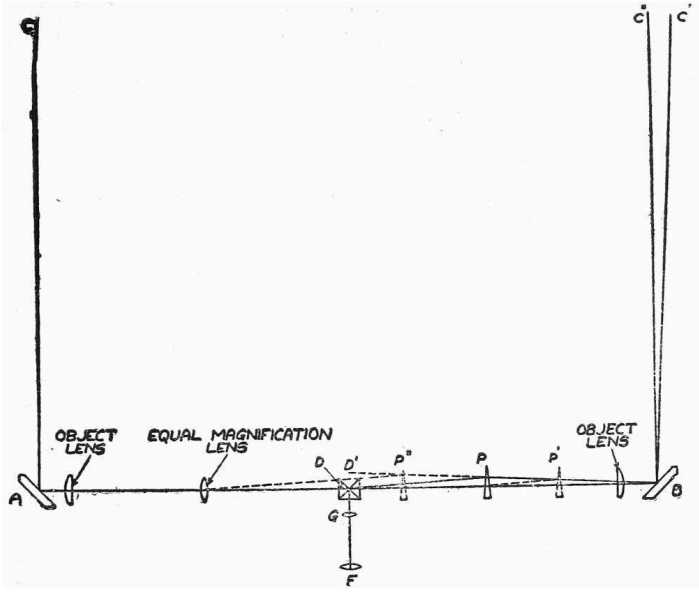


DIAGRAM TO ILLUSTRATE THE GENERAL PRINCIPLE OF RANGE-FINDERS.

The objective openings on the end boxes are opened and closed by means of rotating shutters (D). Buffers (E) are provided on the ends as a protection against shocks.

The range finder is of the type known as the fixed base, invert, single coincidence. The magnifying power is 15; actual field of view 50 mils; shortest distance measurable 400 yards. The instrument weighs about 20 pounds. Under favorable conditions and with expert operators the average errors are:

1000 yds. 5

yds.

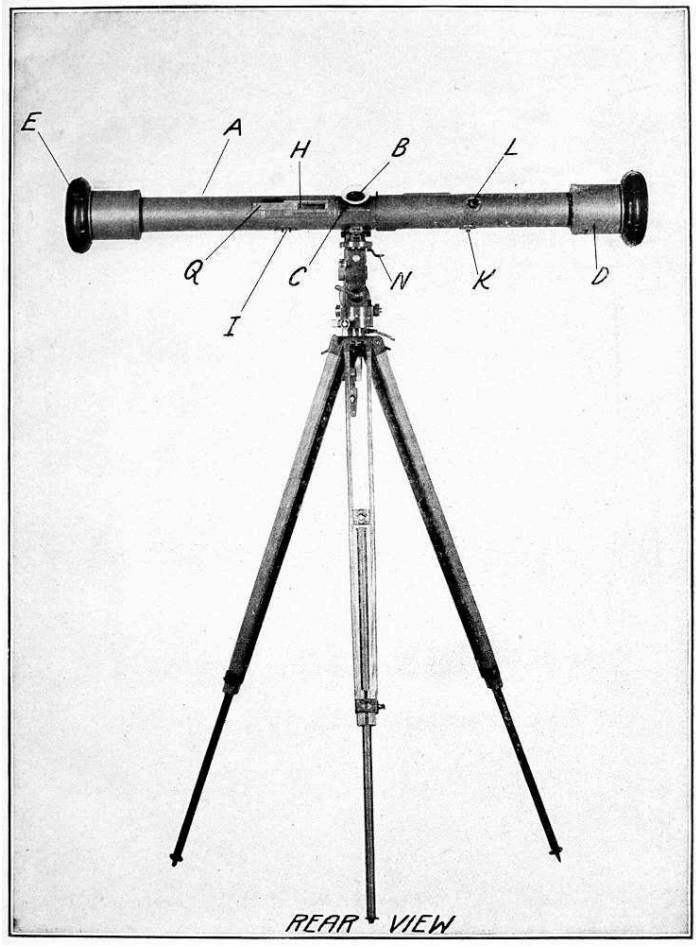
2000 yds.	15 yds.
3000 yds.	30 yds.
4000 yds.	55 yds.
5000 yds.	90 yds.
6000 yds.	130 yds.
7000 yds.	175 yds.
8000 yds.	225 yds.

In practical use under ordinary conditions and with average operators, the errors are three times as great.

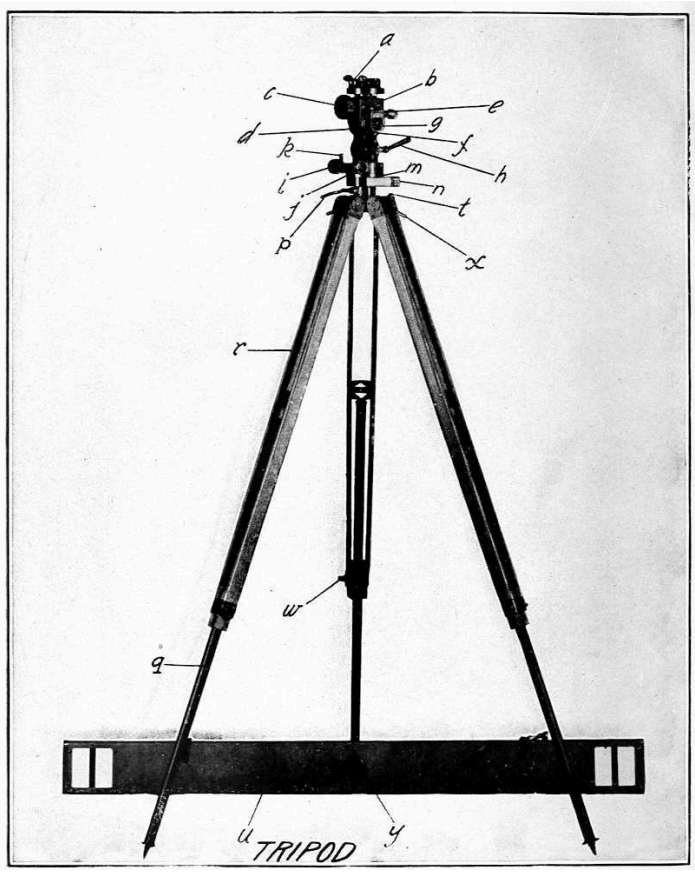
The tripod mount consists of a spring catch (a); clamping lever (N); elevation worm case (b); elevation worm knob (c); worm wheel support (d); angle of site micrometer (e); angle of site housing (f); angle of site vial holder (g); clamp screw handle (h); azimuth worm knob (i); azimuth micrometer (j); azimuth worm lever (k); azimuth scale (m); adjusting worm knob (n); and the vertical spindle clamping lever (p). The tripod, consisting of spindle bushing locking screws (t); tripod legs upper (r); tripod legs lower (q); clamping wing nuts (w); and locking clamp arms (x), is similar to that provided for the B. C. telescope and the aiming circle.

Care and Instructions.

To set up the Range Finder.—Set up the tripod as heretofore prescribed, take the range finder from its case, holding it with the eye piece toward the body, hook down. Place the instrument on the support and engage the spring catch (a). The instrument is then firmly seated on the tripod. Remove the protective hood from the eye piece and the rotating shutters (D) from the objective apertures. Loosen the locking lever so that the range finder may be made horizontal, then turn toward the target and clamp the lever. To dismount the range finder the operations are executed in an inverse manner.



RANGE FINDER.
REAR VIEW



RANGE FINDER.

To Measure a Distance.—Focus the eye piece. In very bright light or in thick haze use the amber ray filter in the eye piece. By means of the clamps and worm knobs of the azimuth mechanism and the worm knob of the elevation mechanism, lay the range finder on the target roughly by looking through the open sight on top of the instrument. Final adjustment in deflection is made by the adjusting worm knob (n) and in elevation by the

elevation worm knob (c).

Now, look into the instrument. The field of view is divided into two parts by a horizontal line. In the lower part the image is erect, in the upper part inverted. By turning the elevation worm knob (c), the images are lined up so that the same points will touch the dividing line. Now, by turning the measuring roller (M) on the right hand top side of the range finder, the upper image is shifted laterally until the same vertically disposed points of the target are exactly opposite each other. The range is then read on the range scale (H), which is protected by a sliding shutter (Q).

In case the target is without prominent vertical features, such as a crest line, the distance is measured by first turning the instrument to a vertical position (Plate XV). This is accomplished by the clamp screw handle (h) on the tripod mount. Final adjustment in deflection is then made by the elevation worm knob (c), and in elevation by the clamping lever (N).

Adjustments.

Adjustment for Height.—The erect and invert images sometimes do not touch the dividing line with similar point so that one image reaches this line before the other. In this case, lay the range finder on an object having a sharply defined horizontal line or very prominent point, and bring the images of this point exactly opposite each other by means of the measuring roller (M). The two images are then brought to the dividing line, the lower image by means of the elevation worm knob (c), and the upper image by means of the halving adjusting roller (J).

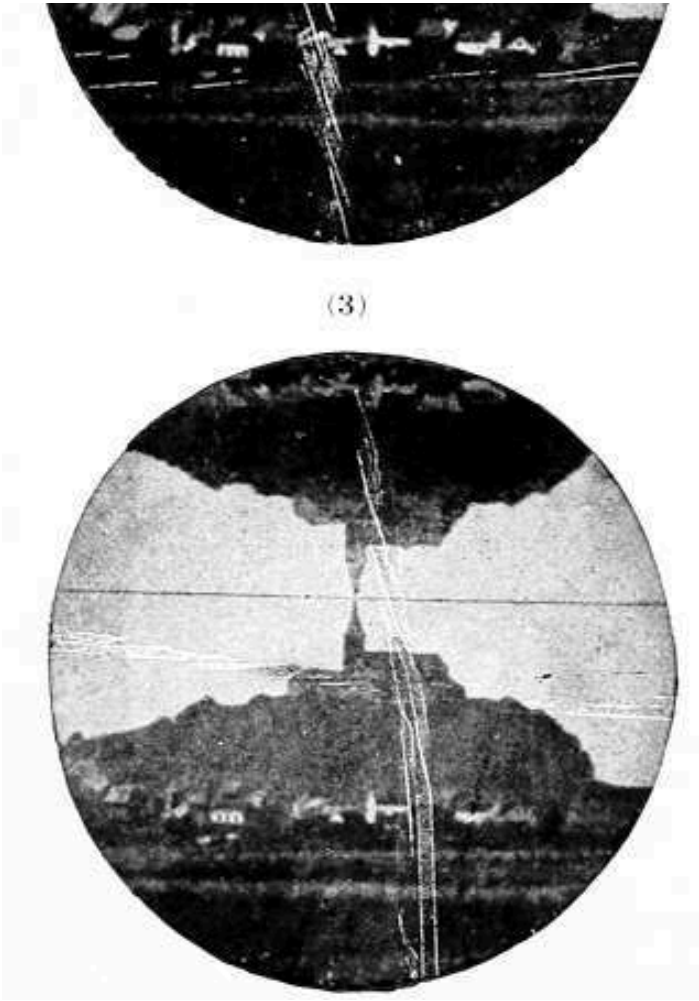
Adjustment for Range.—Three methods are available for adjusting the range finder for range; the artificial infinity method, using the adjusting bar; the actual infinity method using the sun, moon, star, or a very prominent distant point; the known range method, using a point the range to which is known. Of the three, the first is the best and should habitually be used.

By the Adjusting Bar.—Set up the range finder; take the adjusting bar and place it 100 yards from the instrument, sighting through the peep sight (y) of the adjusting bar and moving it until the range finder appears in the center of the field of view. Set the range scale at infinity by turning the measuring roller (M), then make an observation on the adjusting bar. The right hand line of the upper image of the adjusting bar and the left hand line of the lower image should now be coincident, in which case the instrument is in adjustment (Fig. 10). If not, bring these lines in coincidence by turning the key which fits the square shaft (K), which operates the range correction dial (L). This operation should be repeated at least three times, the reading of the range correction dial being noted each time. Now, set the range correction dial at the mean of the three readings. Remove the key. The instrument is now in adjustment. Before using, always note the reading of the range correction dial.



(2)





(3)

THREE STEPS IN MEASURING A DISTANCE.

By the Actual Infinity Method.—This method is in all respects the same as the one with the adjusting bar, except for the images. After the instrument is set for infinity, actual coincidence is made as in paragraph 99.

By the Known Range Method.—Operate the measuring roller (M) until the range dial reads the

actual distance to the object. After the range finder has been set for this known range, actual coincidence is obtained by using the key which operates the range correction dial.

FIELD GLASSES.

The instruments for focusing the eyepieces and for adjusting the interpupillary distance are the same as for the telescope.

The two barrels should revolve easily about the central pivot and clamp in any position of the interpupillary scale.

After being once adjusted, the field glasses should fit into the case without being changed.

Carrying strap, button strap and rain shield should always be part of the equipment. Amber shades and camels hair brush should be carried in the case for use.

The vertical scale in the Type EE Field Glass represents the Infantry range scale and does not apply to Field Artillery.

Compass should always be securely clamped except when in use.

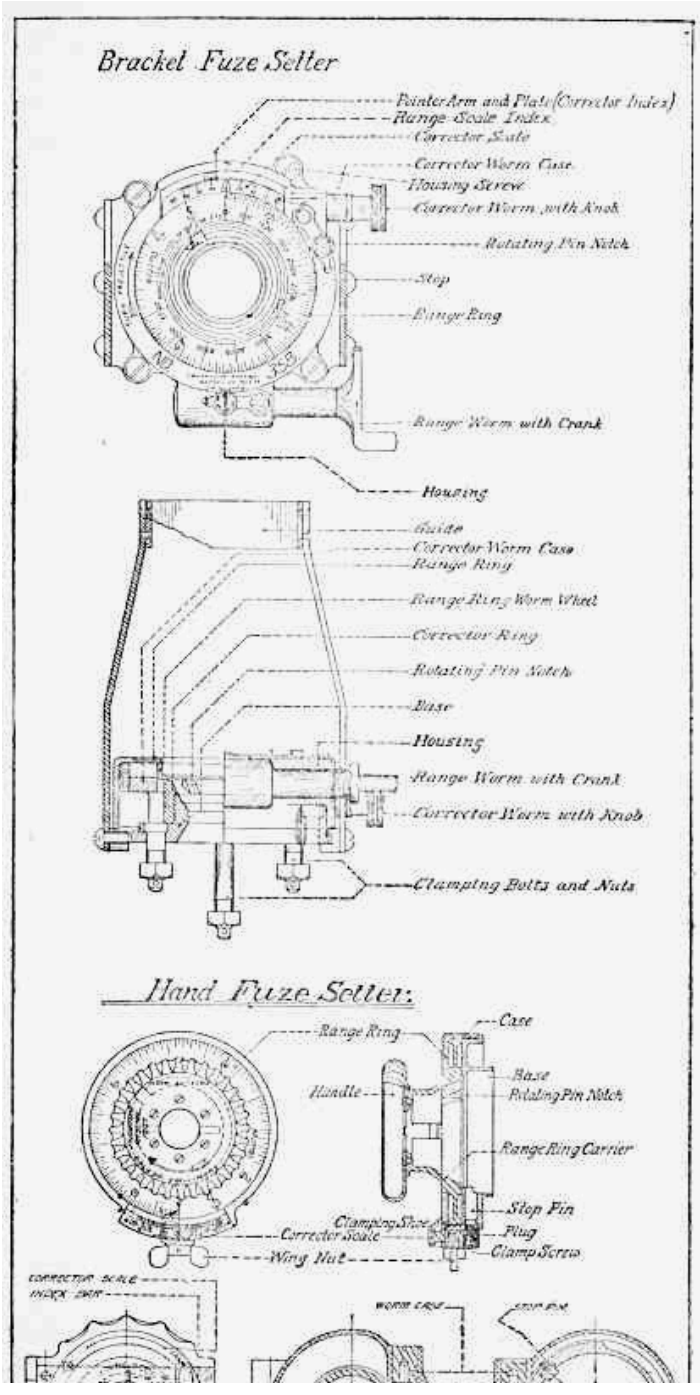
THE BRACKET FUZE SETTER, MODEL 1905 M.

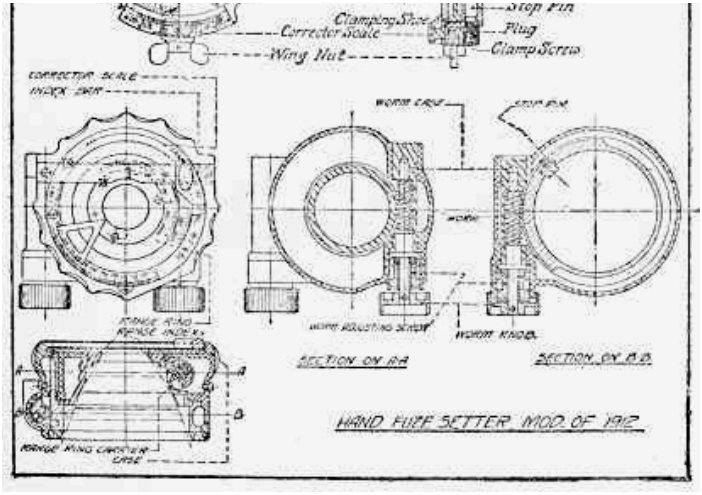
The bracket fuze setter is attached to the rear end of the fuze setter bracket on the caisson. It consists of the following principal parts: Base, housing, corrector-worm case, guide, range and corrector worms, rings, and scales.

The corrector scale reads from 0 to 60, numbered every 10 points, 30 being the normal or mean arbitrary point. The range ring is graduated to 6400 yards, numbered every 500 yards, least reading 50 yards. These rings are graduated for the F. A. fuze on one side and for the Ehrhardt fuze on the other. Care should be taken that the proper side is up when firing the two different kinds of shrapnel.

THE HAND FUZE SETTER, MODEL 1912.

The hand fuze setter is provided for the same purpose as the bracket fuze setter, and is intended to supplement the latter. One hand fuze setter is issued in a leather case and is carried in the trail box of each gun. It is intended for the use in case the bracket fuze setter should become disabled, or in case the gun should for any reason be separated from its caissons. The principal parts are the case, the range index mechanism, range mechanism, corrector mechanism, and guide plate.


Bracket Fuze Setter
Pointer Arm and Plate (Corrector Index)
Range Scale Index
Corrector Scale
Corrector Worm Case
Housing Screw
Corrector Worm with Knob
Rotating Pin Notch
Stop
Range Ring
Range Worm with Crank
Housing
Guide
Corrector Worm Case
Range Ring
Range Ring Worm Wheel
Corrector Ring
Rotating Pin Notch
Base
Housing
Range Worm with Crank
Corrector Worm with Knob
Clamping Bolts and Nuts
Hand Fuze Setter:
Range Ring
Case
Handle
Base
Rotating Pin Notch
Range Ring Carrier
Stop Pin
Clamping Shoe
Plug
Corrector Scale
Wing Nut
Clamp Screw
CORRECTOR SCALE
INDEX PLATE
WORM CASE
STOP PIN



HAND FUZE SETTER, MOD. OF 1912

CHAPTER XV
SIGNAL EQUIPMENT.

CLASSIFICATION.

The most important and widely used means of communication used by artillery with their advantages and disadvantages follow:

(a) Telephone. The telephone is the quickest and most satisfactory means of communication, and is the most generally used of all means. Near the front, in areas subjected to fire it is often difficult to maintain lines and unless a line be a very carefully insulated and transposed metallic circuit, conversations held over it are picked up by the enemy listening service. To guard against such information being of value to him, telephone codes have been devised, for use in important messages.

(b) Radio. Radio provides a reasonably certain means of communication, but such messages are always intercepted by the enemy. Its use requires enciphered messages.

(c) Projectors. Projectors afford a very reliable means of communication, but their use depends, to a great extent, on atmospheric conditions, and frequently they may not be used from rear to front and are slow in operation.

(d) Flags. Semaphore and wig-wag prove fairly satisfactory only on exceptionally favorable conditions and in open warfare.

(e) Runners. Used as a last resort. Slow and wasteful but usually reliable.

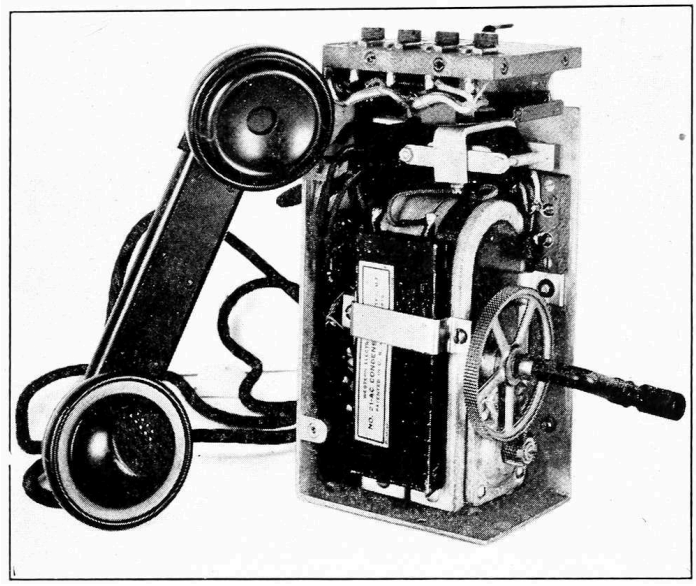
In each battalion (F. A.) there are a radio officer, telephone officer, and enlisted personnel for the maintenance of the communication system.

The Camp Telephone.

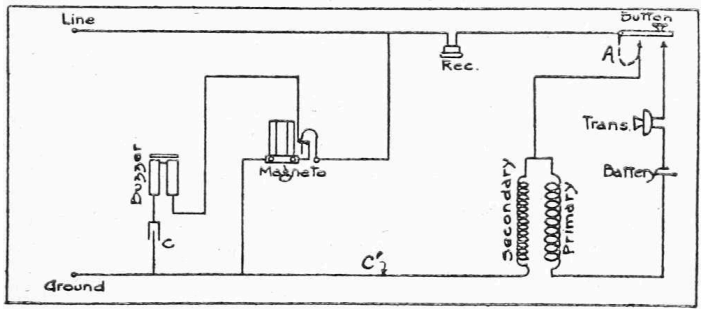
This telephone, which supersedes the field telephone, was developed by the Signal Corps for use in connection with camp telephone systems and small arms target range systems, and may be installed in tents and structures, or considered a portable instrument for use in the field for testing lines or other purposes. It is of local battery type. The battery employed is one unit of Tungston Type A which is made up of two small cells so placed in a rigid paper that they are connected in series. The combination gives a total voltage of 3—1½ being normal voltage of each cell. The instrument is made as compact as practicable and is contained in an oak case 4¼ × 7 × 10" high. The top consists of a metal hinged cover with circuit diagram on inside, held rigid when closed by a spring snap which can be readily released by depressing a button. The bottom of the case is covered by a flanged piece of metal, the flange projecting approximately one-half inch up sides of case. Through one side of the case are six three-eighths inch holes which are covered on the outside by a close mesh metal screen held in place by a metal frame. These apertures are for the purpose of allowing the ringer to be distinctly heard. The case is equipped with a substantial, adjustable carrying strap, each end of which is fastened to the case by means of hinged metal rings. A small 3-bar magneto

generator, small ringer, induction coil, aluminum chamber for the single unit of tungston Type A dry battery, hard rubber block upon which are mounted line binding posts, plug connections for the handset used with the instrument, hook switch and hook operating it and auxiliary battery binding posts, are all mounted on a common base which may be readily removed from case after removing magneto generator crank, metal housing for it and three screws which extend through the case. The instrument may be operated with cover closed which is highly advantageous in inclement weather. To accomplish this there is a suitable opening for leading out the 3-conductor cord to receiver and transmitter, the two latter being mounted in the form of a unit, termed a handset. This handset consists of a transmitter and a receiver mounted on a metal piece and is so designed that when the transmitter is normally placed to the mouth, the receiver is automatically adjusted to the ear. The hook of hook switch is so designed that it protrudes through the case. When it is desired to transport the instrument or to remove the base upon which is mounted all parts of the instrument, it is merely necessary to depress the hook and push it toward the base. By this arrangement the hook is not only held in the down position thereby opening the battery circuit, but it is also protected. The aluminum chamber for housing the single unit of tungston type A battery is equipped with a spring catch so located that when upper hinged piece is depressed to proper position, the battery compresses a helical spring, thereby insuring continual contact. The base is equipped with two screw binding posts which may be used to connect leads to an outside battery in the event of there being no tungston type A batteries available. An

aluminum frame which is supported on the base previously mentioned forms a compartment for the handset when instrument is being transported. When the instrument is installed for a temporary period, unless in actual operation, the proper place for the handset is hanging on hook of hook switch, there being a ring on the handset for this purpose. A small screwdriver which will fit practically all the screws used in the construction of the instrument is supported by the metal frame and is furnished with each instrument. The instrument complete weighs about 11 pounds.



THE CAMP TELEPHONE.



CAMP TELEPHONE WIRING.

The Monocord Switchboard.

The liaison of telephone intercommunication between army units is frequently such that a temporary, quickly installed and flexible type of small central exchange located in the field, is essential. Such an exchange is usually placed in a well protected dugout at the infantry battalion headquarters, artillery battalion headquarters, central artillery observation post, etc., where it will be the central terminal point of from four to twelve or more lines connecting with the headquarters of the higher command, with the several units working with the battalion, and with the joining similar battalions. The switchboard which has been designed to meet these requirements is called the “monocord switchboard” and is made up of either four, eight or twelve of the type EE-2 switchboard units.

The monocord switchboard is made up of unit panels, on each of which is mounted all the apparatus needed for the central exchange end of one telephone line. These panels are made of insulating material and are mounted in special

wooden frames in groups of four, eight and twelve units, according to the size of the installation necessary. The two sizes most commonly used in overseas work are the four unit and twelve unit boards. Each unit is removable from the frame, thereby lending flexibility to the board and facilitating repair and replacement. Generally, this type of board is used only for a small number of lines as the operating facilities do not permit speedy connections, and it is always better practice to use only three lines on a four unit board and 11 lines on a twelve unit board in order to have a spare unit immediately available.

The monocord switchboard may be used with either a magneto telephone, camp telephone, field telephone Model 1917, buzzerphone or service buzzer. The operator's telephone set is not furnished as a part of the switchboard and a separate telephone set of one type previously mentioned must be supplied for this purpose.

Switchboard Frame.—The switchboard frame is made of hard wood, varnished in order to make it moisture proof. Its function is to hold the various units together and to protect them from dust and mechanical injury. In the back of the frame there are three horizontal brass bars extending the width of the board. In addition to providing a mechanical support for the various units, the top bar serves as a common ground connection and the middle and bottom bars as common night bell and battery connections for all units. Three Fahnestock clips on American made boards and binding posts on French made boards are installed at the top of the frame and four at the bottom. On the French made boards the upper three binding posts are marked S1, S2 and T,

and are used for connecting by independent wires, respectively, the night bell and ground. The two posts at the bottom of the frame marked ZS and CS are used for connecting the two poles of the night bell battery. To the other two marked P1 and P2 are connected the operators telephone and the operators plug. The terminals at the top of the American made boards are marked A, A1 and G, corresponding with the French S1, S2 and T, and those at the bottom are marked B, B1, L1 and L2, corresponding to ZS, CS, P1 and P2, respectively.

If two or more multi-unit boards are connected in parallel for operation at one exchange, the interconnections between boards in order to use one ground, one night bell and one battery for the whole exchange are made. The corresponding binding posts at the top and bottom of the frames are simply connected to each other, as S1 and S2 of No. 1 board to S1 and S2, respectively, of No. 2 board.

Unit Panel.—Each unit comprises all the necessary apparatus for the exchange terminals of one line (two wires). The various parts are listed below according to their position on the panel from top to bottom:

Two connecting blocks for the line wires.
Lightning arrester between these blocks.
Two fuses.
Line number plate.
Line drop signal and night bell contact.
Jack.
Cord and line plug.

Each unit is held in the frame by means of two machine screws, one at the top and one at the

bottom of the unit, which engages the brass bars in back of the board and hold the unit firmly in place. Rigidity of construction is essential, as constant use and transferring from one place to another tend to loosen the units from the frame and disturb the sensitiveness of the adjustment of the line drop.

Lightning Arrester.—The lightning arrester is a simple toothed washer held against the panel by the supporting screw. This screw is grounded through the upper brass bar. If lightning comes in on the line wires, the main portion of it jumps the small air gap from the binding post to the grounded washer and thence passes to the ground, so that only a small portion of the high frequency current flows through the switchboard apparatus. If the latter portion is at all heavy, the fuses burn out, opening the circuit through the switchboard with a much wider gap, and hence higher resistance than that in the circuit to ground across the arrester.

Line Fuses.—Two glass enclosed removable fuses, which fit into spring connections, are provided to protect each side of the line from excessive currents. In order that burned out fuses may be readily seen, the panel is painted white behind them. The glass is usually smoked up more or less when a fuse burns out and this against the white background is easily noticed.

Line Number Plate.—The line number plate is a small white celluloid strip on which the line number is written. This number may easily be erased if it is necessary to change it.

Line Drop Signal.—The line drop signal consists of a shutter held normally in a vertical position by a brass trip latch. This trip latch is attached to the armature of a small electromagnet which is normally

connected across the line through the anvil and the jack tip contact spring of the switchboard jack. When the coils of the magnet are energized by a current sent over the wire from a calling station, the armature and trip latch are lifted, thereby releasing the shutter, which falls by gravity to a horizontal position and attracts the attention of the operator. The electromagnet is adjusted to operate on a very small current. For locking the shutter in the vertical position and protecting it from mechanical injury during transport, a flat spring lever is provided which may be turned up from a pivot at one end to press against the shutter.

Night Bell Spring Contact.—The night bell contact is located in the back of the panel. The battery and bell circuit through this contact is closed when the line signal drop shutter is released by the electromagnet, this forcing the spring back against the contact point. The night bell spring contact consists of a narrow flat brass spring, screwed at one end to the drop mounting plate. The contact point is mounted on the back of the panel, the rear end of this rod making contact with the night bell bus bar, against which the rod presses when the panel is screwed in place on the bars along the back of the switchboard.

Switchboard Jack and Line Plug.—Each unit is provided with a jack and plug. The jack consists of a cylindrical opening in the panel of the unit, behind which are arranged the tip contact spring, the sleeve contact spring and the anvil. The tip spring is connected through one of the fuses to one of the line wires. The anvil is connected to the other line wire through the electromagnet coils and the other fuse. The magnet circuit is normally closed across the line

when there is no plug in the jack, as the tip spring and the anvil are then in contact. A current coming in over the line, then, would energize the coil. The sleeve spring of the jack is connected directly to the same line wire as the anvil, the line plug is bridged across the tip and sleeve contact spring. It is a standard two-contact type, the tip and the sleeve making direct connection to the line.

Operators Equipment.—Any equipment which is not individual to a line, but which is used in common to all lines in the process of interconnection, is called the operator's equipment. This consists of an ordinary telephone set, employing either magneto or buzzer and including a transmitter, receiver, induction coil, generator, battery and connection, together with the wiring and the associate parts necessary to co-ordinate them with the rest of the apparatus. An operator's equipment also includes a night bell and battery.

Carrying Case.—Carrying cases made of fiber and provided with hand straps are furnished with monocord switchboards to provide a convenient means of carrying them and to protect them from damage during transportation. These cases are made so that they will hold not only the frame with the assembled unit, but also the switchboard cords. To move the board it is necessary to disconnect the night bell battery, the night bell, the ground connection, the operator's set and the several line wires.

Care and Adjustments.—Care must be exercised when a board is installed to make sure that the frame is in a vertical and level position. When assembled at the factory, all adjustments are made with the board in a vertical position and all operations conductive to

satisfactory service depends on this prerequisite being observed. The line signals of the monocord switch boards are of the gravity type and require careful adjustment. Any adjustment further than that done at the factory should be made by an expert who is thoroughly familiar with this work. During transportation and installation of this board, the line drop shutters should be held closely by the flat springs previously described. The burning out of a fuse when excessive current comes in on a line that is detached by an open circuit on that line. A bad fuse generally shows plainly against the white background on the panel. However, if it is not possible to see whether or not the fuse is burned out, the line may be short circuited momentarily by means of a piece of bare copper wire placed across the two line terminals. The operators is then inserted in the jack of the unit under test, and the magneto crank turned. If the fuse is burned out, the crank will turn over easy; if not, it will turn hard, indicating that the open circuit is elsewhere on the line. A burned out fuse should be replaced immediately in order to keep all lines working. Several spare fuses should be kept on hand at all times but in case no fuse is available, a strand of small copper wire may be connected across the upper and lower fuse clips. To remove a fuse, take the bottom metal cap of the fuse between the thumb and finger and push upward against the spring holder on the line terminal block, at the same time pulling outward. To install a fuse, hold it in the same manner and put the other end of the fuse in the upper spring contact, forcing it upward until the bottom ends slip into place. Care should be taken to keep the small air gap between the toothed washer and the line terminal clean. If this precaution is not taken, and the air gap is

allowed to clog up with dust and dirt, it will introduce a leak to ground or between wires with resulting poor transmission. All mounting screws and all wire connections should be kept tight. Whenever the unit is damaged, it should be replaced by another one, the damaged unit being sent back to headquarters for repair. In this connection it should be noted that the American unit panels and parts have been made interchangeable with the French to facilitate repair. To remove a unit from the frame, it is only necessary to disconnect the line terminals and remove the top and bottom screws which engage the brass bars behind the board. In handling the switchboard cords, they should be grasped by the plug, not by the cord. The connection of the wires to the tip and sleeve of a plug will break, is subject to undue strain or abuse, and by taking hold of the plug while inserting it and pulling it out, the likelihood of breaking the internal connections and wearing out the wires will be reduced to a minimum.

Disadvantages of the Monocord Switchboard.

1. It does not afford as quick connections as the by-cords switchboard type.

2. It is not self-contained. A self-contained switchboard includes operators, receiver and transmitter and ringing and night alarm circuits.

3. The operator's telephone is usually equipped with a hand set, (receiver and transmitter) which leaves him with only one free hand for making connections.

4. One switchboard is equipped with but one

master, or operators cord, this affords only one means of answering and calling.

Advantages of the Monocord Switchboard.

1. Small, compact, light weight.

2. Simple wiring.

3. Quickly installed.

4. Particularly suited for small central exchanges.

5. Units can be removed quickly, in case of trouble in interior circuits. Any unit can be removed without disturbing other units.

Common Faults and Remedies of the Magneto Telephone.

The most common trouble in telephone instruments are due generally to one of three causes. (1) Loose or dirty connections at the binding posts of the instrument, at the binding posts of the batteries, or in joints of the line wires, (2) exhausted, poor, or weak batteries, (3) crossed, open, or defective wires. These troubles, of course, do not include those arising from inferior or defective instruments. If the connections are dirty, corroded or greasy, scrape the wires and clean out the binding posts, then screw the wires firmly in place. If the telephone does not then work properly, examine the batteries and see whether they are run down or whether the zincs are eaten away. With wet batteries, it may be possible that the water has evaporated; in dry batteries, the zincs may be eaten through or the batteries may be otherwise defective. The simplest way to test a battery is to try a new battery, and see whether it

will make the telephone work properly; if it does, the trouble is with the old battery. If the trouble is present after changing the battery, examine the line connections and the line outside; if any loose connections are found, correct them at once. When inspecting the line outside see that it does not touch anything except the insulators, and that it is neither crossed nor broken. On grounded lines—grounded lines are obsolete now in modern warfare on the account of the many means of detecting and picking up messages now employed; in fact the metallic circuit telephone lines are now used within a mile of the front lines except for messages which would be of no value to the enemy—examine the ground connections the first thing and see whether it is in good condition, and if a plate is used see that it is in moist ground. The frequent trouble with transmitters is the frying noise; that is usually caused by induction or static electricity, and may also be caused by loose connections.

1. Open Line.
   - Effect: Cannot receive a call or get central.
   - Test: Follow line with portable magneto test set and ring; if central gets ring, open is toward station or visa versa.
2. Open Battery.
   - Effect: Can hear and receive central call but cannot talk.

3.	Open primary winding.	Test: Strap out primary winding or transmitter with test receiver, and leaving the receiver off the hook at station, listen in either for click while moving switchhook up and down. If no noise be heard, battery circuit must be open, and circuit should be followed with test receiver, which will click loud where battery is found to be O. K.
4.	Open Transmitter.	
5.	Short Circuited Line.	Effect: No signal will show at magneto switchboard, and use of station instrument will be impaired and magneto will turn hard.
6.	Wet or short Circuited Instrum't.	Test: Open line and ring; if magneto still turns hard open connections one at a time, where available throughout entire winding until magneto turns freely.
7.	Line crossed with another line.	Effect: Other talking heard on the line when the receiver is off the hook. Test: Ring magneto and with central's help try to locate other party; then trace line.
8.	Open secondary winding.	Effect: Can ring and hear central ring but cannot hear in receiver although can be heard.
9.	Open receiver.	Test: Strap test receiver across open part.
10.	Receiver diaphragm missing or badly dented.	
11.	Weak battery Cells.	Effect: Can hear well but cannot be heard clearly.

		Test: Use ampere meter and see if each cell be weak.
12.	Open Bell.	Effect: Can talk and hear in receiver but bell does not ring. Test: Strap bell coils out with test receiver and listen in.
13.	Open magneto Armature Winding.	Effect: Bell rings from central but does not ring when magneto handle is turned nor can central be called. Test: Ring with another magneto or test set.
14.	Slight Short Circuit (escape) to Ground.	Effect: Can ring operator but cannot hear nor be heard clearly. Test: Open line, one line at a time, and follow circuit with test set. Escapes are due to wires touching damp walls, metal roof, or other grounded wire where insulation has been rubbed off.

Signaling by Means of Lamps.

Visual signaling by means of the lamp has been found to be very important and efficient. Experience has shown that during the first hours of a battle, particularly in an advance, before it has been possible to establish the telephone systems, the lamp has furnished the most dependable means of communication both by day and night. Even in stationary or trench warfare in sectors with well organized systems of communication, the lamp is most serviceable in transmitting short messages such as calling for a barrage, reinforcements, etc., for which arbitrary signals are used. In fact, this method

is more precise than the use of rockets and more rapid than the telephone in transmitting information covered by these arbitrary signals. For these reasons, all important telephone lines near the front are paralleled by the lamp system.

Description of the Lamps.—The signaling lamps are made in three sizes called the 14, 24 and 35 centimeter lamps. These dimensions indicate the diameter of the reflector. The 24 cm lamp consists of a portable searchlight, similar in principal to an automobile headlight, but equipped with a sighting or aiming tube on top, a hinged lid to cover the glass reflector, and a two-wire cable used to connect the batteries for operating the bulb. The battery comprises eight dry cells in series, carried in two leather pouches, each holding four cells. These pouches are attached to a leather belt supported by shoulder straps. The belt has also an additional pouch in which three extra lamp bulbs are carried. A brass push button which projects through this pouch is used as a key in completing the battery and lamp circuit to make signals of short and long flashes. Connection between the lamp and battery is completed by the two wire cable and the plug and socket connector. The complete apparatus, comprising the lamp and the belt and three spare light bulbs and eight dry batteries, is furnished in a wooden carrying case. The 14 cm lamp is similar to the 24 cm, but smaller, using a battery of four dry cells and being slightly different in the manner in which it is carried. The 14 cm lamps come three in a wooden case with extra batteries and lamp bulbs. The 35 cm lamp is a larger model of the 24 cm lamp, is not as readily portable and employs a storage battery. it is used only for permanent installations.

Method of Operation. The lamp and battery circuit is completed by means of the plug and socket connector. The lid covering the reflector is then opened and the operator sights through the tube to locate the station with which he is to communicate, and signals by means of the push button key. It is essential that the lamp be held rigidly and the sighting tube be continuously aimed exactly at the receiving station during signaling. A slight movement of the lamp makes the signals appear blurred or entirely invisible to the receiving station. A lamp station should always be located in the shade or protected from direct sun rays, which would otherwise produce a continuous glare from the reflector and make the electric light signals invisible. A lamp may be held in the hand while signaling or fastened to anything that will aid stability. In permanent and semi-permanent stations an arrangement for holding the lamp in a fixed position, directed at the receiving station, should be installed. In addition, a wooden tube tapering down in size toward the outer end and being 6 ft. to 9 ft. long and approximately the size of the lamp at the inner end, should be constructed and also permanently aligned on the receiving station. This reduces the diffusion of the rays of the lamp, and also minimizes the possibility of the signals being read where not intended.

Adjustments of Lamps.—The reflecting apparatus of a lamp is carefully adjusted before it is issued. However, it is possible that a slightly different adjustment will give better results when a new bulb is inserted. To focus the lamp the light is flashed on some dark background, such as wall a few yards away, and the screws supporting the parabolic mirror carefully turned until the light becomes

concentrated in the smallest possible circle. The adjustment screws are then tightened, but they should never be set tight. If the receiving operator is having trouble in receiving signals, he will inform the sending station by sending a series of dots. The sending operator will then examine his apparatus to see if the lamp is properly directed at the receiving station, if the reflector is out of focus, or if the battery has become weak. The receiving operator indicates the manner in which he is receiving the signals by the method in which he sends the dots. If the signals become worse, the dots are made more rapidly. As the adjustment becomes better, the dots are made more slowly. When a good readable adjustment has been obtained, he will signal BR, meaning “go ahead.”

PRECAUTIONS IN LAMP SIGNALING.

Don’t leave the lamp cover open when not in use.

Don’t forget to open it when you start to transmit.

Don’t touch the mirror. If necessary, it should be cleaned by wiping with gauze or cotton or wiped with clean water.

Don’t pull the wire cable fastened to the bottom of the lamp when removing from the box.

Don’t return broken or burned-out globes to the pouch, but throw them away unless ordered to turn them in. Don’t use the lamp for illuminating purposes.

Don’t neglect to keep a constant watch on the stations with which you are supposed to communicate.

SIGNALING RANGE OF LAMPS.

	Day.	Night.
14 cm	1 to 3 kilometers	2 to 6 kilometers.
24 cm	1 to 6 kilometers	3 to 10 kilometers.
35 cm	5 to 10 kilometers	8 to 15 kilometers.

Signals may be transmitted by using either white or red bulbs, but the range when using red bulbs is reduced approximately 50%.

GENERAL SERVICE CODE AND CONVENTIONAL SIGNALS FOR USE WITH PROJECTORS, BUZZERS AND WIGWAG.

A .-	G --.	M --	S ...	Y -.--	5 .....
B -...	H	N -.	T -	Z --..	6 -....
C -.-.	I ..	O ---	U ..-	1 .---	7 --...
D -..	J .---	P .--.	V ...-	2 ..---	8 ---..
E .	K -.-	Q --.-	W .--.	3 ...--	9 ----.
F ..-.	L .-..	R .-.	X -..-	4 ....-	10 -----

Manner of Sending Messages.

Messages are sent by using the General Service Code and should always be as short as possible. Every time a letter can be omitted, the chance of error is reduced. A dot is made by a short flash of about ½ second duration. A dash is a longer flash of about two seconds duration. The interval between dot and dash is about ½ second duration. The

interval between letters is about 2 seconds duration. The interval between words is about 4 seconds duration. In order that lamp signals may be easily read, it is necessary that the signals be not too rapid, 15 to 20 characters per minute should be taken as the upper limit. Successive letters must be well spaced. An interval of 2 seconds between letters will enable the receiving operator to call off each letter to his assistant as he receives it. In general, two men for each shift are necessary to operate a lamp station. At the sending station one man dictates the message letter by letter, and watches the receiving station for breaks. The other sends the message. At the receiving stations, one man receives the message and calls it off by letter to his helper who writes it down. To call a station, its call letter should be sent several times and at intervals the station calling should signal its own call letter. As soon as a station observes that it is being called, it will answer by signaling its call letter and the signal BR, “go ahead.” The message is then transmitted and the receiving station acknowledges receipt of each word. By one dot, if it has been understood. By the interrogation mark, if it has not been understood and repetition is desired. (While the interrogation is official, two dots are invariably used for this signal.) At the end of a message the sending station signals AR, meaning, “end of message.” The receiving station sends a dot if the message has been understood.

Signaling by Means of Fireworks.

The use of fireworks in modern battles for sending signals has been greatly developed and is now one of the most important means relied upon to send a few fundamental signals from the front line of the

infantry to the supporting artillery within the division and between the ground and the airplanes.

The Fireworks Code.

As the signals that are made by fireworks are always of the most important character, it is essential that the system for their use be so perfectly worked out that there will be no chance of confusion. The smaller the number of signals to be sent by fireworks, the less chance there is of confusion.

Classification of Fireworks.

The fireworks now being used by the American Army are divided into the following classes:

1. Very Pistol cartridges.
2. VB cartridges (commonly called “Tromblons”).
3. Rockets.
4. Flares.

The complete directions for firing these various fireworks are generally attached to the container or box in which they are packed. They are fully discussed in Annex 14, Translation of the 1917 “Instruction on Liaison for Troops of all Arms, A. E. F.”

1. Very Pistol Cartridges.

The Very pistol cartridges are made in two sizes, a 25-mm size, which is issued to the companies of infantry, and a 35-mm size, which is used by the airplanes. These Very pistols fire both signal and

illuminating cartridges.

2. VB Cartridges.

The VB cartridges are fired from a cylinder which is attached to the end of a rifle. This cylinder, on account of its resemblance to the old-fashioned blunderbuss (which the French call “Tromblon”) has taken the name of tromblon and now even the VB cartridges, which are fired from this cylinder, are often spoken of as Tromblons.

3. Rockets.

The rockets comprise fireworks which are made in the form of cartridges attached to a wooden stick and fired from a tube or trough. They are used both for signaling and illuminating.

4. Flares.

Flares are used only in the front lines to mark the position of the advanced troops when called for by an airplane.

THE USES OF VARIOUS CLASSES OF FIREWORKS.

It will be seen that the above classification of fireworks is an arbitrary one, made according to the method of projecting them. The same signal can be made by several different means. The means employed depend upon the type of fireworks issued to the particular unit using them and also upon the distance through which the signal must be read.

Flares are not projected at all and consequently have the most limited range of visibility in any but a perpendicular direction.

The 25-mm Very pistol projects its signals about 200 ft. and can be seen from the immediate vicinity.

The tromblon projects its signals to a height of 300 ft. and is next in range of visibility.

The rockets which project a signal at the height of 1000 ft. or over have the maximum range of visibility.

The 35-mm Very pistol projects signals which are larger than those of the 25-mm pistol, but throws them a shorter distance (about 150 ft.). As its use is confined to the airplane this is not a factor in its visibility.

The following are important uses that may be made of fireworks:

1. By the infantry platoon, company or battalion commander in signaling to the artillery for a barrage, or otherwise directing the fire of the artillery.

2. For signaling between the front line troops and the contact airplane in an advance.

3. Warning of enemy gas attack given by the fireworks signaler nearest to where the gas is discovered.

4. As a method of acknowledging various visual signals.

5. Occasionally, during the preparation of an attack and upon orders from the General Staff, fireworks may be used in liaison between the artillery and the artillery airplanes.

Signaling by Means of Panels.

The increasing use of the airplane in modern warfare has necessitated the development of reliable communication between it and the earth. This has gradually been worked out in the following methods:

1. The direct dropping of messages by the airplane.

2. The use of radio apparatus.

3. The use of visual signaling by means of lamps, fireworks and panels.

Panels are pieces of cloth or other materials of various designs which are spread out on the ground in a manner to be easily seen by the airplane. They are for three purposes.

1. To signal to an airplane the identity and location of a unit's headquarters by the use of its distinctive panel, called its "identification panel." This is displayed either when the airplane requests it (by means of radio) or when the headquarters desires to attract the attention of the airplane.

2. To signal to the airplane other brief information by the use of rectangular panels known as "signaling panels" and arranged in various ways, either by themselves or in conjunction with the unit's identification panel.

3. To signal to the airplane the position of the front line in a daylight advance by the use of special panels called "marking panels." These are displayed only when called for by the airplane.

All panels are removed as soon as an acknowledgment is received from the airplane.

As the use of panels is always in conjunction with

airplanes, all panel signallers should understand some of the uses of the various airplanes.

Miscellaneous Methods of Visual Signaling.

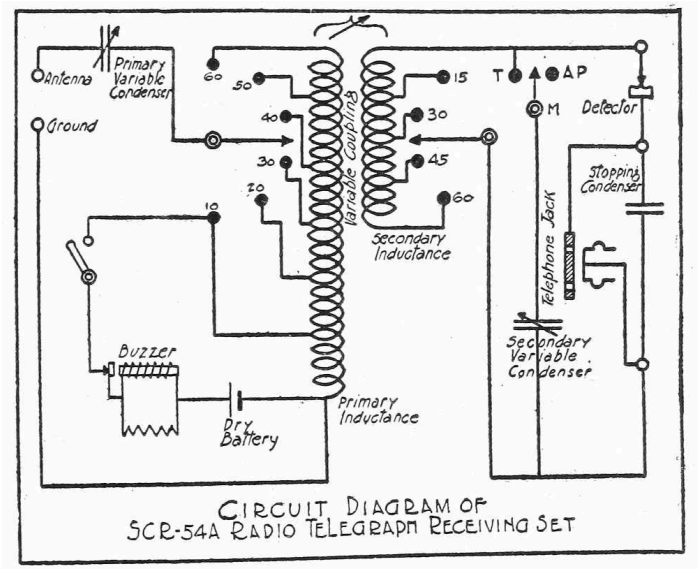
Wig-Wag Flags.—Flags for use in wig-wagging are now issued to divisions under the name of "kits, flag, combination, standard." Each kit includes one wig-wag staff and two wig-wag flags, and also two semaphore staff and two semaphore flags. A division is supplied with 1,022 of these kits. The use of the wig-wag flags is already fairly well known in the American Army. Signals are transmitted by describing an arc of 90 degrees to the right and left to form dots and dashes, and spaces by a downward front motion. The general service can be transmitted by this means. Wig-wag flag signaling should be thoroughly understood and practiced by all signal men, as it forms an excellent method for becoming familiar with the code. Signals can be sent by this means merely by the use of the hand, and consequently the system forms an excellent way for troops to put in their time when traveling by train or on shipboard. Its use in the present war has been limited, but it will undoubtedly be used more and more, especially when open warfare is resumed.

Semaphore.—Signals by semaphore are transmitted by the arms, either alone or with the semaphore flags that are issued in the standard combination flag kits. It is a standard means of communication in the American Navy and well known in the army. It is not used by the armies of Europe, but it might serve a useful purpose to linemen and others for intercommunication.

Radio Equipment.

The Radio receiving sets, type SCR-53 and SCR-54-A form the standard units for the reception on the ground of signals from airplanes, and in general, of all damped wave signals or modulated wave signals. The use for these sets may perhaps be said to be that in connection with the work of the fire control airplanes in directing the fire of the artillery. But in addition, they are used for so many other classes of radio work, that they may indeed be considered among the most important radio sets.

Type SCR-54 Set.



CIRCUIT DIAGRAM OF
SCR-54A RADIO TELEGRAPH RECEIVING SET

The type SCR-54 set is very similar to the French

type A-1 receiving set. The SCR 54-A set is an improved American product, designed along the same general lines as the type SCR-54 but differing in some respects, both mechanical and electrical, to improve the operating characteristics. The type A-2 and A-2-B antennae are fully described in Radio Pamphlet No. 2. With their use the receiving sets have a wave length range of approximately from 150 to 650 meters. If properly operated, they afford quite sharp tuning. This feature and their compact, rugged and simple construction have made them of very considerable value on the Western Front.

As shown in the wiring diagram, Fig. 1, the type SCR-54A receiving set comprises a primary (antenna) circuit and a secondary circuit, both of which may be tuned by means of the variable capacitance and variable inductance comprised in both circuits. The secondary circuit may also be made aperiodic by placing the switch M on the position marked “AP.” This connects the condenser in or disconnects it from the circuit. A separate buzzer circuit is installed in the cover of the box to excite the set when adjusting the crystal detector.

The adjustable capacitance in each circuit is a variable air condenser which is adjusted by means of an insulating handle, marked “Primary” or “Secondary,” mounted directly on the rotating shaft of the condenser. The relative amount of capacitance in the circuit, corresponding to the various positions of these handles, is indicated by a pointer fastened to the shaft, which moves over a dial graduated from 0 to 90. The position 0 corresponds to the minimum and the position 90 to the maximum capacitance of the condenser. The two condensers are identical in design, and have a maximum capacitance of 500

micro-mfd.

The primary and secondary inductances are varied by means of two dial switches marked “P” and “S,” respectively. The primary inductance comprises 60 turns of wire divided into six steps of 10 turns each, while the secondary inductance comprises 60 turns divided into four steps of 15 turns each. These two inductance coils are wound on separate wooden cylinders so arranged that their relative positions may be readily varied. The coupling of the two circuits, which is accomplished by the mutual induction effect of these two coils, is varied by changing the relative mechanical positions of the coils. The secondary coil may be rotated by means of a handle marked “Coupling,” and a pointer moving over a scale graduated from 0 to 90 indicates its position. When in the 0 position the axes of the two coils are at right angles to each other, and the degree of coupling is 0. When in the position “90” the axes are parallel, and the coupling is a maximum.

The telephone and detector circuit shunts the secondary condenser. This circuit consists of a crystal detector connected in series with the telephone receiver which are shunted by so-called stopping condensers. The latter is a .002 mfd. mica condenser. Two crystal detectors are furnished with a set; one of them is enclosed in a glass tube, which protects the crystal from dust or dirt. The other is open, having no such protecting casing. Either one may be used by screwing it to the two binding posts of the set marked “Detector.”

The buzzer is mounted in a compartment of set box cover, and consists of a small buzzer connected in series with a dry battery type BA-4, and a switch. The buzzer is energized when this switch is closed. A

spare dry for the buzzer, a screwdriver, the enclosed detector, some spare wire and spare crystals are normally stored in compartments or metal clips in the cover. Two type P-11 telephone head sets are kept in a special compartment in the box. This set box when closed may be carried by a leather strap attached to it.

Method of Operating.

The first step in putting the set in operating condition is to select a suitable place and set up the antenna. The set box is then installed in a dry and protected place, and the arial and ground (or counterpoise) leads are connected to their respective terminals on the operating panel, and the telephone head set plugged into the jack with the installation thus completed the first step is to adjust the crystal detector. To do this, place the “Coupling” handle near the maximum position, and connect the short piece of wire from the terminal clip in the buzzer circuit to the “Antenna” or “Ground” terminal of the operating panel. Close the buzzer switch to energize the buzzer, and carefully explore the surface of the crystal with the spring contact point until a sensitive spot is found, as evidenced by a good audible sound in the telephone receiver. The short wire running from the buzzer to the panel is then removed and the buzzer stopped by opening the buzzer switch. Care should be taken not to disturb the crystal adjustment by mechanical vibration or shock. This adjustment is very delicate, and if destroyed, it must be restored before any signals can be received. With the crystal adjusted, the set is then ready for tuning. The procedure varies somewhat according to whether the wave length of the station it is desired to receive is

known or not.

(a) Wave Lengths of Signals Unknown.—The switch M in the center of the panel is thrown to the position "AP" (aperiodic). This disconnects the secondary condenser, and makes the secondary circuit responsive to signals of any wave length. The coupling is made a maximum, and the secondary inductance dial switch S placed at the position "60." The primary inductance switch P is then placed successively at the positions marked 10, 20, 30, 40, 50 and 60, and, at each point, the handle of the primary condenser is slowly turned over its full range, until the loudest signals are obtained in the telephone. The station is then identified by its call letters, and if it is the station desired, tuning of the set is completed as explained below. It may happen however, that in this search for signals, several stations are heard, simultaneously or for different positions of the handles. The process of searching is kept up until the desired station, as identified by its call letters, is heard with the greatest intensity.

The coupling pointer is then moved toward the minimum position, so that the signals will be just loud enough to be easily read. The switch M is placed in the position T (tune), which connects the secondary condenser in the secondary circuit. The secondary circuit is then tuned by operating the secondary inductance dial switch S and the secondary in the same way that was followed in tuning the primary. The secondary circuit is in tune when the signals are heard loudest. The set is then ready for operation.

If necessary, the strength of the signals may be increased by increasing the coupling, but this should not be done unless the signal become too faint to be

read, since increasing the coupling increases the likelihood of interference by other sending stations. When the coupling is changed, some slight adjustments of the primary and secondary condensers will be found to improve the signals.

(b) Wave lengths of Signals Known.—When the receiving operator has been advised of the wave length of the signals he is to pick up, the process of tuning in is somewhat facilitated by the use of the table of wave lengths which is pasted in the cover of the box.

The primary circuit of the set is first tuned, as explained above, with the switch on "AP," the secondary inductance on "60" and with maximum coupling. After the signals have been identified and the primary has been tuned to give maximum loudness, the coupling is reduced as before and the switch M moved to T. The secondary inductance setting to be used is then given in the table. Thus, for a wave length of 280 meters, the setting may be 30 or 45. It is best to use the higher value 45. The final secondary adjustment is then made as before by means of the secondary condenser.

Use of a Vacuum Tube Detector with the SCR-54 Set.

It is sometimes desirable to use a vacuum tube detector in place of the crystal detector supplied with the set. In this case, the telephone stopping condenser of the set must be short circuited by inserting a dummy brass plug in the telephone jack. The crystal detector is then disconnected, and wires are connected from the detector binding posts of the set to the proper terminals of the vacuum tube

detector set. The telephone receivers should not be plugged in, as before, in the jack of the set box, but must be connected to the proper terminals or jack of the vacuum tube detector box.

Precautions, Sources of Trouble, Maintenance.

In using this set, care should be taken to always keep it in as dry a place as possible. It should be kept in a clean condition, especially the operating panel, the contacts, binding posts, dial switch studs, and the telephone jacks. Oil or grease on these contacts will make the connections uncertain and unsteady and impair or even prevent the satisfactory operation of the set.

The set should be handled carefully to avoid warping the condenser plates or otherwise damaging the set. No foreign substance should be placed in the set box. Care should be taken that the telephone receiver cords do not get wet, for the resulting leakage of current through them would considerably decrease the strength of signals and introduce an annoying noise. The telephones do not require any adjustment, and the earpieces should always be kept screwed up tight. The telephone receiver should never be taken apart, since their adjustment at the factory is very accurate and permanent. If it becomes necessary to remove the cord connections from either the telephones or the plug, the wires must be connected as found, according to their different colors. This is important since otherwise the permanent magnets will be partially demagnetized and the efficiency of the telephone receivers will be seriously impaired. In packing the set for transportation the telephone head set receivers are

placed face to face so that the diaphragms will be protected and kept free of mud and dirt. The telephone cord is then wound around the head band in such a way as to hold the receivers together. The telephone plug is finally slipped inside the coil thus formed by the connection cord, and the entire set is carefully placed in its compartment in the set box. Among the troubles most frequently encountered are those considered below. It may happen that the buzzer does not work. This may be due to a poor adjustment of the buzzer vibrator, or to a run down dry battery. If the radio does not work it may be because the crystal detector is not making contact with the sensitive spot. Readjust it with the aid of the buzzer. No sound in the receiver may be due to the fact that the telephone is not all the way in the jack, or that it is dirty. In this case see that the plug is clear in, or remove it and wipe it off with a clean cloth. Also, the dummy brass plug may be in the telephone jack. This would prevent operation entirely with the crystal detector.

Scratching noises in the telephone may be the result of wet connection cord, or the connection at the plug or either telephone receiver may be loose.

If the antenna or ground connections is loose, or if the ariel or lead in wire is grounded through a branch of a tree, or in some other way, the set will fail to operate. Make sure of good insulation all around. It sometimes happens that a wire will break inside the set box. This generally occurs to one of the wires connecting the secondary induction coils to the various taps to the secondary dial switch. One way to discover this fault is to turn the “Coupling” handle back and forth; the signals may then suddenly stop for a certain position of the handle, although they

will be audible with the handle on either side of this position. Finally, a plate of one of the variable air condensers may become warped and short circuit the condenser. This is generally evidenced by the fact that the condenser, when varied over its whole range, does not change the loudness of the signals. In active service, the receiving sets are required to be in continuous working condition. To insure this, spare parts must be kept on hand at all times in order to replace defective parts with the least possible delay. Such spare parts should include spare crystals, telephones and telephone cords. Complete extra set should always be in stock at the central Radio supply station to provide for replacement promptly when sets are destroyed. The sets in use should also be frequently tested to determine and readiness for an intensive and continuous activity. The condenser and inductance circuits should be tested to make sure that each part of each circuit is in perfect working condition. Testing of circuit parts may be simply done with a head phone and dry cell, a click through closed circuits, and the absence of a click through the condenser circuits, being the indication which should be noted.

CHAPTER XVI.
SMALL ARMS.

Notes on the Automatic Pistol, Cal. 45, Model 1911.

The pistol is known as the Automatic Pistol, Cal. 45, Model 1911. By caliber is meant the caliber of the bore. All pistols used in the service are marked on the left side of the receiver, "United States Property," and on the right side with the serial number, which must be memorized by the person to whom the pistol is issued.

It is important that every man have a thorough knowledge of the nomenclature, care and repair, method of assembling and dismounting the pistol as well as its use and operation.

The principal parts of the pistol are the *receiver, the barrel and the slide*.

To Dismount and Assemble the Pistol:—Press the magazine catch and remove the magazine. Press the plug inward, turn the barrel bushing to the right and by easing off on the spring let the plug and spring protrude gradually. Draw the slide to the rear until the small recess is opposite the thumb piece of the slide stop. Press gently against the end of the pin of the slide stop on the opposite side and remove the slide stop. This releases the link and allows the barrel and the slide with all its parts to be slid forward off the guide rails of the receiver.

To Disassemble the Slide:—Remove the plug by turning it to the left and withdraw the recoil spring with its guide from the rear; or remove the recoil spring guide and withdraw the coil spring with its plug from the front. Turn the barrel bushing to the left and withdraw it forward from the slide. The barrel may now be withdrawn from the slide. To remove the firing pin, press the rear end of the pin forward until it clears the firing pin stop. Then withdraw the stop downward from its seat, whereupon the firing pin, the firing pin spring, and the extractor are removed by withdrawing them to the rear.

For ordinary cleaning, no further dismounting will be found necessary and no disassembling of the receiver should be permitted except by permission of an officer. When the interior of the pistol has been exposed to water, or when it is desired to make repairs, the receiver may be completely dismounted as follows:

Cock the hammer, move the safety lock to a position half way between its upper and lower position. Press the end of the safety lock pin on the opposite side and withdraw the safety lock. Now lower the hammer by pressing the trigger. Push out the hammer pin and take out the hammer and strut. Next push out the housing pin. This may require a little extra pressure. It is the only pin pushed out by pressure from the left side of the receiver. The main-spring housing may then be withdrawn downward and the grip safety withdrawn to the rear. This exposes the sear spring, which is easily removed. By pushing out the sear pin, the sear and the disconnector are released.

The main-spring housing is disassembled by

compressing the main spring, pushing out the small main-spring cap pin, whereupon the main-spring cap, the main spring and the housing pin retainer will come out. The main spring may be easily compressed by using the pin of the slide stop.



THE AUTOMATIC PISTOL, CALIBER 45, MODEL 1911.



RECEIVER, BARREL AND SLIDE.

To remove the magazine catch, press the button inward. By means of a small screw driver or the short leaf of the sear spring, give the screw head of the magazine catch lock a quarter turn to the left and remove the magazine catch. The trigger can then be withdrawn to the rear.

The hammer strut, a small nail or the long arm of the screw driver may be used to push out all pins

except the main spring cap pin and the ejector pin. To remove these a tack or pin may be found necessary.

To assemble the pistol proceed in the reverse order, except that the main spring housing should be left to project about one-eighth inch. Do not push the main-spring housing home and insert the housing pin until after the safety lock is replaced and the hammer lowered.

The Operation of the Pistol.—The act of drawing back the slide in loading cocks the hammer, compresses the recoil spring, permitting the magazine follower to raise the upper cartridge into the path of the slide. Upon releasing the slide, the recoil spring forces the slide forward, carrying the first cartridge into the chamber of the barrel. As the slide approaches its forward position, it encounters the rear end of the barrel, forcing the latter forward. Since the front of the barrel pivots in the barrel bushing and the rear end is free to swing upward on the link, the rear end of the barrel is raised, causing the locking ribs on the outside of the barrel and the inside of the slide to engage, thus positively locking the barrel and the slide together. The joint forward movement of the barrel and the slide (about three-eights of an inch) is stopped when the barrel lug encounters the pin of the slide stop.

The pistol is then ready for firing. When the hammer is cocked, the hammer strut moves downward, compressing the main spring. The sear, under the action of the long leaf of the sear spring, engages its nose in the notch of the hammer. Upon pulling the trigger and pressing on the grip safety, the sear is moved, thus releasing the hammer. The latter then strikes the firing pin which transmits the

blow to the primer of the cartridge. The explosion of the cartridge generates the necessary gas pressure to force the bullet through the barrel, the initial muzzle velocity being about 800 ft. per second. The pressure exerted to the rear against the face of the slide carries the latter and the barrel to the rear together. But due to the link attachment, the barrel is almost immediately swung down and unlocked from the slide, leaving the slide to continue its movement to the rear, thus opening the breech, cocking the hammer, extracting and ejecting the empty cartridge and compressing the recoil spring. When the slide reaches its rearmost position the magazine follower raises another cartridge into the path of the slide. This cartridge is then forced into the barrel by the forward movement of the slide as before described.

Although it might be supposed that the downward swinging of the barrel would affect the accuracy of the fire, this is not the case. The bullet has gained its maximum velocity and passed out of the muzzle before the unlocking movement between the barrel and slide commences.

When the magazine has been emptied the magazine follower is free to press against the projection on the slide stop, thus forcing the slide stop into the front recess of the slide, thereby locking the slide in the open position and reminding the person firing that the empty magazine must be replaced before firing can be continued.

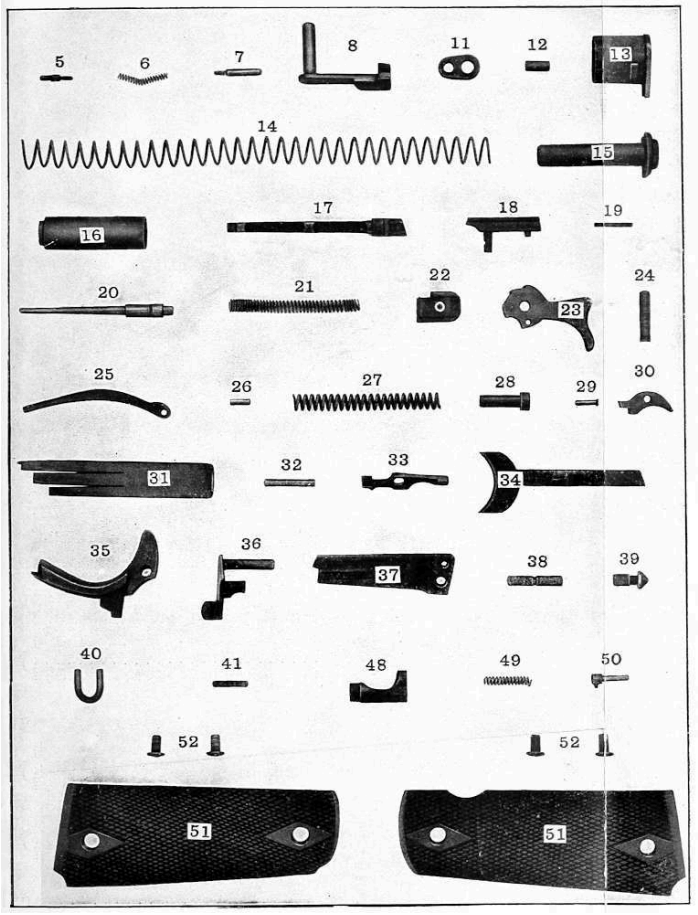
Interesting Facts about the Pistol.

(a) Weight 2½ pounds. Trigger pull, about 7 pounds.

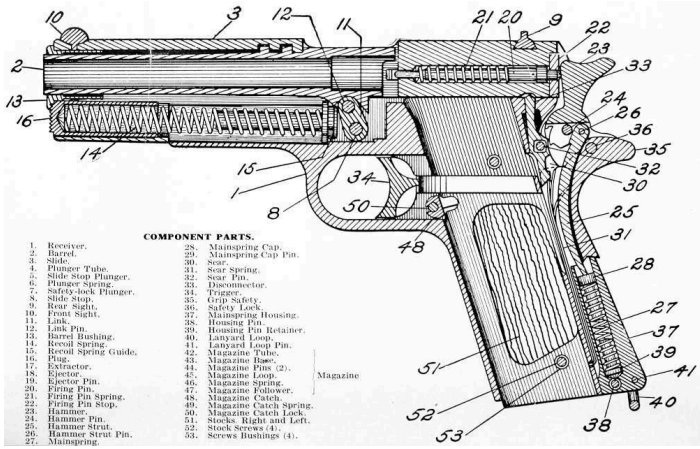
(b) Rifling, 6 grooves with left-hand twist. The

drift due to the rifling is therefore to the left, but this is more than neutralized by the pull of the trigger when the pistol is fired from the right hand.

(c) For ranges up to 75 yards the trajectory is very flat and the drift slight, giving the pistol great accuracy.



COMPONENT PARTS.



COMPONENT PARTS.

1. Receiver.
2. Barrel.
3. Slide.
4. Plunger Tube.
5. Slide Stop Plunger.
6. Plunger Spring.
7. Safety-lock Plunger.
8. Slide Stop.
9. Rear Sight.
10. Front Sight.
11. Link.
12. Link Pin.
13. Barrel Bushing.
14. Recoil Spring.
15. Recoil Spring Guide.
16. Plug.
17. Extractor.
18. Ejector.
19. Ejector Pin.
20. Firing Pin.
21. Firing Pin Spring.
22. Firing Pin Stop.
23. Hammer.
24. Hammer Pin.
25. Hammer Strut.
26. Hammer Strut Pin.
27. Mainspring.
28. Mainspring Cap.

29. Mainspring Cap Pin.
30. Sear.
31. Sear Spring.
32. Sear Pin.
33. Disconnector.
34. Trigger.
35. Grip Safety.
36. Safety Lock.
37. Mainspring Housing.
38. Housing Pin.
39. Housing Pin Retainer.
40. Lanyard Loop.
41. Lanyard Loop Pin.
42. Magazine Tube. }
43. Magazine Base. }
44. Magazine Pins (2). }
45. Magazine Loop. } Magazine
46. Magazine Spring. }
47. Magazine Follower. }
48. Magazine Catch.
49. Magazine Catch Spring.
50. Magazine Catch Lock.
51. Stocks, Right and Left.
52. Stock Screws (4).
53. Screws Bushings (4).

(d) Beyond 250 yards the trajectory is very curved and the drift becomes considerable. Firing is therefore very inaccurate.

(e) To hit a target at ranges over 75 yards it will be necessary to lay on a displaced point above and to the right of target for ranges approximately as follows:

Range, Yards.	*Vertical Displacement.*	*Lateral Displacement, right.*
100	½ yard	½ yard
150	1½ yards	¼ yard

200	3 yards	1 yard
250	5 yards	2 yards

(f) The striking energy of the bullet is sufficiently great to surely disable a man by causing a dangerous wound at all ranges up to 500 yards.

(g) The pistol has been fired by experts at 25 yards, aimed fire, at the rate of 21 shots (3 magazines) in 30 seconds. Such rapidity is, however, not necessary or desirable in service firing. Accuracy is always the first consideration.

Precautions.

1. Whenever the pistol is taken out of or returned to the arm rack, also both before and after drill or other exercises with the pistol, remove the magazine and see that it is empty. Then draw back the slide which will eject any cartridge in the chamber. Finally look through the bore to see that the pistol is unloaded and the bore not obstructed by a plug or wad. Replace all parts, come to raise pistol and lower hammer.

2. Never place the trigger finger within the trigger guard until it is intended to fire and the pistol pointed toward the target.

3. Do not carry the pistol in the holster with the hammer cocked and the safety lock on, except in an emergency.

4. Always press the trigger with the forefinger.

5. After each shot relieve the pressure on the trigger so that the sear may re-engage.

6. When inserting the magazine be sure that it

engages the magazine catch. Never insert the magazine by striking it smartly; always apply a continuous push.

7. The pistol must be kept clean, free from rust and properly oiled.

8. Never disassemble the receiver except by permission of a officer.

9. In disassembling the receiver be sure that (a) the disconnector and sear are properly assembled; (b) that the hammer is not snapped when the pistol is partially assembled; (c) that the stocks are not removed; (d) that no hammer is used in either assembling or disassembling.

Care and Cleaning of the Automatic Pistol.

In **cleaning** the barrel of the automatic pistol after firing proceed as follows: Swab out the bore with soda solution to remove powder fouling. Remove and dry with a couple of patches. Examine to see that no patches of metal fouling are in evidence, then swab out with the swabbing solution—a dilute metal-fouling solution. The amount of swabbing required with the swabbing solution can be determined only by experience assisted by the color of the flannel patches. Normally a couple of minutes' work is sufficient. Dry thoroughly and oil with sperm oil.

The proper method of **oiling** a barrel is as follows: Wipe the cleaning rod dry; select a clean patch and thoroughly saturate it with sperm or light slushing oil, being sure that the oil has penetrated the patch; scrub the bore with the patch, finally drawing the patch smoothly from the muzzle to the breech, allowing the cleaning rod to turn with the rifling.

The bore will be found now to be smooth and bright so that any subsequent rust or sweating can be easily detected by inspection.

The principles as outlined above apply equally well for the care of the barrel of the sub-calibre cartridge.

MACHINE GUNS AND AUTOMATIC RIFLES AS EMPLOYED BY THE ARTILLERY.

The field artillery employs machine guns and automatic rifles only defensively, either against hostile aircraft, or against enemy infantry in case of a break-through. For this reason the tactical use of these weapons by the artillery is considerably different from that by the infantry, and the dispositions that must be made are adapted to particular needs.

The field artillery must defend itself:

(a) On the march.
(b) In position.
(c) At the echelon (horse-lines).

Defense on the March.

1. Machine Gun.

Machine guns may be used on the march in case of surprise attack or against low-flying aeroplanes. Fire on roads and convoys from low-flying aeroplanes has been developed to such an extent that it is imperative at all times for a column to be prepared to defend itself against such attacks.

1. When a battery is in the advanced zone, one

machine gun is mounted on a special mount on the second caisson of the fifth section. This gun is kept ready for fire at all times, the loaded belt if it is a Browning, being kept in the loaded position. About 500 rounds Cal. 30 ammunition are carried on the caisson. The machine gunner in charge of the gun marches with the 5th section.

A mechanic can very easily modify the special mount for the Browning, for use against aircraft, so that it also will be adaptable for use on the caisson.

One gun is attached to the fifth section, so that on subdivision of the battery for action, the other gun will be with the Combat Train or echelon, being carried in the battery wagon or the park wagon.

The second gun may be carried stored in the battery wagon or on escort wagon. In position warfare the firing battery goes into position usually at night. The escort wagon then goes up with tools, officers' rolls, etc. and the machine gun with its special mount, the regular tripod, and about 2000 rounds of ammunition. If not carried as stated, provision must be made for carrying the gun with the firing battery.

2. Automatic Rifles.

The automatic rifles are assigned one to each section.

All eight automatic rifles should be in readiness for instant use when on the march. They should be evenly distributed throughout the battery, and handled by men who have had special training. At least two magazines per gun (40 rounds) should be instantly available. While it is difficult to bring down a plane with a machine gun or rifle, a well directed

fire will limit the action of hostile planes.

It should be borne in mind that often when in the advanced zone friendly aeroplanes are detailed to guard a battery on the march. Great care must be taken to make no mistakes in identifying aeroplanes. Never shoot at a ship unless the distinctive markings on the wings are clearly distinguished and identified. Upon subdivision for action, the automatic rifles go with the section to which assigned. This, of course, may be varied according to the situation.

(B.) Defense of the Position.

The machine gun emplacement should be carefully selected and constructed. The first consideration is a good field of fire; the second is good concealment.

Usually it is placed on a flank of the battery. Situated on the flank of the battery, a greater field of fire is obtained for the gun. Moreover when firing against hostile airplanes, the position of the battery will not necessarily be disclosed. In case the battery is shelled, the position of the machine gun on the flank renders it less liable to be hit.

The emplacement for a machine gun at a battery position differs from those generally built by the infantry in that it is designed primarily for anti-aircraft shooting.

There can be no overhead cover, all protection being provided by well constructed concealment. Camouflage must be arranged for and so placed that it can be instantly thrown aside for firing.

The plans for close defense of the battery should include the assignment of positions and sectors of fire for the automatic rifles.

The methods of fire and the technical points involved, in firing against hostile airplanes, will be considered elsewhere. A sentinel equipped with a pair of field glasses must be on duty in the emplacement at all times. The members of the machine gun squad are detailed for this duty by roster.

Types of Anti-Aircraft Mounts.

The Ordnance Department furnishes no anti-aircraft mount, but improvised mounts can be easily made.

BROWNING MACHINE GUN—MODEL 1917.

The Browning Machine Gun, Model 1917, is water-cooled and is chambered for caliber .30 U. S. Standard Rifle Ammunition. The gun is classed as a heavy water-cooled gun, recoil operative and belt fed.

The water jacket holds about 7 pints of water and is perfectly smooth on its interior. The steam escape tube is in the top of the water jacket, and is made up of two tubes. They slide one upon the other, the outer one being a little shorter than the inner one. This allows the outer tube to slide toward either end and uncover the highest steam escape hole. The force of recoil is utilized to perform the various mechanical operations of feeding in the cartridges, loading, cocking, firing the gun and ejecting the empty shells through the bottom.

The several cams of the gun make each moving part of the gun have a positive motion.

The feed belt is made of woven fabric and has no metal parts to cause feed jams and to add extra weight to the piece. Also the metallic disintegrating links are used with the aeroplane gun. The fibre belt usually contains from 250 to 500 rounds. The metallic belts can be made to contain any number of rounds desired.

The gun has very few screws and springs. It is composed of about forty parts which may be taken down in the field. There are a few parts which can be assembled incorrectly and it cannot be determined that they are so assembled until the gun is ready to be put into action. At this point the gunner will find that the gun will not operate, therefore great care should and must be used in the study of a quick and positive assembling.

The weight of this gun is about 30 pounds without water. This weight makes it necessary to use the gun on a tripod or other suitable mount.

General Data.

Weight of the gun—no water	30 lbs.
Weight of the gun filled	36.75 lbs.
Weight of the belt, 250 rounds	15.25 lbs.
Length of the barrel	24 in.
Weight of the belt, empty	7.5 oz.
Sight graduated to	2800 meters.
Rate of fire (shots per minute)	400-525.
Aimed shots per minute	120.
Calibre of bore	.30 in.
Weight of bullet	150 grs.
Weight of cartridge	394 grs.
Chamber pressure lbs. per sq. in.	47,000-50,000.
Muzzle velocity (ft. per sec., theoretical)	2700.

THE BROWNING AUTOMATIC RIFLE.

General Description.

The Browning Automatic Rifle, Model of 1918, is chambered for the United States standard ammunition. This rifle is classified as a light automatic rifle commonly referred to as the “Light Browning.” It has been fired 148 shots per minute, semi-automatic, while marching, and 110 shots per minute, semi-automatic, from the shoulder while in prone position. The rates of fire, which give the best results are from 80 to 100 rounds per minute, semi-automatic marching fire and 50 to 60 shots per minute, semi-automatic aimed fire.

Operation.

Expanding powder gases furnish the energy for the operation of the gun. After the gun is fired and the bullet has passed the gas port in the barrel, the live powder gases expand through the gas port into the gas cylinder and impinge against the head of the piston. This sudden blow forces the piston to the rear, compressing the recoil spring and storing up energy for the return movement. The various lugs and cams actuate the feeding, firing, extraction and ejection, and also control the operation of the gun. The feeding is accomplished through a magazine holding 20 or 40 rounds in double rows. It is held between the sides of the receiver, in front of the trigger guard. This magazine is composed of a rectangular tube and a round wire spring wound to fit the tube. Also there is a bottom plate which slide in the bottom and forms the rest for the spring. On top of the spring is a follower, which forces the

cartridge up against the lips of the magazine tube and which holds it in place until stripped out by the lug on the bottom of the bolt. The automatic action of this gun is not disturbed by holding it in any position whatever. The magazine can be inserted while the mechanism of the gun is in either the cocked or forward position.

All parts of the gun are designed so as to impose a minimum of shock and strain upon them. They are also made strong enough to hold up under the maximum amount of work that they can be made to perform. There are few parts that can be assembled incorrectly but the gun will not function unless these parts are assembled correctly. The dismounting and assembling of the rifle can be accomplished without the aid of a single tool unless the barrel and gas cylinder are removed which necessitates the use of a special spanner wrench provided in the kit.

General Data.

Weight of gun	15 lbs. 8 oz.
Weight of Magazine, empty (20 rounds)	7 oz.
Weight of Magazine, filled (20 rounds)	1 lb. 7 oz.
Length of barrel	24 inches.
Sights graduated up to	1,600 yards.
Calibre bore	0.30 inch.
Gas port form muzzle	6 inches.
Rate of fire	500 shots p'm.
Aimed shots per minute, semi-automatic	60 shots p'm.
Weight of bullet	150 grains.
Weight of Powder	47 grains.
Weight of Cartridge (total)	395.5 grains.
Chamber pressure, pounds per square inch	47,000 to 50,000.
Muzzle velocity	2,682 ft. p's.

Habitual type of fire	semi-automatic.

Cooling System.

It has no special cooling system or device, the barrel merely being exposed to the air and the hand of the firer being protected on the under side of the barrel by a large wooden forearm. Since the barrel soon becomes very hot, care must be taken to avoid touching it during firing or for five or ten minutes thereafter.

CHAPTER XVII.
MOTORS.

RECONNAISSANCE CAR.

The reconnaissance car as supplied to regiments of 155-mm howitzers, motorized, consists of two units: Reconnaissance body, model 1918; 1-ton truck chassis, White, T E B-0.

Further information concerning these units will be found in Ordnance Handbooks "Reconnaissance Body, Model 1918;" "1-Ton Truck Chassis White, T E B-0" (No. 1972).

Weights and Dimensions.

Rated load capacity (body allowance plus normal load)	1 ton—1,040 kg.
Body weight allowance	1,500 lb.—862 kg.
Chassis only	3,850 lb.—1,750 kg.
Oil, water and gasoline	190 lb.—86.5 kg.
Chains	69 lb.—31.5 kg.
Tool kit	37 lb.—16.8 kg.
Chassis weight on front tires (without load)	54%.
Chassis weight on rear tires (without load)	46%.
Gross weight (capacity load)	7,150 lb.—3,250 kg.
Load weight on front tires	0.78%.
Load weight on rear tires	99.22%.
Gross weight on front tires	27%.
Gross weight on rear tires	73%.
Overall length of chassis (without body)	205 in.—5,220-mm.
Overall width of chassis (at widest part)	61 in.—1,550-mm.
Chassis wheel base	140 in.—3,560-mm.

Permissible loading space back of driver's seat	97 in.—2,470-mm.
Width of frame (outside dimension, widest part)	34 in.—865-mm.
Height of rear end of frame from ground (empty)	33.75 in.—856-mm.
Diameter of turning circle (right)	60 ft.—18.3 meters
(left)	45 ft.—13.7 meters.
Tread of wheels	56 in.—1,422-mm.
Road clearance under front axle (lowest point)	10.75 in.—273-mm.
Road clearance under rear axle (lowest point)	10 in.—254-mm.
Length of reconnaissance body, overall	160 in.—4,072-mm.
Width of body	59.875 in.—1,522-mm.
Height of body, overall (including top)	62.125 in.—1,580-mm.
Weight of body (without equipment)	1,180 lbs.—536 kg.

Brief Description.

The reconnaissance car is provided with a special steel body, mounted on a 1-ton truck chassis, White Model T E B-0. Four seats are built into the body. The two front seats are placed back to back. The two rear seats have a space between them of about 2 feet and are also placed back to back. There is a compartment between the two pairs of seats. The floor boards at the back end are extended to form a foot rest for the rear seat. The car is protected by a canopy top and roll curtains. A full set of tools is carried on the car. Also five chests are provided in which are carried all the special equipment assigned to the car. One chest slides into the body compartment under the rear front seat, one into the compartment between the rear seats, and the other

three under the rear seat.

The chassis used is similar to that used with the Staff Observation car on page 95. A complete description and directions for care, operation, and maintenance are contained in the "Handbook of the Reconnaissance Car, Model of 1918." Ordnance pamphlet No. 1972.

ARTILLERY TRACTOR, 5-TON MODEL OF 1917.

Weights and Dimensions.

Overall length (armored)	133.5 in.—3,400-mm.
Overall width	63 in.—1,605-mm.
Height (armored, to top of muffler)	72.5 in.—1,845-mm.
Length of ground contact	91 in.—2,315-mm.
Ground clearance	11 in.—280-mm.
Weight (complete with full equipment)	9,200 lbs.—4,180 kg.
Ground pressure (9 and 11 inch treads)	5.6-4.5 per sq. in.—0.394-0.316 kg. per sqcm.
Weight of each track	545 lbs.—548 kg.
Weight of each track shoe (9-in.)	12 lbs.—5.45 kg.
Width of track shoes	9-11 in.—299-280-mm.
Tread of tracks (center to center of tracks)	48.875 in.—1,243-mm.
Diameter of turning circle (overall clearance)	176 in.—4,425-mm.
Engine, number of cylinders	4
Bore	4.75 in.—220.8-mm.
Stroke	6 in.—152.5-mm.
Horsepower at 1,200 revolutions per-min	56.
Oil reservoir capacity	3.25 U. S. Gal—12.22 liters.
Road speed-gear used (per hour)	
Low speed at 1,200 rev. per minute of engine	1.94 miles—3.12 kilos.

Direct speed at 1,200 rev. per minute of engine	3.92 miles—6.31 kilos.
High speed at 1,200 rev. per minute of engine	7.37 miles—11.85 kilos.
Reverse speed at 1,200 rev. per minute of engine	1.41 miles—2.27 kilos.
Capacity of main gasoline tanks (two) combined	24 U. S. Gal.—90.5 liters.
Capacity of auxiliary tank under armor	10 U. S. Gal.—37.85 liters.
Capacity of transmission case	3 U. S. Gal.—11.3 liters.
Capacity of track oiler tank	2.5 U. S. Gal.—9.43 liters.

Brief Description.

The 5-ton artillery tractor, Model 1917, is a self-propelled road vehicle of the "Track laying" type; that is, the power is transmitted to the ground through a flexible endless chain which acts as a track and is composed of steel links and shoes cast integral and connected by hardened steelpins. The advantage of this type of tractor as compared with the usual type of wheel tractor or truck, is its ability, due to very low unit ground pressure, to negotiate very soft and uneven surfaces, impassable to the usual type of self-propelled vehicle except under the most extreme difficulties.

The general design and construction of the 5-ton tractor does not differ materially from that of the modern truck except in the method of transmitting the power from the transmission unit to the ground. It is used solely as a power vehicle for hauling howitzers carriages and caissons. Each carriage and carriage limber are drawn by one tractor and each pair of caissons are drawn by one tractor.

A complete description and instructions for care,

maintenance, and operation are contained in the "Handbook of 5-Ton Artillery Tractor, Model of 1917." (No. 1996).

Outline Specifications.

Engine.—Four cylinder, four cycle, valve-in-the-head type. Bore 4.74". Stroke, 6". Cylinder case in pairs. Horsepower 56 at 1,200 revolutions per minute.

Radiator.—Honey-comb tubular type. Eight separate headers.

Ignition.—Eisemann, Model G-4, high tension magneto with automatic impulse starter.

Carburetor.—Model A Schebler carburetor with Stewart vacuum feed system; 1.5".

Governor.—Centrifugal flyball type mounted on special shaft and driven off camshaft gear.

Master Clutch.—Dry plate multiple disk type.

Transmission.—Selective sliding gear type. Three speeds forward, one reverse. Direct drive on second. Stepped up on high.

Drive.—From transmission through bevel gears to steering clutch shaft through steering clutches to spur pinions, which mesh with intermediate spur gears, thence through outside gears, encased, to sprocket drive sleeve and drive sprockets.

Steering Clutches.—Two used of dry plate multiple disk type.

Steering.—By means of steering clutches operated from hand steering device and brake bands operated by foot pedals, which act on outside of steering

clutch drums.

Control.—Steering gear located on the right hand side. Change gear, master clutch operating lever, and brake lever, left of steering gear, left to right respectively. Spark and throttle levers operate on sector clamped to steering column. Steering clutch pedals right and left at bottom of, and in front of steering column.

Brakes.—One set. External contracting type. Raybestos, or equal, lined. Operate on steering clutch housings.

Gasoline Tank.—Terneplate tanks. Two independent duplicate tanks each of 12 gallon capacity. Auxiliary terneplate tank under armor, 10-gallon capacity.

Main Frame.—Cast in one piece-open hearth steel.

Roller Frames.—Four frames steel channel, joined by oscillating shaft. Two frames right and left front. Two frames right and left rear.

Truck Rollers.—Six on each side of tractor, fitted with roller bearings, turned on steel gudgeons, flanked to follow track rail.

Track.—Made up of malleable iron track shoes with track links. Integral, fitted with space blocks, and 1.25” pins.

Track Drive Sprockets.—Two. Teeth mesh with opening in tracks.

Blank Sprockets.—Two. Fitted with roller bearings which turn on steel gudgeons. Used to adjust track tension.

Track Supporting Rollers.—Four on each side of tractor, two mounted on brackets attached to front

roller frame channel, and two in the rear mounted on spring bracket which is bolted to main frame.

Springs.—Four double coil springs at rear, two on each side between rear roller frame and bracket on main frame and four—two on each side of equalizing bar at front.

Equalizing Bar.—Spring supported on front roller frame sections.

AMMUNITION TRUCK.

The ammunition truck supplied to regiments of 155-mm howitzers, model of 1918, motorized, consists of two units: Ammunition truck body, model of 1918; 2-ton truck chassis, Nash model 4017-A and 4017-L.

Further information concerning those units will be found in the Ordnance Handbooks. "Ammunition truck body, model of 1918" (No. 2002); "2-ton truck chassis, Nash model 4017-A and 4017-L."

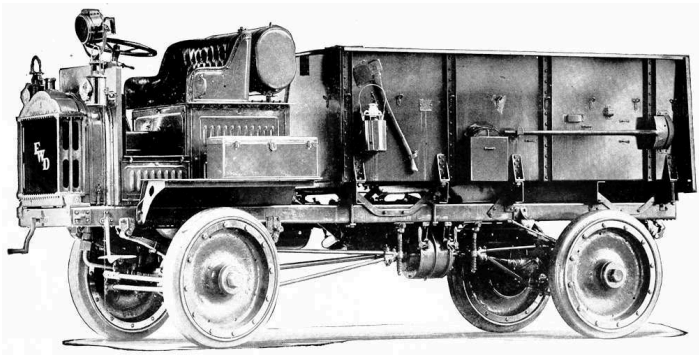
Weights and Dimensions.

Weight of body	1,200 pounds.
Overall length of body	120 inches.
Overall width of body	56 inches.
Overall height of body	54 inches.
Width of floor (inside)	43 inches.

Length of floor (inside)	114 inches.
Height of sides (inside)	36 inches.

Brief Description of Ammunition Truck Body.

The ammunition truck body, model of 1918, consists of a box-type steel body opening only at its rear end. The body is designed to accommodate original packing cases of any type of ammunition. When this vehicle is used near the front lines all four sides and its floor are lined with detachable heavy cocoa matting to prevent undue noise. A tarpaulin cover attaches to the body, and so protects its contents.



AMMUNITION TRUCK.

In addition to the designation of “ammunition truck,” as explained the ammunition body with various loads is designated when mounted on chassis models as follows: “Wireless,” “Telephone,” “Tanks,”

“Personnel,” “Baggage,” and “Ration.”

The chassis and bodies for the above are identical for all purposes. The differences in chassis and body equipment and the load carried when the truck is used for different purposes are noted under tables of equipment on page 161. All of the above bodies are mounted on a 2-ton Nash truck chassis.

Outline Specifications of all 2-Ton Chassis, Nash Models

Rated load capacity	4,000 lb.—1,820 kg.
Body weight allowance	1,200 lb.—546 kg.
Weight of chassis only	6,700 lb.—3,030 kg.
Maximum gross weight (including chassis, body and load)	11,900 lb.—5,420 kg.
Percentage of chassis weight on front tires (without load)	66.66%
Percentage of chassis weight on rear tires (without load)	33.33%
Percentage of load weight on front tires	30.00%
Percentage of load weight on rear tires	70.00%
Percentage of gross weight on front tires	45.00%
Percentage of gross weight on rear tires	55.00%
Overall length of chassis (without body)	202.50 inches—5,100-mm.

Overall width of chassis (at widest part)	78.50 inches—1,950-mm.
Chassis wheelbase	124.00 inches—3,155-mm.
Length of frame back of drivers seat	117.13 inches—2,980-mm.
Width of frame (outside dimensions)	38.13 inches—968-mm.
Height of rear end of frame from ground loaded	35.50 inches—890-mm.
Height of rear end of frame from ground unloaded	38.50 inches—980-mm.
Diameter of turning circle	50.00 feet—15.25 meters.
Tread of front wheels	60.50 inches—1,540-mm.
Tread of rear wheels	60.50 inches—1,540-mm.
Road clearance under front axle (lowest point)	14.75 inches—374-mm.
Road clearance under rear axle (lowest point)	14.75 inches—374-mm.

Brief Description, Models 4017-A, 4017-L, and 4017-F.

The chassis of all these models is of 124-inch wheel base and is fitted with a Buda model H-U four-cylinder engine, dry disk clutch, four speed transmission, and a drive to all four wheels through shafts and internal gearing. Although the greater number of units in all three chassis are alike, there are certain structural differences which exist, mainly

in the model 4017-F chassis as against the other two. The 4017-F is a two wheel steer chassis, while the others have four wheel steering. All of them use four wheel drive and braking. The models 4017-A and 4017-L are fundamentally the same, differing only in certain details of equipment. Model 4017-L has an acetylene generator and searchlight, and oil side and tail lamps, both speedometer and odometer and an impulse starter on the magneto shaft, while the 4017-A has no impulse starter, uses a Bijur electric generator, storage battery and electric lamps, and is fitted with an odometer only. Aside from the two wheel steering and the necessary changes brought about by it, models 4017-F and 4017-L are practically the same, though a few slight differences exist in the dash, the brake cross shaft and rods and the wheel universals as described in detail in the Ordnance Handbook No. 1999.

The engine is a standard design L-head, Buda model H-U using force-feed lubrication, pump cooling, and fitted with a Stromberg carburetor feeding through cored passages in the cylinder block, and Eisemann magneto, and on the model 4017-A only, with a Bijur generator.

The clutch is of the dry plate type and the drive from it is through an open two-joint propeller shaft to a four speed sliding jaw-clutch type transmission. From the latter extend two-joint propeller shafts, one forward and one rearward, to internal gear-drive axles. The live member has exposed axle shafts extending from it, and the ends of these shafts are fitted with a universal joint and a spur pinion, the latter meshing with an internal gear bolted to a disk steel wheel. All the wheels are interchangeable and are all driving and steering wheels in models 4017-A

and 4017-L, while in the model 4017-F only the front wheels steer.

A complete description of the 2-ton truck chassis, models 4017-A, 4017-L, and 4017-F, with instructions for care, maintenance, and operation, is given in the "Handbook of the 2-ton Chassis Nash Models 4017-A, 4017-L and 4017-F," Ordnance Pamphlet No. 1999.

HOW TO DRIVE.

Before starting an engine the driver should see that the gear shift lever is in neutral position and that the emergency brakes are set. The spark lever should be set at the proper position. If battery ignition is used it is best to have the lever in full retard position, as the spark will occur no matter how slow the engine is cranked. If magneto ignition is used the lever should be advanced slightly as a hotter spark is obtained in the advanced position than in the retarded. There is less probability of a kick back when starting on magneto since it is necessary to turn the engine at a fairly high rate of speed, approximately 100 R. P. M. to generate sufficient current to produce a spark.

The position of the throttle hand control should be set so that the throttle will be slightly open. In case the carburetor is equipped with an air-choking device this should be closed to cause a rich mixture for starting.

The ignition switch should be turned on and the engine cranked by pulling up quickly on the crank handle a quarter turn at a time. If an electric cranking motor is provided depress the starting button and advance the spark. If magneto ignition is

used it is best to spin the engine. Crank the engine with the left hand if possible and stand in such a position that if the engine should kick back the crank will not cause injury.

After the engine has started release the choke on the carburetor advance the spark and close the throttle to a position which will prevent racing. If a special dash adjustment is provided for regulating the mixture allow this to remain in a position to cause a rich mixture until the engine warms up.

To Start the Car.

Allow the engine to warm up sufficiently to overcome missing and to run smoothly. When satisfied that the engine is running properly release the emergency brake. In case the car is on a grade apply the foot brake to prevent the car from moving. Press the clutch pedal all the way down and move the gear shift lever to first speed position. The clutch should be allowed to engage gradually and at the same time the throttle should be opened sufficiently to prevent stalling, but not cause racing of the engine. If the foot brake has been employed it should be released as the clutch is engaged. After the clutch has been fully engaged the throttle should be opened sufficiently to accelerate the car to change to the next higher speed. The throttle should be controlled by the foot accelerator pedal. Once the car is in motion the driver must at all times keep his eyes on the road in the direction in which the car is moving or about to move when changing direction.

To Shift Gears (Increasing Speed).

Before starting a driver should practice moving the

gear shift lever to the different positions and getting his feet and hands accustomed to the location of the foot pedals and hand levers. Then it will not be necessary to look away from the road in order to shift gears or in any other way to control the operation of the car. To change gears the clutch pedal should be depressed (it may not be necessary to push it all the way down against the floor boards) and the foot removed from the accelerator pedal at the same time. Move the gear shift lever from first to neutral position, pausing if necessary and then move to second speed position. Engage the clutch immediately and open the throttle with either hand or foot control as soon as the clutch is engaged. The process of changing from second to third or third to fourth is identical. Bear in mind that before each change is made the speed of the car should be accelerated. Care should be taken when changing from lower to a higher speed that the car is moving at a sufficient rate of speed so that an undue strain will not be put on the engine. Practice alone in driving the particular apparatus will acquaint the driver with the necessary speed required to change from one gear ratio to another.

To Shift Gears (Decreasing Speed).

When it is desired to change from a higher to a lower gear ratio release the clutch and allow the hand or foot throttle control to remain open far enough so that the engine will speed up. Move the gear shift lever to the neutral position and again engage the clutch for an instant. Release the clutch immediately and quickly move the gear shift lever from neutral to the next lower speed position and engage the clutch immediately, opening the throttle

by hand or foot control.

Another method of shifting to a lower gear ratio is to leave the throttle open and release the clutch just enough to allow it to slip and the engine to speed up. The gear shift lever should then be moved through neutral directly to the next lower speed position and the clutch engaged. This method does not require as much practice but is objectionable since it wears or burns the clutch facing.

To Stop the Car.

To stop the car, the throttle should be closed, the clutch released, and the brakes applied, all being performed at the same time. The amount of pressure applied at the brake pedal depends upon the distance in which the driver desires to stop the car. Before allowing the clutch to engage after the car has stopped, move the gear shift lever to the neutral position. If the car is to stand apply the emergency brakes. If the engine is to be stopped speed it up by opening the throttle just before turning the ignition switch to the position “off.” If the weather is cold use the choke when stopping the engine or set dash adjustment to give a rich mixture. This will make starting easier if the engine is started in a reasonable length of time.

Driving Suggestions.

In operating a car it is always best to alternate the service and emergency brakes rather than to use one continuously, to equalize the wear on them. When approaching a very steep down grade it is safest to move the gear shift lever to a lower speed position, closing the throttle and permitting the car to drive

the engine. When the grade is not excessively steep the engine can be used as a brake with the position of the gear shift lever remaining unchanged. This will save the brakes and tend to cool the engine. The brakes should never be applied suddenly enough to slide the driving wheels except in cases of emergency. When a stop is to be made apply the brakes soon enough so that the motion of the car will be gradually diminished and brought to a stop at the point desired.

To avoid accidents on the road all rules and regulations governing the driving of motor vehicles on the road should be observed. When turning corners or approaching cross-roads warning should be given to avoid collision with other vehicles which may be hidden from the view of the driver. Before backing the machine the driver should be sure that the road is clear. In manipulating the car the front wheels should never be turned by moving the steering wheel when the car is not in motion. This puts undue strain on the steering apparatus and will cause lost motion in the steering gear. If it becomes necessary to move the front wheels of a car while it is standing still, they should be moved by applying force not only to the steering wheel but also by pulling the front wheels around.

When a car skids, the tendency is for an inexperienced driver to apply the brakes and turn the front wheels in the opposite direction to that in which he is skidding. This should not be done as it only accentuates the skidding and the car may be ditched or skid into another vehicle or the curbing. When the machine starts to skid turn the steering wheel in the direction in which the car is skidding and partially close the throttle but not entirely, or it

will have the same effect as applying the brakes. When the car straightens out the power may again be applied gradually, and the machine brought back to the center of the road. When skidding on narrow roads it is best to apply the power and steer to the center of the road. This will aggravate the skid for a moment but brings the machine around at an angle with the front wheels in the center of the road. The momentum of the car will cause the rear wheels to climb back onto the road again.

ENGINE TROUBLES.

If the machine will not start the trouble, can only be located by a systematic search. It is always best to look over the ignition system first, then see if there is any gasoline in the carburetor. It will often take some time to find the trouble. However, if the engine once starts there is little difficulty in locating the trouble as there will always be an indication which should point to the source of trouble. The great difficulty with inexperienced drivers is that they do not reason out the matter carefully before attempting to remedy it. Also an inexperienced man usually looks for trouble in the same place no matter what the indication may be. Nearly all difficulties arise from one of three sources, ignition, carburetion, or engine. These are outlined in the following table. The trouble is located by the trouble it gives the driver.

I. Engine misses:

A. Ignition.

1. Plugs.

a. Short circuit. b. Broken porcelain. c. Too large a gap.

2. Cable.

a. Broken. b. Grounded.

3. Instrument.

a. Dirty carburetor. b. Interrupter points on magneto.

B. Carburetor.

1. Water in carburetor. 2. Dirt in the line. 3. No pressure or no gas.

4. Too lean a mixture.

C. Engine.

1. Cold.

2. Valves sticking.

II. Back Fires Through Carburetor:

A. Ignition

1. Wired wrong.

2. Timed wrong.

B. Carburetor.

1. Water in carburetor.

2. Dirt in line.

3. No pressure or no gas.

4. Too lean a mixture.

C. Engine.

1. Valve sticking (Inlet).

III. Engine Knocks:

A. Ignition.

1. Retarded spark. Spark too far

advanced.

B. Engine.

1. Carbonized cylinders (pre-ignition).

2. Overheated engine.

3. Loose bearings.

4. Loose pistons.

IV. Engine Lacks Power:

A. Ignition.

1. Retarded spark.

B. Carburetor.

1. Too rich a mixture.

C. Engine.

1. Exhaust valve not seating.

2. Carbon in cylinder.

3. Overheated engine.

4. Lack of lubrication.

5. Governor connections sticking.

D. Brakes.

1. Dragging.

E. Clutch.

1. Slipping.

V. Engine Overheats.

A. Ignition.

1. Retarded spark.

B. Carburetor.

1. Rich mixture.

C. Engine.

1. Cooling system.

a. Fan belt off.

b. No water.

c. No circulation.

d. Anti-freezing mixture.

2. Carbonized cylinder.

3. Lack of lubrication.

VI. Engine Stops:

A. Engine and car stop gradually.

1. Trouble with fuel.

B. Engine and car stop suddenly.

1. Mechanical trouble.

C. Engine stops suddenly, car gradually.

1. Trouble with ignition.

VII. Engine Won't Stop:

A. Ignition.

1. Cable.

2. Switch.

B. Pre-ignition.

1. Carbon in cylinders.

2. Overheated engine.

Consider how each of these indications may differ so that it is possible to locate the exact source of trouble without first investigating. If the car has been

on the road for some time and the engine misses it will either miss regularly in one or more cylinders or irregularly in all cylinders. If the former, the miss is due to ignition. The cylinder in which the miss is occurring can be easily determined by short circuiting each plug with a screw driver. This is done by allowing the screw driver to touch the central electrode of the plug and also the engine. When a plug is short circuited and it does not affect the operation of the engine, it shows there was no spark jumping across the electrodes of the plug. If the cable to this plug is disconnected and held a short distance from the electrode of the plug from which it was removed, a spark will or will not jump this gap. If it does jump the gap it shows that the plug is short circuited. Then the plug is either carbonized or the insulator is broken. If a spark does not occur place the cable near the engine and if a spark occurs it shows that the gap was too large at the electrodes of the plug. If no spark occurs it shows that the trouble is not in the plug but at some point ahead of this. If the engine is firing on all but one cylinder the trouble must be some place between the distributor rotor and the plug. First see if the distributor is dirty and then check up the cable to see if it is broken or grounded. One point to be remembered is that the parts of the magneto or the battery ignition system incorporated in the instruments will affect the operation on all the cylinders and there is no need of looking for the trouble there if only one cylinder misses. If every other cylinder to fire misses and magneto ignition is used, it is often due to the time lever housing being jammed over to one side so that the interrupter points are opened only by one cam. In no case is it necessary to file the interrupter points to overcome a miss, for the interrupter affects the

operation on every cylinder and not on one.

If the miss is irregular it is due to carburetor or to fuel trouble. To locate the trouble open the pet cock at the bottom of the carburetor and if there is any water in the carburetor it will run out. This operation also shows whether or not the gas runs freely. If it does not there may be dirt in the line or no gasoline supply. After everything else has been tried to overcome the trouble, adjust the carburetor to compensate for too lean a mixture.

When an engine is first started it will often miss. This is due to the engine being cold. Under no circumstances should time be wasted to overcome missing until the engine is warm. If an exhaust valve sticks it will cause the engine to miss as the gases will be forced out on the compression stroke. This is difficult to locate as it is a regular miss but usually results from an overheated engine.

If an engine backfires when first started and does so continuously it is best to check up on the wiring and timing of the ignition system. If the engine is running smoothly and suddenly starts to backfire through the carburetor it is possible that the magneto coupling has slipped.

If there is water in the carburetor it may suddenly shut off the supply of gasoline and cause so lean a mixture that backfiring results. Dirt in the line or running out of gasoline would have the same effect. If backfiring in the carburetor is experienced in addition to the missing of the engine it is probably due to too lean a mixture. Backfiring also results from the inlet valve sticking or not seating properly.

If the engine suddenly develops a knock while in operation it may be due to the ignition being too far

advanced for the condition for which the car is operating and the spark lever should be retarded. This will be noticed mostly when the car is under a hard pull such as on hard hills or going through sandy roads. If the engine develops a knock, after having been run for a short while, which can not be overcome by retarding the spark it may be due to carbon in the cylinders or an overheated engine, both of which would cause pre-ignition of the charge. By pre-ignition is meant that the incoming charge when under compression is ignited due to the heat in the cylinder regardless of when the ignition spark takes place. Loose bearings and loose pistons will knock but these should be easily distinguished from ignition knocks as they are present at all times.

If the engine shows a lack of power it may be that the ignition system is too far retarded due to the coupling driving of the magneto having slipped. If too rich a mixture is used it will cause a loss of power but can easily be distinguished by the black smoke which is given off at the exhaust pipe. Every precaution should be taken to locate the trouble when an engine shows a lack of power as it may be caused from the valve not seating properly, carbon in the cylinders, overheated engine, lack of lubrication, or the governor connection sticking. If lack of lubrication is causing the trouble it will soon lead to mechanical trouble such as scoring the cylinder walls or burning out the bearings. An engine will often give an apparent indication of a lack of power due to the brakes dragging or the clutch slipping.

If an engine overheats it is best to check up and see whether or not the car is being operated on a retarded spark or if the mixture is too rich. The usual trouble of the engine overheating are troubles

experienced with the cooling system. Fan belts often break or slip, the water may have leaked out somewhere in the cooling system, or the circulation may be stopped up in some way. If anti-freezing mixtures are allowed to remain in the cooling system in warm weather they will cause overheating of the engine due to their low conductivity of heat. Carbon in the cylinder causes the cylinder to overheat and is detrimental to its operation. If the engine is not lubricated properly it will overheat due to the additional friction of the parts.

If after the car is in operation the car and engine slow down gradually the trouble is without doubt due to lack of fuel or some trouble with the fuel system or the carburetor. When the car stops under these conditions the engine usually backfires into the carburetor just before the car stops.

If the car and the engine stop suddenly it is an indication of some mechanical trouble such as a frozen bearing, broken connecting rod, or some other part which suddenly puts a brake on the movement of the car.

If the engine suddenly stops operating and the car continues to coast the trouble can be traced to the ignition system. A disconnected or a broken wire usually causes the trouble.

If the engine will not stop when the ignition switch is thrown to the “off” position it is possible with magneto ignition that the cable between the switch and the magneto is broken or disconnected. That is, the switch does not connect the primary of the magneto to the ground. If the engine is overheated, due to lack of proper cooling or carbon in the cylinders, the engine will continue to operate due to

the pre-ignition.

APPENDIX "A"
GUNNERS' EXAMINATIONS.

PREPARATION.

In the preparation for the gunners' examination men should pay particular attention to the following points.

Setting the Panoramic Sight.

Before starting to use the panoramic sight, the peep sight should be turned as far as possible to the right or left. This should be done to make it easier for the gunner to look through the panoramic sight and also to prevent him from looking through the peep sight.

Men should get in the habit of working from the top of the sight down, performing their duties *always in the same order*—this is very important. In other words in indirect laying he sets the deflection, applies the deflection difference, levels the cross level bubble and then lays for direction. In direct laying, he sets the deflection, sets the range, levels the cross level bubble, and lays the piece for direction and range. In setting the range on the sight shank the gunner should place his eye *on a level* with the index so that the range can be set exactly. If a range of over 500 yards is given, the fast motion of the scroll gear should be used. As soon as he has laid his gun he will call "Ready" and step clear of the

piece. After he has called “Ready” *under no circumstances will he attempt to finish any of his duties*. If he does he will lose that trial.

All scales should be set rapidly. In order to do this, men must not try to make any mathematical calculations. The setting of sights should be absolutely mechanical. The gunner should know exactly in what direction to turn the knobs, wheels and cranks in order to increase or decrease the settings and to move the bubbles in any particular direction. A list of reasons for disqualification are given in the Regulations for Gunners’ Examination.

It is most important in indirect laying that the gunner be assisted by TRAINED chiefs of sections and No. 2’s. Men should be picked for this during the earlier part of the course and trained for that work. A great deal depends on the ability of these men.

Setting the Peep Sight.

In using the peep sight in direct laying the panoramic sight head should be turned to either flank so that there will be no chance of the gunners looking through the panoramic sight. The gunner in looking through the peep sight should keep his eye about six inches from it.

Setting the Quadrant.

Candidates should get in the habit of performing the required duties in the following order: (1) Setting the site with his **right** hand. (2) Setting the range with his left hand as prescribed for No. 1 (Instruction Memorandum No. 11—5th hour, 1st week). (3) Centering the cross level bubble with his right hand.

(4) Leveling the range bubble with his right hand. The candidate should be sure to look and see where the bubble is before he starts to turn the elevating crank handle. He should turn the handle quickly. After leveling the range bubble he calls “Set” and steps clear of the wheels.

Fuse Setting.

Candidates in setting the bracket fuze setter should stand immediately in rear of it and should crouch down. The corrector should be set first and the range next, both scales being set with the **right** hand. His assistant should stand immediately to the left and should pass the round to the candidate who is being examined, as No. 5 passes the round to No. 4 in percussion fire. The candidate after setting the scales rises up, grasps the projectile and inserts it in the fuze setter. He then sets the fuze and calls “Ready.” The assistant should hold the projectile so that the lug on the time ring is at 10 o’clock (vertical clock face). The candidate when he inserts the round in the fuze setter should place it so that the lug on the time ring falls just to the left of the rotating pin notch. This is done so that the two shall engage as soon as possible.

In setting the fuze with the hand fuze setter, the candidate takes the position prescribed for No. 3 in the service of the piece, his assistant takes the position of No. 5 when the hand fuze setter is used. The candidate must be sure to press down on the hand fuze setter while setting the fuze.

Candidates must be cautioned to remember all necessary data. They cannot ask the examining officer for any. It must be impressed on them also

that under no circumstances can they start to set the scales before the instant prescribed by the Regulations for the Gunners' Examinations.

Drill of the Gun Squad.

Candidates should be familiar with the following paragraphs of the D. and S. R. F. A.: Formation of the gun squads (135, 138); to form the gun squad (170-173); to tell off the gun squad (174); post of the gun squads (175-177); to post the gun squad (178-179); post of the cannoneers, carriages limbered (180-182); to mount the cannoneers (183-185); to dismount the cannoneers (186-187); to change posts (189-190); to move by hand the carriages limbered (191-192); to leave the park (204); action front (199); posts of the cannoneers, carriages unlimbered but not prepared for action (188); limber front and rear (202); action rear (200); limber rear (203); to move by hand the carriages unlimbered (937); prepare for action (938); march order (942); posts of the cannoneers, carriages unlimbered and prepared for action (941); duties in detail of the gunner (845-869); duties in detail No. 1 (807-891); duties in detail of No. 2 (892-901); duties in detail of No. 3 (902-911); duties in detail of No. 4 (913-918); duties in detail of No. 5 (919-924); methods of laying (985-988); and methods of fire (995-1008).

The questions will only cover the important points covered in the paragraphs above.

Materiel.

Candidates should be familiar with the following (Handbook of the 3-inch Materiel): Nomenclature of

harness and of the parts and accessories of the wheeled materiel; use of oils; method of cleaning and lubricating parts and mechanisms; method of cleaning cylinder oil and of emptying and filling cylinders; use of tools; the kinds of projectiles, of fuses, and of powder actually issued for use, and their general purpose and effect, omitting questions as to construction, weight, manufacture, and technical description; the care and preservation of saddle and harness equipment in use. Description of: breech mechanism to dismount, to assemble, elevating screws, to dismount; to assemble; hub liner, to remove, to assemble; brakes, piece and caisson, to adjust; wheel, to remove, to replace.

REGULATIONS FOR THE EXAMINATION OF GUNNERS.

A record of marks will be kept during the examination, and at the conclusion thereof it will be submitted directly to the commander ordering the examination. The mark received by each man in each subject will appear opposite the man's name and the appropriate totals will be carried out. The tabular list, upon approval by the commander ordering the examination, will be published in orders.

Men, to be classified as expert first class gunners, must attain an average of not less than 85% in each of the subjects which follow: to be classed as first class gunners, a general average of not less than 85% with an average in each subject of not less than 75%; to be classed as second class gunners, a general average of not less than 75%, with an average in each subject of not less than 65%.

Examinations will include the following:

Subject.	Value of Subjects. Gun Batteries.
Direct laying	24
Indirect laying	24
Laying for range	18
Fuse setting	18
Drill of the Gun Squad	8
Materiel	8

The following general rules will govern the Examining Officers:

1. The conditions of examination will be made, as nearly as possible, the same for all of the men.

2. Setting of scales will be considered correct if any part of the index is coincident with any part of the line of the graduation of the setting ordered.

3. Settings ordered will always be even divisions of the scale, and not fraction thereof. When a number greater than five is used, it will be a multiple of five, except in settings of the angle of site and corrector scales.

4. The man may select any of the assistants authorized.

5. The man is permitted to traverse the piece to the middle point of traverse before each trial at direct laying.

6. The sight, quadrant, or fuse setter, etc., will be in the position in which it would be in service before the command for trial with it is given; the scales will be set at readings different from those to be given for the trial.

7. The trials for direct laying will be with different deflections and ranges; for indirect laying with

different deflections and deflection differences; for laying for range, with different angles of site and ranges. The trail will be shifted in three trials at direct laying.

8. Changes in setting of scales required of men will not exceed the following: Deflection scale of peep sight, 15 mils; of panoramic sight, 200 mils; deflection difference scale, 30 mils; corrector scale, 10 mils; angle of site scale, 10 mils; range scales, 800 yards. At direct laying the deflections announced will be between 6370 and 30. At direct laying the cross level of the tangent sight will be thrown out of level by the examiner for the trials requiring shifting of the trail.

In time trials, time will be taken from the word at which the candidate is instructed by this order to commence his trial to the candidate's "Ready," or to the last word of any announcement required. No credits will be allowed if the candidate performs any part of the trial after this interval or if the time taken exceeds the maximum given in the appropriate table of those shown hereinafter.

Should any trial be vitiated through the fault of an examiner, of an assistant, of the sight or other instrument used, that trial will be void and the candidate will be given immediately another trial of the same nature.

Direct Laying.

12 trials: Six with the peep sight and six with the panoramic sight.

The target will represent a shielded gun and caisson and will be placed, as nearly as practicable,

at a distance of 1,000 yards from the gun used in the trials.

The candidate being seated on the gunner's seat, an officer of the battery commands, for example:

1. Target, that gun.

2. Deflection, 10.

3. 2400.

At the indication of the target, the candidate causes an assistant at the trail to point the piece in its general direction; **at the last word of the last command** he sets off the deflection and the range ordered; corrects for difference of level of the wheels; operates the elevating and traversing apparatus so as to bring the line of sight upon the target; calls "Ready," and steps clear.

No credits will be given in the following cases:

(1) If the sight is incorrectly set for deflection or range.

(2) If, when the bubble of the cross level is accurately centered, the line of sight is found not to be on any portion of the target.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows

Time in seconds, exactly, or less than	16	18	20	21	22	23
Credits	2.0	1.9	1.7	1.5	1.4	1.3

Indirect Laying.

12 trials.

Two aiming points will be selected, one toward the front and one toward the rear. They should be of the type used in actual firing and, for the purpose of this examination, should be about 2 mils in width, well defined, of such height as readily to be brought within the field of view, and about 1500 yards distant. They should be clearly pointed out to the candidates.

All of the guns of the battery will be placed in the order in battery and a candidate will be assigned to each.

For all trials the board will assume a situation in the conduct of fire for adjustment by battery, commencing with the first salvo, that will require commands involving a shift of the trail for this first trial, and, for all trials, such deflection and deflection difference settings and changes of settings of scales, not exceeding the limits prescribed in paragraph 5 of this order, as may reasonably be expected in service.

When the aiming point is in rear the candidate will be allowed an assistant who, from a position in front of the axle, signals to a man at the end of the trail to move it, if necessary, so as to bring the aiming point within the field of view of the sight. When the aiming point is in front, an assistant at the end of the trail is allowed.

The candidates being seated on the gunners' seats, an officer of the battery commands, for example:

1. Aiming point, the chimney on that white house.

2. Deflection, 440.

3. On No. 2 close 10.

At the last word of command for the deflection each man sets off the deflection; applies the correction for deflection difference appropriate for his piece; causes the trail to be shifted until the sight is directed upon the aiming point; corrects for difference of level of the wheels; raises or lowers the panoramic sight until the field of view will include the aiming point; traverses the piece until the vertical hair is on the aiming point; calls “Ready” and steps clear.

The trial being completed and the men again being seated, the officer commands for example, in continuance of the assumed situation:

1. Right, 120.

2. On No. 4, close 5.

At the last word of command for the deflection, each man operates the sight and, if necessary, the trail as before; traverses the piece until the vertical hair is on the aiming point; calls “Ready” and steps clear.

The third and fourth trial is similarly conducted.

No credits will be given in the following cases:

1. If the sight is incorrectly set for the deflection or deflection difference.

2. If, when the bubble of the cross level is accurately centered, the vertical cross hair is found not to be on the aiming point.

3. If, at any time during the trial, the man has operated the elevating device.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

Time in seconds, exactly, or less than	18	20	21	22	23	24
Credits	2.0	1.9	1.7	1.5	1.4	1.3

Laying for Range.

Six trials, using the range quadrant.

The man being seated on the seat on the right side of the trail, an officer of the battery commands, for example:

1. Site, 280.

2. 3400.

At the last word of the command, the man sets off the angle of site; sets the quadrant for range; corrects for difference of level of wheels; turns the elevating crank so as to center the range bubble; calls “Ready” and steps clear.

No credits will be given in the following cases:

1. If the quadrant is incorrectly set for angle of site or range.

2. If no part of the bubble of the cross level is between the middle two lines on the glass tube.

3. If there be found to be an error of more than 50 yards in laying for any range less than 1,500 yards or more than 25 yards for any equal range to or exceeding 1,500 yards.

If the piece is found to be correctly laid within the limits prescribed, credits will be given as follows:

Time in seconds, exactly, or less than	14	16	18	19	20	21
Credits	3.0	2.3	2.6	2.4	2.2	2

Fuse Setting.

12 Trials: 6 with the bracket fuse setter, 6 with the hand fuse setter.

Drill cartridges with fuses in good order set at safety are placed as in service. An officer of the battery commands, for example:

1. Corrector, 24.

2. 2700.

At the last word of the command for the corrector, in trials with the bracket fuse setter, the man sets the fuse setter at the corrector, and, as the data are received, at the range ordered, receives the cartridge from an assistant, inserts its head in the instrument, sets the fuse and calls “Ready.”

At the **last word of the command for the corrector**, in trials with the hand fuse setter, the candidate sets the fuse setter at the corrector, and, as the data are received at the range, ordered; with the aid of an assistant, sets the fuse, and calls “Ready.”

No credits are given in the following cases:

1. If the fuse setter is incorrectly set for corrector or range.

2. If the candidate fails to obtain a correct fuse setting within one-fifth of a second.

If the fuse setter is found to be correctly set and is properly operated, credits are given as follows:

Time in seconds, exactly, or less than	8	9	10	11	12	13
Credits	1.5	1.4	1.3	1.2	1.1	1.0

Drill of the Gun Squad.

The subjects will embrace such parts of the following exercises (D. and S. R. F. A.) as will thoroughly test the candidate's familiarity with the service of the piece: Formation of the gun squad (135, 138); to form the gun squad (170-173); to tell off the gun squad (174); post of the gun squads (175-177); to post the gun squad (178-179); posts of the cannoneers, carriages limbered (180-182); to mount the cannoneers (183-185); to dismount the cannoneers (186-187); to change posts (189-190); to move by hand the carriages limbered (191-192); to leave the park (204); action front (199); posts of the cannoneers, carriages unlimbered but not prepared for action (188); limber front and rear (202); action rear (200); limber rear (203); to move by hand the carriages unlimbered (937); prepare for action (938); march order (942); posts of the cannoneers, carriages unlimbered and prepared for action (941); duties in detail of the gunner (845-869); duties in detail of No. 1 (870-891); duties in detail of No. 2 (892-901); duties in detail of No. 3 (902-911); duties in detail of No. 4 (913-918); duties in detail of No. 5 (919-924); methods of laying (985-988); and methods of fire (995-1008).

The questions will only cover the important parts covered in the paragraphs above.

Materiel.

The examination of each candidate will be sufficiently extended to test his familiarity with the use and care of the materiel of his organization, and will be theoretical. The examination will be conducted by questions on the following subjects: Nomenclature of harness and of the parts and accessories of the wheeled materiel; use of oils; method of cleaning and lubricating parts and mechanisms; method of cleaning cylinder oil and of emptying and filling cylinders; use of tools; the kinds of projectiles, of fuses, and of powder actually issued for use, and their projectiles, of fuses, and of powder actually issued for use, and their general purpose and effect, omitting questions as to construction, weight, manufacture, and technical description; the care and preservation of saddle and harness equipment in use. Description of: breech mechanism, to mount, to assemble; elevating screws, to dismount, to assemble; hub liner, to remove, to assemble; brakes, piece and caisson, to adjust; wheel, to remove, to replace.

Chevrons will be issued to those candidates who qualify and will be worn as prescribed in orders.

DON'TS FOR CANNONEERS.

Don'ts for All Cannoneers:

—Sacrifice accuracy for speed.

—Guess at the data.

—Expose yourself.

—Let your attention be distracted.

—Make unnecessary moves.

—Talk.

Don'ts for Chief of Section:

—Forget that you are responsible for the work of your squad.

—Fail to assist the gunner in laying on the aiming point.

—Say "Muzzle Right (left)," merely move your hand in the direction you desire the trail shifted.

—Write down the data.

—Forget your proper pose, covering No. 3 opposite the float.

—Forget to extend your arm vertically, fingers joined, after the gunner has announced "Ready."

—Fail to caution "With the Lanyard" for the first shot.

—Fail to look at both gunner and executive.

—Command "Fire;" merely drop your arm.

—Fail to designate who shall assist No. 2 when he is unable to shift the trail.

—Forget to announce "Volley Complete."

—Forget to select the individual Aiming Points for the gunner.

—Forget to announce "No. (so & so) on Aiming Point," in reciprocal laying.

—Ever say “Range 3000,” merely “3000.”

Dont’s for Gunner:

—Forget to place the sight bracket cover in the left axle seat.

—Forget to put the sight shank cover in the trail box.

—Forget to close the panoramic sight box, and fasten it with your left hand.

—Forget to clamp the panoramic sight in its seat.

—Forget to close the ports in the shield.

—Forget to put your weight against the shoulder guard while laying.

—Touch any adjustment after calling “Ready.”

—Forget to move your head from the panoramic sight after calling “Ready.”

—Lean against the wheel.

—Fail to take up lost motion in the proper direction.

—Fail to watch the executive after calling “Ready.”

—Signal with your hand for movements of the trail.

—Fail to identify Aiming Points or Targets.

—Fail to secure hood on sight bracket.

—Say “Whoa” to No. 2 while the trail is being shifted. Say “Trail Down.”

—Fail to lower the top shield at once at

the command “March Order.”

—Forget to relay vertical hair on A. P. at completion of sweeping volley.

—Forget to set range 1000, deflection zero in “Fire at Will.”

—Forget to say “Ready” just loud enough for the chief of section to hear.

—Forget to chalk up the deflection on the main shield in reciprocal laying.

—Forget to set site and level bubble (British).

—Forget to release the brake in trail shifts (British).

—Forget to count “1001, 1002” to preserve proper firing interval.

Dont’s for Number 1:

—Touch the firing handle until you announce “Set.”

—Fire the piece with the right hand.

—Try to throw the drill cartridge over the float by jerking the breech open.

—Slam the breech.

—Fail to level bubbles.

—Fail to set and release brake in trail shifts.

—Fail to look squarely at the scales of the quadrant.

—Fail to take up lost motion properly.

—Forget to close the quadrant box.

—Fire the piece until the command is given.

—Lean against the wheel.

—Forget to keep up with the range in direct laying.

—Forget to lower the top shield immediately at “March Order.”

—Talk.

Dont’s for Number 2:

—Throw the breech cover on the ground.

—Fail to engage the handspike.

—Slam the apron.

—Put feet on the float.

—Wait for the command in shifts of 50 mils or more.

—Move the trail in a series of shifts.

—Fail to mark off 11 lines 50 mils apart at once on taking your post.

—Fail to secure the breech cover.

—Fail to secure the handspike in “March Order.”

—Run between carriages.

—Fail to throw empty cartridge cases out of the way of the cannoneers.

—Forget the tow and waste.

—Talk.

Dont’s for Number 3:

—Run between the carriages.

—Throw the muzzle cover on the ground.

—Throw the front sight cover on the ground.

—Slam the apron.

—Fail to see that fuze is set at safety at "March Order."

—Fail to look directly down at the fuze setter while adjusting scales.

—Take right hand from the corrector worm knob and left from the range worm crank, during drill.

—Forget to set range zero in "Fire at Will."

—Cross your legs.

—Forget to set each announced range regardless of the kind of fire being used.

—Talk.

Dont's for Number 4:

—Throw the fuze setter cover on the ground.

—Slam the apron.

—Forget to set the fuze at "Safety" in "March Order."

—Fail to glance into the bore to get the alignment.

—Touch a round after inserting it in the breech.

—Fail to completely set each fuze.

—Forget to take the round from No. 5 from beneath in percussion fire and from the top when the hand fuze setter is used.

—Forget to say, “3200, 2, last round,” only loud enough to reach the chief of section.

—Forget to secure the cover on the fuze setter.

—Attempt to move the caisson with the door open.

—Forget to set and release the caisson brake (Model 1902).

—Turn the round to the left after setting.

—Talk.

Dont’s for Number 5:

—Slam the apron.

—Attempt to move the caisson with the door open.

—Forget to put your left elbow on the outside of your left knee in using the hand fuze setter.

—Forget to set the brake on the 1916 caisson.

—Throw the waterproof caps under your feet.

—Talk.

TRAINING GUN CREWS.

This article is not intended to cover all of the work of the gun crew, it is intended merely to cover certain points sometimes lost sight of. References are to the 3” gun, but any crew efficient in serving that excellent weapon will have little trouble in mastering any other.

All refinements taught have but one prime object, that is accuracy of fire. It is of no value to make atmospheric and velocity corrections if still greater variations are constantly introduced by poor service of the piece. The foundation of battery efficiency is well-trained gun crews. Officers may be able to lay out orienting lines with the greatest facility, may know the range tables in the dark, but it will avail little if they cannot train men to apply properly and accurately the data determined.

The safety of our own infantry and the effectiveness of our fire are absolutely dependent on the continuous training of gun crews, and the resultant precision and sureness with which they perform their work. This can only be obtained by constant drill from the day the recruit joins until the day of his discharge; not by long drills in which he grows tired and loses interest, but by short periods broken by instruction in other subjects; not by many hours one week and none the next, but by a short period every day of the week. The best gunners grow rusty in a very few days; constant short drills will give results and are the secret of success. Every man must get instructions every day, be he raw recruit or expert gunner.

Cannoneers should be taught that the greatest crime that can be committed in laying the piece is to make an error—the only crime for which there is no punishment. An error or mistake in the correct

service of the piece should not be punished, but it should be carefully explained how the efficiency of the battery depends on each member, and to insure that crime is not committed again, additional hours of instruction beyond that required for the rest of the crew will be necessary.

Every man must be on his toes from the time he comes in sight of his gun, every movement at the piece must be at a run. Slow and sleepy motions of one man will kill all the snap and energy of every other member of the crew. Do not, however, confuse speed of performing any given motion with hurry in execution of detail. For example, the gunner must move with snap and energy in getting his eye back to the sight and his hand on the traversing handwheel after the piece is fired, but he must never be hurried in getting the vertical wire exactly on the aiming point, or in making the ordered changes in the deflection setting. Stop watches should not be used. They are a fruitful cause of errors. Speed comes from continual practice and it cannot be artificially attained by stop-watch timing. Do not understand that speed is not desirable, it is highly desirable, but practice alone will give it and it will nearly always be found that the best-trained crew is the fastest crew. Competitions between crews must be for accuracy, not speed. If every motion is made with a snap and at a run the results as regards speed will be satisfactory.

The accuracy of fire is affected by brakes not being adjusted for equal tension, by direction of recoil not being in line with the trail, by No. 2 sitting on the handspike and shifting his weight after the gunner has called “Ready;” by No. 1 jerking the firing handle; by the gunner not keeping his shoulder

against the guard; by elevating cranks not being properly assembled; by sights and quadrants not being properly adjusted or locked with means provided (this subject deserves several pages); by variations in the amount of oil in the cylinder; by improper adjustment of the gland; by the gunner coming on to the aiming point sometimes from the right, sometimes from the left; by the No. 1 centering the bubble sometimes from front to rear, sometimes from rear to front.

You may have stood behind a battery firing and noticed how one or two guns jump violently in recoil, while others would hardly disturb the proverbial glass of water on top of the wheel, although all guns of equal service. This was due almost entirely to the lack of proper adjustment of some of the parts mentioned above.

Every member of the crew must know his duties so well as to make his motion automatic; the direction to turn the various handwheels, milled heads, and gears to obtain the desired result, and he must always do these things in the same way. The effect of small differences in laying may be graphically shown the gun crew by firing sub-caliber ammunition at a small arms steel target which rings a bell when a bull's-eye is made. Erratic shots means poor adjustments of equipment or poor training of the gun crew. Pleas that worn material or lost motion, or defective ammunition are the causes of erratic shooting are largely excuses for ignorance, laziness, and lack of proper instruction. Worn materiel requires more makeshifts, takes longer to lay and more careful watching, so that fire cannot be so rapid, but except for wear in the bore of the gun it is possible to do almost as accurate shooting with worn

materiel, especially if the new materiel has not been thoroughly worked in.

Among the more important duties of the men may be mentioned in the following:

Chief of Section.—Must teach his men to have pride in the gun they serve, and the reputation of the section. He shows each member how the accuracy of firing is dependent on him, and that one man may ruin the best efforts of all the others. He must keep his materiel as clean as when it left the makers hand, every part functioning properly, every screw and nut tightened, no burred nuts or bolts, or missing split pins. He helps each member to take a pride in keeping the part for which he is responsible as clean as a new pin and in perfect condition. He sees that the various canvas covers and sponge and rammer never touch the ground where they will gather dirt. He knows the proper use of his tools, and the correct adjustment of the firing mechanism. He must be able to assemble and disassemble blindfolded the firing lock and breech mechanism. In firing he knows the settings of all scales without reference to a data book.

The Gunner.—Knows that turning the levelling screw clockwise moves cross bubble to the right; that turning scroll gear clockwise increases the range; that turning the peep sight screw clockwise increases deflection, and so on with all handwheels, etc., that he operates and must know these things so well that he operates them in the proper direction automatically. Must always bring vertical wire on aiming point from the left to take up any play in traversing mechanism. He verifies that he is on the aiming point after the breech is closed and if there is any delay, again immediately before firing. He gets

his eye back to the sight and relays *immediately* the gun returns to battery. He knows his scale readings at all times. He keeps his sight scrupulously clean, never permits his finger to touch the objective prism when turning the rotating head, nor wipes off eye piece with hand. He keeps his shoulder against the guard at all times.

The Number 1.—He knows his site and range scale readings without having to look at them. In centering the bubble he brings it always from front to rear to take up play in the elevating mechanism. He centers the bubble so accurately that it is not the thickness of a sheet of tissue paper nearer one graduation than the other, and what is most important he sees that it stays there until he fires the pieces, when he promptly recentres it. (The latitude allowed in centring the bubble by our gunners' examination is responsible for 20 per cent. of our field probable error.) He must not fire the piece with a jerk but with a constant even pressure, else he may destroy all his accuracy of levelling. The same principle applies if he uses the lanyard. He keeps his quadrant free from any sign of dirt and assures himself that it is in perfect condition. If the gunner fails to keep his shoulder against the guard when the piece is fired he reminds him of it. In centring the bubble or setting the scales he gets his eye squarely opposite the scale or bubble.

The Number 2.—He knows the width of the spade, float, etc., in mils, and is able to make any shift under two hundred mils, within 5 mils. He shifts the trail so as to bring the direction of recoil in line with it (except for moving targets). In receiving empty cases he should not permit them to strike the trail or throw them against each other, as they must

then be resized before they can be again used. If he sits on the handspike he must not shift his weight after the piece is laid.

The Number 3.—He knows that turning the corrector worm knob clockwise decreases the setting; turning the range worm crank clockwise increases the range. In making these settings he keeps his eye squarely over the scales. He knows his scale settings at all times. He is taught to keep his fuze setter and its cover clean, and is shown how a small pile of dirt or wax behind the stop pin or in the rotating pin notch can throw out his settings and ruin the reputation of his section. Gum from the fuze often collects in these places. The surest way is to keep a match stick handy and clean out these places whenever there is a lull in the firing.

The Number 4.—If necessary to reset the fuze he must turn the projectile until it brings up against the stop pin, then cease all turning movement and draw the projectile straight out of the fuze setter. If he continues the turning motion unconsciously he can easily alter the setting by a fifth of a second. In loading he is careful not to strike the fuze against the breech and so alter the fuze setting.

The Number 5.—He knows where the rotating pin notch is in the fuze setter, and where the corresponding pin is on the fuze. He places the fuze so that the pin is seated in the notch with little or no turning movement and turns rapidly but with no more force than required. He is careful to set all fuzes with the same force, that is, not turn one with a violent twist and the next barely up to the stop.

APPENDIX "B"—Comparative table of guns used in World's War.

	Austria, 1905	France, 1897	Germany, 1906	Gt. Britain, 1917	Italy, 1912	Russia, 1903	U. State 190
Caliber, inches	3.01	2.95	3.03	3.3	2.95	3.	3.
Weight of shrapnel, lbs.	14.72	16.00	15.00	18.00	14.3	14.41	15.0
Muzzle velocity, f. s.	1640	1750	1760	1680	1510	1930	170
Muzzle energy, ft. tons	275	335	242	340	224	273	30(
Weight of gun	700	1000	766	880	690	785	71(
Weight of gun and carriage	2000	2650	1860	2600	2260	2075	223
Weight of g., c. and limber	3750	4150	4200	4100	3350	3850	373
Maximum elevation	18	18	16	33	65	16$	16
Total traverse, degrees	8	6	8	8	52	5½	8
Length of recoil, inches	51.5	47	44	28-48	18-53	42.5	50
Height of wheels	4'3"	4'	4'5½"	4'3"	4'3½"	4'4"	4'8
Independent line of sight	No.	Yes.	No.	Yes.	Yes.	No.	No.
Sights, goniometric, telescopic, panoramic, ordinary	P.	G.	T. G.	O. P.	T. P.	O. P.	O. F

Breech block, wedge swinging, eccentric screw.	W.	E. S.	W.	S.	W.	S. B.	S. B
Traverse, axle or pintle	P.	A.	P.	A.	P.	A.	A.
Recuperation, spring or hydro-pneumatic	S.	H.	S.	H.	H.	S.	S.
Length of gun, calibers	30	36	27.3	28.0	30	30	29.1
Width of track, inches	60	60	60	66	58	60	60
Range, maximum	6400	7550	7600	9000	8850	7800	650

APPENDIX "C"

TABLE OF EQUIVALENTS.

1 mil.	3.37 minutes.
1 meter (m)	39.37 inches.
1 centimeter (cm)	.3937 inch.
1 millimeter (mm)	.03937 inch.
1 kilogram (kg)	2.2046 pounds.
1 dekagram (dkg)	.3527 ounce.
1 gram	15.432 grains.
1 liter	1.05671 quarts (U.S.).
1 inch	2.54 centimeters.
1 foot	.3048 meter.
1 yard	.9144 meter.
1 square inch	6.452 square centimeters.
1 cubic inch	16.39 cubic centimeters.
1 cubic foot	.02832 cubic meter.
1 cubic yard	.7645 cubic meter.
1 ounce	28.35 grams.
1 pound	.4536 kilogram.
1 quart (U. S.)	.9463 liter.
1 degree	17.777 mils.
1 kilogram (kg) per square centimeter	14.223 pounds per square inch.

INDEX

Abatage, French 75-mm, 95
Action of Recoil Mechanism, 3-inch Gun, 70
Aiming Circle, 274
Air and Liquid Pumps, 155-mm Howitzer, 189
American 75, 105
Ammunition, 199
Ammunition 3-inch Gun, 214
Ammunition, Definition of, 11
Ammunition Marking, 233
Ammunition Truck, 334
Angle of Site Mechanism, American 75, 127
Anti-Aircraft Guns, 60
Armament, Modern, 46
Army Artillery, 57
Artillery, Definition of, 11
Artillery Tractor, 330
Assembling 3-inch Gun, 76, 242
Assembling American 75, 133
Automatic Pistol, 315
Automatic Rifle, 322, 325
Axles, Discussion, 44

Ballistics, Definition of, 11
Battery Commander's Telescope Model 1915, 270
Biblical References to Artillery, 16
Bicarbonate of Soda, 239
Bore, Definition of, 11
Borax, 238
Bracket, Fuze Setter, 283
Breechblock, 4.7-inch Gun, 156
Breechblock, British 75, 150
Breechblock, French 75, 87
Breechblocks, Discussion of, 31
Breech, Definition of, 12
Breech Mechanism 3-inch Gun, 63
Breech Mechanism, American 75, 106
Breech Mechanism, G. P. F., 162
Breech Mechanism, 155-mm Howitzer, 173
British 75, 147
Browning Automatic Rifle, 325
Browning Machine Gun, 323
Built-up Guns, Discussion of, 29

Caisson 3-inch Gun, 74
Caisson, Definition of, 12
Caliber, Definition of, 12
Camp Telephone, 286
Canvas Buckets, 241

Care of 3-inch Gun, 242
Care and Cleaning of Cloth, 252
Care and Cleaning of Leather, 249
Care and Cleaning of Metal, 252
Care and Inspection of Sights, 267
Care and Preservation, French 75, 101
Care of Guns During Firing, 253
Care of 155-mm Howitzer, Notes on, 194
Care and Preservation of Materiel, 236
Carriages, Gun, 3-inch, 65
Carriage, Gun, Definition of, 12
Carriage, American 75, Description, 111
Carriage 4.7-inch Gun, Description, 154
Carriage 155-mm Howitzer, Description, 179
Cartridge Case, Care of, 219
Cartridge, Case, Definition, 12
Charge, Definition, 12
Classification of fuzes, 224
Cleaning Material, 236
Cleaning Schedule, 254
Clock Oil, Use of, 237
Cloth Equipment, Care of, 252
Coal Oil, Use of, 237
Combination Fuzes, Tables of, 232
Cannoneers' "Don'ts", 360
Conventional Signals, 301

Corps Artillery, Discussion, 55
Cradle, Definition of, 12
Cradle, American 75, Description, 118
Cradle, G. P. F. Description, 162
Cradle 155-mm Howitzer, Description, 181
Cradle 3-inch Gun, Description, 66
Cylinders 3-inch Gun, Care of, 244
Cylinders 155-mm Howitzer, Description, 181
Cylinders, Outer, Discussion, 31

Detonating Fuzes, Tables of, 229
Detonators, Discussion, 199
Dismounting American 75, 133
Dismounting French 75, 101
Dismounting 3-inch Gun, 76
Divisional Artillery, 47
“Dont’s” for Cannoneers, 363

Elevating Gear, 3-inch Gun, 66
Elevating Mechanism, American 75, 129
Elevating Mechanism, British 75, 150
Elevating Mechanism, Definition, 13
Elevating Mechanisms, Discussion, 37
Elevating Mechanism 4.7-inch Gun, 157
Elevating Mechanism, 155-mm Howitzer, 185
Engine Oils, Use of, 238
Engine Troubles, Motors, 345

Equalizing Gear, American 75, 127
Equivalents, Tables of, 371
Explosives, Discussion, 199
Extractor, French 75, 87

Faults, Common in Telephones, 297
Field Glasses, 283
Filling American 75 Cylinders, 145
Filloux 155-mm Gun, 160
Fire Control Equipment, Definition, 13
Fire Control Instruments, 260
Firing Mechanism, American 75, 110
Firing Mechanism, French 75, 89
Firing Mechanism, Definition, 13
Firing Mechanism, 4.7-inch Gun, 156
Firing Mechanism, 3-inch Gun, 64
Firing Mechanism, 155-mm Howitzer, 175
Fireworks, Signalling, 304
Fixed Ammunition, 203
Flags, Signalling, 285
Floats, American 75, 114
French 75, 84
Front and Rear Sights, 3-inch Gun, 260
Fulminates, 199
Fuzes, 221
Fuze Classification, 224

Fuze, Definition, 13
Fuze Setter, 3-inch Gun, 283
Fuze Setters, Definition, 13

General Service Code, 301
Gribeauval, Reference to, 20
G. P. F. (Grande Puissance Filloux), 160
Gun, Definition, 13
Gun Crews, Training of, 367
Gun Carriages, Discussion, 33
Gun Carriage, 3-inch Gun, 65
Gunners Examinations, 352
Guns, Care of in Firing, 254
Guns Used in World War, 370
Gustavus Adolphus, Reference to, 18

H and H Soap, Use of, 239
Hand Fuze Setter, 284
Heavy Field Gun, Discussion, 58
Heavy Field Howitzer, Discussion, 59
High Explosives, 202
History and Development of Materiel, 16
Hollingshead Soap, Use of, 239
How to Drive Motors, 340
Howitzers, 155-mm, Care of, 194
Howitzer, 155-mm, Model 1918, 167
Howitzer, Definition of, 13

Hydroline Oil, Use of, 239

Independent Angle of Site, 111
Initial Velocity, Definition of, 13

Lamps, Signalling, 298
Lanterns, 242
Lavaline, Use of, 238
Leather, Care of, 249
Light Gun and Howitzer, Discussion, 48
Light Slushing Oil, Use of, 237
Limber, Definition of, 14
Limber, 3-inch Gun (Caisson), 72
Line Sights, 258
Louis XIV, Reference to, 20
Liquid Pumps for 155-mm Howitzer, 189
Lubricating Oil, Use of, 236
Lye Powdered, Use of, 238

Machine Gun, Browning, 324
Machine Guns, Use of, 321
Marks on Ammunition, 233
Materiel, Definition of, 14
Medium Gun and Howitzer, 55
Metal, Care of, 252
Modern Armament Discussion, 46
Monocord Switchboard, 288
Motors, 328

Mortar, Definition of, 14
Motorization, 50
Muzzle, Definition of, 14
Muzzle Velocity, Definition of, 14

Naphthaline, use of, 238
Neats-foot Oil, Use of, 237
Nitrogen Compounds, 203

Observing Instruments, 270
Obturation, 204
Ogive, Definition of, 14
Ordnance, Definition of, 14
Outer Cylinders, Discussion of, 31

Paint, Rubberine, 238
Panels, Signalling, 305
Panoramic Sight, Model 1917, 260
Panoramic Sight, Model 1915, 263
Paulins, 242
Percussion Primers, 208
Petrolatum, 237
Picket Ropes, 242
Piece, Definition of, 14
Pistol, Automatic, 315
Polish, Gibson's Soap, 238
Powder Bags, 206
Preparation for Gunners Examinations, 349

Pressure Gauge, 155-mm Howitzer, 192
Primers, 206
Primer, Brown Enamel, 238
Primer, Definition of, 14
Primer, Pressing, 208
Projectile, Definition of, 14
Projectile, Shape and Nomenclature, 209
Projectors, Signalling, 298
Propelling Charges, 201
Pumps, Air and Liquid, 189

Quadrant, Gunners, Definition of, 14
Quadrant, Range 3-inch Gun, 265
Quadrant, Sight 155-mm Howitzer, 192

Radio, SCR 54 and 54a, 307
Railway Artillery, Discussion, 60
Range Finder, 278
Range Quadrant 3-inch Gun, 265
Recoil Mechanism, Definition of, 14
Recoil Mechanism, Discussion, 39
Recoil Mechanism, 3-inch Gun, 68
Recoil Mechanism, American 75, 120
Recoil Mechanism, British 75, 150
Recoil Mechanism, French 75, 99
Recoil Mechanism, 4.7-inch Gun, 156
Recoil Mechanism, G. P. F., 162

Recoil Mechanism, 155-mm Howitzer, 182
Reconnaissance Car, 328
Regulations for Gunners' Examinations, 352
Rifle, Definitions of, 14
Rifling, Definition of, 15
Rounds, Definition of, 15
Runners, 285

Sal Soda, 239
Schedule, Cleaning, 254
Semi-fixed Ammunition, 204
Semaphore, 306
Separate Ammunition, 204
Shell, Definition of, 15
Shell Fillers, 201
Shields, Discussion of, 43
Shrapnel, Definition of, 15
Sights, 258
Sights, Care of and Inspection, 267
Sights, Discussion of, 43
Sights, Front and Rear, 258
Sights, Line, 258
Sights, Panoramic, 260
Signals, Conventional, 301
Signal Equipment, 285
Small Arms, 315

Soap H and H, 239
Soap, Castile, 239
Soap, Saddle, 239
Spades, American 75-mm, 114
Spare Parts 3-inch Gun, 240
Sperm Oil, Use of, 237
Swabbing Solution, 239
Switchboard, Monocord, 288

Table of Equivalents, 371
Table of Explosives, 202
Table of Fuzes, 232
Telephone, Camp, 286
Telephone Faults, 295
Telescope, B. C. Models, 1915 and 1917, 270
Tools and Accessories 3-inch Gun, 239
Training Gun Crews, 364
Trail, 3-inch Gun, 66
Trail, American 75, 114
Trail, British 75, 150
Trail, 4.7-inch Gun, 157
Trail, G. P. F. Gun, 165
Trails, Definition of, 15
Trails, Discussion of, 45
Traversing Mechanism 3-inch Gun, 66
Traversing Mechanism, American 75, 133

Traversing Mechanism, British 75, 153
Traversing Mechanism, 4.7-inch Gun, 156
Traversing Mechanism, G. P. F., 165
Traversing Mechanism, 155 Howitzer, 187
Traversing Mechanism, Definition of, 15
Traversing Mechanisms, Discussion of, 36
Tubes, Discussion of, 27
Twist, Discussion of, 29
Type SCR 54 and 54a Radio, 307

Vacuum Tube Detector, 311
Vaseline, 237
Variable Recoil, American 75, 126

Weights and Dimensions 3-inch Gun, 62
Weights and Dimensions 4.7-inch Gun, 154
Weights and Dimensions American 75, 105
Weights and Dimensions British 75, 147
Wheels, Care of, 248
Wheels, Discussions of, 44
Wheels, 3-inch Gun, 65
Wheels, 4.7-inch Gun, 157
Wheels, G. P. F., 165
Wig-Wag, 306
Wire-Wrapped Guns, Discussion, 28

Transcriber's Notes

- pg 8 Changed: Harley-Davidson motorcicles
  to: Harley-Davidson motorcycles
- pg 9 Changed: Gun Carriage, Ear View
  to: Gun Carriage, Rear View
- pg 23 Changed: which could best be handled to manuever
  to: which could best be handled to maneuver
- pg 24 Changed: we fined the now famous long range
  to: we find the now famous long range
- pg 34 Changed: If the guns were rigidily attached
  to: If the guns were rigidly attached
- pg 35 Changed: The leverages with which the overturning
  to: The leverage with which the overturning
- pg 46 Changed: little more than phyrric victories
  to: little more than pyrrhic victories
- pg 57 Changed: and the concensus of opinion
  to: and the consensus of opinion
- pg 63 Changed: Breezh recess.
  to: Breech recess.
- pg 100 Changed: (2) The diaphram with its hollow rod
  to: (2) The diaphragm with its hollow rod
- pg 100 Changed: may communi?ate freely with the air
  to: may communicate freely with the air
- pg 101 Changed: Canoneer Dismountings.
  to: Cannoneer Dismountings.
- pg 110 Changed: forced over horiztonal shoulders
  to: forced over horizontal shoulders
- pg 124 Changed: (b) Flood slides with oil,
  to: (c) Flood slides with oil,
- pg 131 Changed: by means of the elevating haulwheel
  to: by means of the elevating handwheel
- pg 135 Changed: Remove lower splint pin
  to: Remove lower split pin
- pg 194 Changed: which the levling mechanism is operated
  to: which the leveling mechanism is operated
- pg 217 Changed: The shell is always issued filled and

fuxed
to: The shell is always issued filled and fuzed

- pg 232 Changed: Will be abanonded by French
  to: Will be abandoned by French
- pg 236 Changed: materiel may funtion easily
  to: materiel may function easily
- pg 239 Changed: Water, 4 oz. or $^1/_4$ pnt
  to: Water, 4 oz. or $^1/_4$ pint
- pg 245 Changed: results from firing of two two kinds
  to: results from firing of two kinds
- pg 250 Changed: have been in contact with meta
  to: have been in contact with metal
- pg 269 Changed: for the same angle of site (roughtly estimated
  to: for the same angle of site (roughly estimated
- pg 272 Changed: To set up the tesescope.
  to: To set up the telescope.
- pg 272 Changed: and sphercial aberration
  to: and spherical aberration
- pg 276 Changed: is set up and horiontal
  to: is set up and horizontal
- pg 276 Changed: turn the teslecope until
  to: turn the telescope until
- pg 278 Changed: Substracting one reading from the other
  to: Subtracting one reading from the other
- pg 280 Changed: and the verticle spindle
  to: and the vertical spindle
- pg 285 Changed: reliable means of communition
  to: reliable means of communication
- pg 289 Changed: connecting by independant wires
  to: connecting by independent wires
- pg 291 Changed: pivot at one to press against the shutter
  to: pivot at one end to press against the shutter
- pg 292 Changed: tip spring and the anvil are then contact
  to: tip spring and the anvil are then in contact
- pg 292 Changed: equipment also inculdes a night bell
  to: equipment also includes a night bell
- pg 297 Changed: station instrument will be imparied
  to: station instrument will be impaired
- pg 298 Changed: particularily in an advance
  to: particularly in an advance

- pg 303 Changed: The Very pistol cartrdiges
  to: The Very pistol cartridges
- pg 309 Changed: adjust the crustal detector
  to: adjust the crystal detector
- pg 312 Changed: kept in a clean contion
  to: kept in a clean condition
- pg 313 Changed: Scratching noises in the telepone
  to: Scratching noises in the telephone
- pg 314 Changed: evidenced by the fact that the condeser
  to: evidenced by the fact that the condenser
- pg 323 Changed: differs from those generaly built
  to: differs from those generally built
- pg 336 Changed: differing only in certin details
  to: differing only in certain details
- pg 341 Changed: may again be applied graually
  to: may again be applied gradually
- pg 354 Changed: maximum given in the appropropriate
  to: maximum given in the appropriate
- pg 361 Changed: completion of sweeping voley
  to: completion of sweeping volley

*** END OF THE PROJECT GUTENBERG EBOOK
FIELD ARTILLERY MATERIEL ***

Updated editions will replace the previous one—
the old editions will be renamed.

Creating the works from print editions not
protected by U.S. copyright law means that no
one owns a United States copyright in these
works, so the Foundation (and you!) can copy
and distribute it in the United States without
permission and without paying copyright
royalties. Special rules, set forth in the General
Terms of Use part of this license, apply to
copying and distributing Project Gutenberg™
electronic works to protect the PROJECT
GUTENBERG™ concept and trademark. Project
Gutenberg is a registered trademark, and may
not be used if you charge for an eBook, except
by following the terms of the trademark license,
including paying royalties for use of the Project
Gutenberg trademark. If you do not charge
anything for copies of this eBook, complying
with the trademark license is very easy. You
may use this eBook for nearly any purpose such
as creation of derivative works, reports,
performances and research. Project Gutenberg
eBooks may be modified and printed and given
away—you may do practically ANYTHING in the
United States with eBooks not protected by U.S.
copyright law. Redistribution is subject to the
trademark license, especially commercial
redistribution.

START: FULL LICENSE

THE FULL PROJECT GUTENBERG™ LICENSE

PLEASE READ THIS BEFORE YOU DISTRIBUTE OR USE THIS WORK

To protect the Project Gutenberg™ mission of promoting the free distribution of electronic works, by using or distributing this work (or any other work associated in any way with the phrase “Project Gutenberg”), you agree to comply with all the terms of the Full Project Gutenberg License available with this file or online at www.gutenberg.org/license.

Section 1. General Terms of Use and Redistributing Project Gutenberg electronic works

1.A. By reading or using any part of this Project Gutenberg electronic work, you indicate that you have read, understand, agree to and accept all the terms of this license and intellectual property (trademark/copyright) agreement. If you do not agree to abide by all the terms of this agreement, you must cease using and return or destroy all copies of Project Gutenberg electronic works in your possession. If you paid a fee for obtaining a copy of or access to a Project Gutenberg electronic work and you do not agree to be bound by the terms of this agreement, you may obtain a refund from the person or entity to whom you paid the fee as set forth in paragraph 1.E.8.

1.B. “Project Gutenberg” is a registered trademark. It may only be used on or associated in any way with an electronic work by people who agree to be bound by the terms of this agreement. There are a few things that you can do with most Project Gutenberg electronic works even without complying with the full terms of this agreement. See paragraph 1.C below. There are a lot of things you can do with Project Gutenberg electronic works if you follow the terms of this agreement and help preserve free future access to Project Gutenberg electronic works. See paragraph 1.E below.

1.C. The Project Gutenberg Literary Archive Foundation (“the Foundation” or PGLAF), owns a compilation copyright in the collection of Project Gutenberg electronic works. Nearly all the individual works in the collection are in the public domain in the United States. If an individual work is unprotected by copyright law in the United States and you are located in the United States, we do not claim a right to prevent you from copying, distributing, performing, displaying or creating derivative works based on the work as long as all references to Project Gutenberg are removed. Of course, we hope that you will support the Project Gutenberg mission of promoting free access to electronic works by freely sharing Project Gutenberg works in compliance with the terms of this agreement for keeping the Project Gutenberg name associated with the work. You can easily comply with the terms of this agreement by keeping this work in the same format with its attached full Project Gutenberg License when you share it without

charge with others.

1.D. The copyright laws of the place where you are located also govern what you can do with this work. Copyright laws in most countries are in a constant state of change. If you are outside the United States, check the laws of your country in addition to the terms of this agreement before downloading, copying, displaying, performing, distributing or creating derivative works based on this work or any other Project Gutenberg work. The Foundation makes no representations concerning the copyright status of any work in any country other than the United States.

1.E. Unless you have removed all references to Project Gutenberg:

1.E.1. The following sentence, with active links to, or other immediate access to, the full Project Gutenberg License must appear prominently whenever any copy of a Project Gutenberg work (any work on which the phrase “Project Gutenberg” appears, or with which the phrase “Project Gutenberg” is associated) is accessed, displayed, performed, viewed, copied or distributed:

> This eBook is for the use of anyone anywhere in the United States and most other parts of the world at no cost and with almost no restrictions whatsoever. You may copy it, give it away or re-use it under the terms of the Project

Gutenberg™ License included with this eBook or online at www.gutenberg.org. If you are not located in the United States, you will have to check the laws of the country where you are located before using this eBook.

1.E.2. If an individual Project Gutenberg electronic work is derived from texts not protected by U.S. copyright law (does not contain a notice indicating that it is posted with permission of the copyright holder), the work can be copied and distributed to anyone in the United States without paying any fees or charges. If you are redistributing or providing access to a work with the phrase “Project Gutenberg” associated with or appearing on the work, you must comply either with the requirements of paragraphs 1.E.1 through 1.E.7 or obtain permission for the use of the work and the Project Gutenberg trademark as set forth in paragraphs 1.E.8 or 1.E.9.

1.E.3. If an individual Project Gutenberg electronic work is posted with the permission of the copyright holder, your use and distribution must comply with both paragraphs 1.E.1 through 1.E.7 and any additional terms imposed by the copyright holder. Additional terms will be linked to the Project Gutenberg License for all works posted with the permission of the copyright holder found at the beginning of this work.

1.E.4. Do not unlink or detach or remove the full Project Gutenberg License terms from this work,

or any files containing a part of this work or any other work associated with Project Gutenberg.

1.E.5. Do not copy, display, perform, distribute or redistribute this electronic work, or any part of this electronic work, without prominently displaying the sentence set forth in paragraph 1.E.1 with active links or immediate access to the full terms of the Project Gutenberg License.

1.E.6. You may convert to and distribute this work in any binary, compressed, marked up, nonproprietary or proprietary form, including any word processing or hypertext form. However, if you provide access to or distribute copies of a Project Gutenberg work in a format other than “Plain Vanilla ASCII” or other format used in the official version posted on the official Project Gutenberg website (www.gutenberg.org), you must, at no additional cost, fee or expense to the user, provide a copy, a means of exporting a copy, or a means of obtaining a copy upon request, of the work in its original “Plain Vanilla ASCII” or other form. Any alternate format must include the full Project Gutenberg License as specified in paragraph 1.E.1.

1.E.7. Do not charge a fee for access to, viewing, displaying, performing, copying or distributing any Project Gutenberg works unless you comply with paragraph 1.E.8 or 1.E.9.

1.E.8. You may charge a reasonable fee for copies of or providing access to or distributing Project Gutenberg electronic works provided that:

- You pay a royalty fee of 20% of the gross profits you derive from the use of Project Gutenberg works calculated using the method you already use to calculate your applicable taxes. The fee is owed to the owner of the Project Gutenberg trademark, but he has agreed to donate royalties under this paragraph to the Project Gutenberg Literary Archive Foundation. Royalty payments must be paid within 60 days following each date on which you prepare (or are legally required to prepare) your periodic tax returns. Royalty payments should be clearly marked as such and sent to the Project Gutenberg Literary Archive Foundation at the address specified in Section 4, “Information about donations to the Project Gutenberg Literary Archive Foundation.”

- You provide a full refund of any money paid by a user who notifies you in writing (or by e-mail) within 30 days of receipt that s/he does not agree to the terms of the full Project Gutenberg™ License. You must require such a user to return or destroy all copies of the works possessed in a physical medium and discontinue all use of and all access to other copies of Project Gutenberg™ works.

- You provide, in accordance with paragraph 1.F.3, a full refund of any money paid for a work or a replacement copy, if a defect in the electronic work is discovered and reported to you within 90 days of receipt of the work.

- You comply with all other terms of this agreement for free distribution of Project

Gutenberg™ works.

1.E.9. If you wish to charge a fee or distribute a Project Gutenberg™ electronic work or group of works on different terms than are set forth in this agreement, you must obtain permission in writing from the Project Gutenberg Literary Archive Foundation, the manager of the Project Gutenberg™ trademark. Contact the Foundation as set forth in Section 3 below.

1.F.

1.F.1. Project Gutenberg volunteers and employees expend considerable effort to identify, do copyright research on, transcribe and proofread works not protected by U.S. copyright law in creating the Project Gutenberg™ collection. Despite these efforts, Project Gutenberg™ electronic works, and the medium on which they may be stored, may contain “Defects,” such as, but not limited to, incomplete, inaccurate or corrupt data, transcription errors, a copyright or other intellectual property infringement, a defective or damaged disk or other medium, a computer virus, or computer codes that damage or cannot be read by your equipment.

1.F.2. LIMITED WARRANTY, DISCLAIMER OF DAMAGES - Except for the “Right of Replacement or Refund” described in paragraph 1.F.3, the Project Gutenberg Literary Archive Foundation, the owner of the Project Gutenberg™ trademark, and any other party distributing a Project Gutenberg™ electronic work under this agreement, disclaim all liability

to you for damages, costs and expenses, including legal fees. YOU AGREE THAT YOU HAVE NO REMEDIES FOR NEGLIGENCE, STRICT LIABILITY, BREACH OF WARRANTY OR BREACH OF CONTRACT EXCEPT THOSE PROVIDED IN PARAGRAPH 1.F.3. YOU AGREE THAT THE FOUNDATION, THE TRADEMARK OWNER, AND ANY DISTRIBUTOR UNDER THIS AGREEMENT WILL NOT BE LIABLE TO YOU FOR ACTUAL, DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE OR INCIDENTAL DAMAGES EVEN IF YOU GIVE NOTICE OF THE POSSIBILITY OF SUCH DAMAGE.

1.F.3. LIMITED RIGHT OF REPLACEMENT OR REFUND - If you discover a defect in this electronic work within 90 days of receiving it, you can receive a refund of the money (if any) you paid for it by sending a written explanation to the person you received the work from. If you received the work on a physical medium, you must return the medium with your written explanation. The person or entity that provided you with the defective work may elect to provide a replacement copy in lieu of a refund. If you received the work electronically, the person or entity providing it to you may choose to give you a second opportunity to receive the work electronically in lieu of a refund. If the second copy is also defective, you may demand a refund in writing without further opportunities to fix the problem.

1.F.4. Except for the limited right of replacement or refund set forth in paragraph 1.F.3, this work is provided to you ‘AS-IS’, WITH NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR

IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PURPOSE.

1.F.5. Some states do not allow disclaimers of certain implied warranties or the exclusion or limitation of certain types of damages. If any disclaimer or limitation set forth in this agreement violates the law of the state applicable to this agreement, the agreement shall be interpreted to make the maximum disclaimer or limitation permitted by the applicable state law. The invalidity or unenforceability of any provision of this agreement shall not void the remaining provisions.

1.F.6. INDEMNITY - You agree to indemnify and hold the Foundation, the trademark owner, any agent or employee of the Foundation, anyone providing copies of Project Gutenberg™ electronic works in accordance with this agreement, and any volunteers associated with the production, promotion and distribution of Project Gutenberg™ electronic works, harmless from all liability, costs and expenses, including legal fees, that arise directly or indirectly from any of the following which you do or cause to occur: (a) distribution of this or any Project Gutenberg work, (b) alteration, modification, or additions or deletions to any Project Gutenberg work, and (c) any Defect you cause.

Section 2. Information about the Mission of Project Gutenberg

Project Gutenberg is synonymous with the free

distribution of electronic works in formats readable by the widest variety of computers including obsolete, old, middle-aged and new computers. It exists because of the efforts of hundreds of volunteers and donations from people in all walks of life.

Volunteers and financial support to provide volunteers with the assistance they need are critical to reaching Project Gutenberg's goals and ensuring that the Project Gutenberg collection will remain freely available for generations to come. In 2001, the Project Gutenberg Literary Archive Foundation was created to provide a secure and permanent future for Project Gutenberg and future generations. To learn more about the Project Gutenberg Literary Archive Foundation and how your efforts and donations can help, see Sections 3 and 4 and the Foundation information page at www.gutenberg.org.

Section 3. Information about the Project Gutenberg Literary Archive Foundation

The Project Gutenberg Literary Archive Foundation is a non-profit 501(c)(3) educational corporation organized under the laws of the state of Mississippi and granted tax exempt status by the Internal Revenue Service. The Foundation's EIN or federal tax identification number is 64-6221541. Contributions to the Project Gutenberg Literary Archive Foundation are tax deductible to the full extent permitted by U.S. federal laws and your state's laws.

The Foundation's business office is located at 41

Watchung Plaza #516, Montclair NJ 07042, USA, +1 (862) 621-9288. Email contact links and up to date contact information can be found at the Foundation's website and official page at www.gutenberg.org/contact

Section 4. Information about Donations to the Project Gutenberg Literary Archive Foundation

Project Gutenberg™ depends upon and cannot survive without widespread public support and donations to carry out its mission of increasing the number of public domain and licensed works that can be freely distributed in machine-readable form accessible by the widest array of equipment including outdated equipment. Many small donations ($1 to $5,000) are particularly important to maintaining tax exempt status with the IRS.

The Foundation is committed to complying with the laws regulating charities and charitable donations in all 50 states of the United States. Compliance requirements are not uniform and it takes a considerable effort, much paperwork and many fees to meet and keep up with these requirements. We do not solicit donations in locations where we have not received written confirmation of compliance. To SEND DONATIONS or determine the status of compliance for any particular state visit www.gutenberg.org/donate.

While we cannot and do not solicit contributions from states where we have not met the

solicitation requirements, we know of no prohibition against accepting unsolicited donations from donors in such states who approach us with offers to donate.

International donations are gratefully accepted, but we cannot make any statements concerning tax treatment of donations received from outside the United States. U.S. laws alone swamp our small staff.

Please check the Project Gutenberg web pages for current donation methods and addresses. Donations are accepted in a number of other ways including checks, online payments and credit card donations. To donate, please visit: www.gutenberg.org/donate.

Section 5. General Information About Project Gutenberg electronic works

Professor Michael S. Hart was the originator of the Project Gutenberg concept of a library of electronic works that could be freely shared with anyone. For forty years, he produced and distributed Project Gutenberg eBooks with only a loose network of volunteer support.

Project Gutenberg eBooks are often created from several printed editions, all of which are confirmed as not protected by copyright in the U.S. unless a copyright notice is included. Thus, we do not necessarily keep eBooks in compliance with any particular paper edition.

Most people start at our website which has the main PG search facility: www.gutenberg.org.

This website includes information about Project Gutenberg, including how to make donations to the Project Gutenberg Literary Archive Foundation, how to help produce our new eBooks, and how to subscribe to our email newsletter to hear about new eBooks.