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DOCUMENT IDENTIFICATION

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REPORT

of

Board of Officers

Appointed by Par.143, Special Orders No.289-O

War Department, 1918.

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SUBJECT:- A study of the armament, calibers and types of materiel, kinds and proportion of ammunition, and methods of transport of the artillery to be assigned to a field army.

1

Washington, D.C.,
May 5,1919.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: USAFAS/MSL/F400007	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Report of a Board of Officers Convened to Make a Study of the Armament and Types of Artillery Materiel to be Assigned to a Field Army	5. TYPE OF REPORT & PERIOD COVERED: Final-1918, 1919
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Chief of Staff, War Department- (Caliber Board")	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Field Artillery School, Morris Swett Library Division, Fort Sill, OK 73503	12. REPORT DATE: May 23,1919
	13. NUMBER OF PAGES: 64
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

This report is approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Recommendations of the Board are summarized in MG William J. Snow's Signposts of Experience, World War Memoirs, Wash., D.C.: U.S. Field Artillery Assoc., c1941. A three-page minority report is appended.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Artillery, Board of Officers, Army Planning, Materiel, Ordnance, Military Organizations, Military Planning, Warfare

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

On January 12, 1919 a Board of Officers, chaired by BG William I. Westervelt, was convened to consider the experience gained by artillery during WWI while serving with the American Expeditionary Forces. Their recommendations were issued in the form of a report during 1919 as to the armament and types of artillery materiel to be used by the U.S. Army's Artillery branch when supporting a Field Army.

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SUBJECT:- A study of the armament, calibers and types of materiel, kinds and proportion of ammunition, and methods of transport of the artillery to be assigned to a field army.

Washington, D.C.,
May 5,1919.

1. Report of a Board of Officers convened pursuant to the following order:

WAR DEPARTMENT,
Washington, December 11, 1918.

Special Orders)
No. 289-0)

Extract.

~~CONFIDENTIAL~~

Par. 142. A board of officers to consist of:

Brigadier General William I. Westervelt, U. S. Army.
Brigadier General Robert E. Callan, U. S. Army.
Brigadier General William P. Ennis, U. S. Army.
Colonel James B. Dillard, U. S. Army.
Colonel Ralph McT. Pennell, U. S. Army.
Lieutenant Colonel Webster A. Capron, U. S. Army.
Lieutenant Colonel Walter P. Boatwright, U. S. Army.

is appointed to meet at A. P. O. 706, France, at the earliest practicable date, to make a study of the armament, calibers and types of materiel, kinds and proportion of ammunition, and methods of transport of the artillery to be assigned to a Field Army.

During the time that the board is in session abroad, it will be under the direction of the Commander-in-Chief, A. E. F., France, who will issue the necessary travel orders.

After completing its investigations abroad, the board will return to the United States to finish its work at such ordnance and other plants in the United States as may be necessary.

334.2 (Field Artillery Equipment).

The travel directed is necessary in the military service.

By order of the Secretary of War:

PEYTON C. MARCH
General, Chief of Staff.

OFFICIAL:

P. C. HARRIS
The Adjutant General.

Washington, D. C., May 5, 1919.

The Board met January 12, 1919, at Chaumont, France, and, after organization, arranged for the accumulation of such artillery data as were available in France, visited manufacturing plants, and had conferences with the French and American artillery officers. It visited Italy, had conferences with the higher technical and artillery officers, visited manufacturing plants and had a conference on types and tactical uses of artillery at the Italian Great Headquarters. Similar opportunities were afforded the Board by the British at their Great Headquarters in France and at their War Ministry in England.

2. In making up its report, the Board has adopted the following general scheme of discussing and developing the subject:

I. The artillery of a field army: its functions (Par.3-5 incl.)

(a) Division artillery missions (Par. 6 - 9).

(b) Corps artillery mission (Par. 10).

(c) Army artillery missions (Par. 12 - 13).

II. Discussion of types of artillery.

(a) Light field gun (Par. 14).

(b) Light field howitzer (Par. 15).

(c) Medium field gun (Par. 16).

(d) Medium field howitzer (Par. 17).

(e) Heavy field gun (Par. 18).

(f) Heavy field howitzer (Par. 19).

(g) Super guns and howitzers (Par. 20).

III. Improvement in design and construction of projectiles (Par. 21 - 28).

IV. Types of artillery recommended: ideal and practical.

Light field artillery.

(a) Gun (Par. 29 - 32).

(b) Howitzer (Par. 33 - 35).

I. THE ARTILLERY OF A FIELD ARMY: ITS FUNCTIONS.

3. The artillery assigned to a Field Army should be of such mobility, power, variety and number as to insure the success of the mission involved 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. While it is not within the province of this board to discuss this question, it may be well not to leave it without stating that many actions of our divisions in France resulted in casualties whose numbers were a decreasing function of the number of guns with which divisions were supported. The proportion of guns per thousand gross strength to 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 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 warfare which necessitated leaving much artillery behind it was about 6 per thousand.

4. A study of the types of artillery actually employed by the

field armies in Europe might lead to some errors in drawing conclusions as to what should constitute a proper armament, for the reason that the various countries involved had to use existing types which they had at the beginning of the war, whether satisfactory or not, and build new and supplementary types, not always the ideal, even from their own standpoint, but such as the manufacturing facilities of their countries permitted. The development of types due to the emergency and the use of antiquated materiel multiplied the types for which ammunition had to be supplied; the war in turn also multiplied the types of ammunition which had to be supplied to a particular type of artillery. Such a condition of artillery materiel could only produce a limited degree of artillery efficiency, a mass of types of questionable value and great expenditure of money and industrial effort.

5. An artillery program should be founded on the object and the means - that is, the destruction of the target and the projectile to accomplish this. It should also admit of a proper series of ranges that would fulfill all the tactical requirements that could reasonably be expected of a series of types. 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 projectile the series could be:

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

The second and more logical method, and the one followed by the board, is to consider the artillery missions and determine the types best

suited irrespective of any theoretical series. However, in the discussions of artillery missions and the proper types for their fulfillment which the board had with our own and foreign officers, there was a remarkable degree of unanimity of thought on these subjects; and the above table actually contains, with slight variations, the types that were 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.

(a) Division Artillery Missions.

6. 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 this mobility; its objective 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 objective; it must have great range because of echelonment in depth, both of its own and the opposing 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 counter-offensive preparation and by annihilating fire on points from which the attacks emerge; and, failing in these, be prepared to use the barrage and the close range shrapnel fire. In the offensive the division artillery must play its part in the complex scheme 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 by echelons; and by its mobility it often becomes for some time the sole artillery protection in the consolidation of a position which has been taken.

7. It would be ideal if one type of weapon could accomplish all the requirements that the division artillery should fulfill, and some artillery officers in one of the foreign armies have made a study of a gun-howitzer with this in mind. The objections to such a gun-howitzer are:

(a) That it would require the use of a projectile of about 30 lbs., which is about twice that of the normal field gun ammunition, thereby greatly increasing the tonnage of ammunition supply for the same volume of fire.

(b) That it would require a complication of the ammunition supply to individual batteries in that both fixed and semi-fixed ammunition would have to be supplied if the double function of the piece was to be taken advantage of at any time. To meet this by having all the ammunition semi-fixed would result in a decreased rate of fire when the piece was used as a gun.

(c) That to obtain fairly good gun characteristics the weight of the piece and carriage would be increased and, therefore, the mobility decreased.

(d) That in any case the piece would not be the best type of either field gun or field howitzer.

8. 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 generally as satisfactory to their own governments and not liable to any radical changes. This 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 offers such protection to infantry that the field gun cannot bring an effective fire. The howitzer has the great advantage that with a proper set of propelling charges and, therefore, a choice of trajectories for the same range, protected positions can be chosen for howitzers that guns could not use, and angles of fall on objectives obtained 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 the 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 and carriage, or about 4500 lbs.

9. In connection with the support of the division infantry by the division artillery the war has intensified the old question of accompanying guns for infantry. A solution of this question by the assignment of batteries of field artillery has been tried but the general opinion is that the field artillery gun is not satisfactory for this purpose; it is too vulnerable a target in motion; the ammunition supply is difficult; it is not sufficiently mobile because it cannot be man-handled; and from the division artillery standpoint the loss of the control of these batteries breaks down the power of the division artillery. One of the most serious obstacles to the advance of infantry is the enemy's machine guns. If the machine gun nest is isolated it is relatively simple to maneuver in such a way as to neutralize it. If, however, there is a line of machine gun nests it becomes necessary to destroy a certain number in order to out maneuver the others. The infantry rifles, machine guns and 37 mm. guns are not sufficient for the latter mission. It is not

always easy to obtain promptly the action of the division artillery, usually some distance in the rear, and it is difficult to indicate to the artillery the exact location of the machine gun nests. For the above reasons it seems proper that a special gun, designed for the destruction of machine gun nests and other light forms of enemy resistance, should be provided. This gun should have such mobility that it can be man-handled as a unit, that is, dragged along on a low wheeled mount; it should be accurate for its purpose up to 2,500 yards and use a large capacity high explosive shell. Its carriage should also admit of ready adaptation for use in trenches.

(b) Corps Artillery Missions.

10. It will be noted above that the division artillery missions did not include their own protection against enemy artillery. This counter-battery work is the principal mission of the corps artillery. There are American officers who advance the idea that, because of their actual experience in not receiving proper corps artillery support, the division should be supplied with counter-battery artillery; the matter is complicated because the 155 mm. howitzer which formed part of our division artillery brigades is an ideal counter-battery weapon, and further by the fact that these howitzers did not form a part of our corps artillery, which organically consisted of guns alone. This should not divert us from the fact that the mission of counter-battering the enemy's gun belongs to the corps which has the proper agencies for determining the position of enemy guns and for coordinating this work so as to fit in with the plans of the corps commander. The corps artillery has also the missions 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 distinct types of artillery necessary, a gun and a howitzer, each having about 16,000 yards range and each weighing with carriage about 11,000 lbs.

There is another class of artillery called anti-aircraft artillery to be considered. This is used first in providing anti-aircraft defense to troops engaged in combat and, second, in providing anti-aircraft defense for army zones, for certain areas in rear of armies or along certain line of anti-aircraft defense.

The first class gives protection from low flying air-planes to troops engaged in combat; it should, therefore, form part of the field army. The second class is part of the general anti-aircraft defense and works in coordination with the air service, balloon defense, searchlights and anti-aircraft machine guns, thus forming the anti-aircraft defense service.

(c) Army Artillery Missions.

11. 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 divisions or corps types, properly transported, for strategic reinforcement of divisions and corps during such times as the normal allotment to such units is insufficient; there must be artillery of special purpose - pack artillery, trench artillery 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, more powerful than the medium field types, add range to the interdiction and harassing, and to the neutralization and destruction

possible with the corps types.

12. Considering paragraphs 3 - 11 inclusive it will be seen that the normal artillery missions of a field army can be accomplished by an assignment of six calibers, 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.

13. The surplus of field army types for strategic reinforcement of their respective units, the artillery of special purpose,- pack artillery, trench artillery, obsolescent types, and super-guns and howitzers,- are believed to be outside of the normal assignment of armament to a Field Army. At times all or any of the special types are necessary in field army missions; these types have no continuing purpose and should, therefore, be looked upon and organized as available reinforcement or reserve for the artillery of field armies.

II. DISCUSSION OF TYPES OF ARTILLERY.

(a) The Light Field Gun.

14. The consensus of opinion of all artillery officers - French, Italian, 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 division artillery. The projectile in question, whether a shrapnel or 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 the light field gun. All the nations whose tendencies have been considered in this report have experimented to a varying degree with field gun carriages, particularly in a desire to design a carriage permitting a greater angle of elevation and a greater movement of the

gun in 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 carriage axis of about 20 degrees. The High Command informed the board that this carriage had given such excellent service that no consideration had been given to the design of a different type carriage.

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-pdr. 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. The Vickers Company have designed and manufactured one split-trail carriage, presumably with a view of having the details of such carriage in hand in the event of a service demand for such vehicle.

The split-trail carriage is fairly well known in the United States; opinion has not yet been crystallized throughout the artillery, which is still more or less open-minded and quite willing to accept the tactical advantages of the split-trail type when some of the present mechanical disadvantages shall have been remedied. It may be stated that the field artillery would be glad to have a possibility of increased elevation and increased traverse, provided the simplicity of construction inherent in the single trail type can be retained. The field artillery believes that a satisfactory split-

trail type of carriage can be made.

It is desirable that the breech blocks of all weapons be confined to one type. The three types of breech blocks in use in the present American 75 mm. guns are the French rotating block, the American drop wedge block and the British swinging block. All three types are in general satisfactory. The firing mechanism should be of the fewest possible number of working parts preferably of the lanyard type.

The consensus of opinion was that the independent line of sight is necessary; also that the general type of panoramic sight of American design with graduations from zero to 6400 mils in aximuth is preferable.

At some time in the future it is probable that all division artillery will be motorized. The result of such 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 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 feature 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 mount of the pedestal type expressing the desires of

the field artillery with respect to maximum horizontal and vertical arcs of fire.

(b) The Light Field Howitzer.

15. The consensus of opinion of American artillery officers consulted is that a howitzer of about 4 inches 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 further 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 7700 yds.; the weight of the howitzer limbered is 4,676 pounds,- 150 pounds more than the weight of the 18-pdr 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 co-efficient of form. During the war the proportion of 4½" howitzers to 3.3" field guns was 33-1/3 per cent; 25,000,000 rounds were fired from the 4½" howitzers as compared with 100,000,000 rounds fired from the 3.3" field guns.

The French artillery was not equipped with the light field howitzer of approximately the same weight as the 75 mm. field gun. There is some difference of opinion among officers of the French artillery as to the necessity for a light field howitzer, though it is believed the best opinion favors the adoption of such type. During the war it was found impracticable to construct a light 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 105 mm. howitzers. The Italian General Staff is not prepared to state that a light field howitzer is altogether a necessary part of the artillery equipment of a field army. The opinion, however, of artillery officers on this subject is divided. 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 are concerned, makes it certain that a light field howitzer will be furnished 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., firing a projectile weighing 34.54 pounds at a maximum range of 10,500 yds (stream line 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 for their '96 field gun and in the years that passed from 1898 until 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 the light howitzers. Their 1916 models of both light gun and howitzer show the endeavor to keep the pieces in the same class; that is, the weight of gun and howitzer in action nearly the same, 2750 lbs and 2700 lbs; the weight of the gun limbered and howitzer limbered the same, 4500 lbs.; the elevation of both the same,- minus 10 to plus 40 degrees; the carriages are the same type; and the extreme ranges of gun and howitzer are respectively 11,700 yards and 10,500 yards.

From the above 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 American artillery was not fully as 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. gun, 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 lighter 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 this purpose.

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

(c) The Medium Field Gun.

16. The consensus of opinion of artillery officers,- Italian, English and American,- is that a medium caliber field gun, i.e., a caliber between the light field gun and the field gun of about 6" caliber is necessary. The French are not entirely convinced of this necessity and hold divided opinion. The Chief of the French Artillery Mission attached to the Chief of Artillery, American E. F., is strongly of the opinion that a medium caliber field gun should be interpolated.

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 8700 yds.

The British army was equipped with the 5" gun,- the carriage permits a maximum elevation of 21 deg. 30 min., giving a maximum range of 12,500 yds.

The French army was equipped, to a certain extent, with the 105 mm. and the 140 mm. gun. The 105 mm. gun has a maximum elevation of 37 degrees, with a maximum range of 13,9000 yds. The 140 mm. gun has a maximum elevation of 30 deg., and, with a high velocity, has a maximum range of 19,500 yds. The French 105 mm. gun is a modern weapon (1913).

The German artillery was equipped with a 105 mm. gun, (Model 1917) with a maximum elevation of 45 deg., and a maximum range of 16,000 yds. The German artillery was also equipped with the 130 mm. gun, having a maximum range of 16,500 yards. The Austrian artillery was similarly equipped.

The Italians were equipped with a 105 mm. gun essentially of the same characteristics as the French 105 mm., Model 1913.

(d) The Medium Field Howitzer.

17. In the opinion of the French, the Italians, the British and the Americans, the 155 mm. howitzer (Schneider) 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 (Schneider) 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 of 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.

(e) The Heavy Field Gun.

18. The consensus of opinion of all artillery officers,- English, Italian and American,- is that the heavy field gun should be of approximately 6" caliber, and that guns greater than this are necessary in limited numbers 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 yds. The French have recently made considerable progress in securing the necessary increase in range with the G. P. F. The latest British 6" gun gives a maximum range with a 100 lb. projectile of 23,000 yards at 38 deg. elevation, the carriage permitting 8 deg. traverse.

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 missions of the heavy field gun are 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 for 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 opinion of all artillery officers,- French, British and American,- that the heavy field gun should be of approximately 6" caliber with a range in excess of 25,000 yds., with not less than 60 degrees 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 2-way traffic in ordinary roads. The Italians differ from this opinion only in that they are satisfied with a maximum range of 18,000 yards.

(f) The Heavy Field Howitzer.

19. No type of heavy field howitzer developed during the war has given general satisfaction. The consensus of opinion of all artillery officers,- French , British and American,- is that two calibers of field howitzers are necessary, one a companion piece for the 6-inch 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 yds. The heavier field howitzer should be of about 9.5 inches caliber with a range in excess of 16,000 yds.; the carriage should provide for wide traverse and must have sufficient mobility to accompany an 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.

(g) Super-heavy Guns and Howitzers.

20. 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.

The British have got satisfactory results from their 9.2" gun and their 12" howitzer and their 14" gun on the Armstrong mount. The French have used a large variety of guns on railroad mounts and during the last year of the war were constructing a considerable number of very long range weapons. While admitting that we may never be engaged in another war in which operations assume exactly the form which for so long existed on the Western front, it is the consensus of opinion of artillery officers,- American, French and English,- that railroad artillery is a necessity in operations that will invariably result when large forces are engaged. These types are needed in limited quantities, considering the needs of Field Armies only, and should be of four calibers: an 8" gun with all round fire, a maximum range of 35,000 yards and capable of being transported on a narrow gauge track; a 14" gun with a range of 40,000 yards and limited traverse; a howitzer of about 12" caliber, with a range of not less than 25,000 yards and a 360 degree traverse, and a 16" howitzer having a maximum range of not less than 27,000 yards and with limited traverse. Of these types the 8" should predominate in number.

These types will not only be needed in field operations but also in the initial contact with the enemy at the coast line and boundaries. The latter use should determine the exact characteristics and numbers of these guns and howitzers and the numbers to be assigned to the general artillery reserve will depend on the general .

military situation as viewed by the High Command.

III. IMPROVEMENTS IN DESIGN AND CONSTRUCTION OF PROJECTILES.

21. Great thought has been devoted to this subject during the war and many experiments have been made. It may be stated that the general laws governing the design of projectiles for maximum ballistic efficiency have not been formulated and, in fact, there is at the present time insufficient data upon which to proceed. The false ogive, boat-tailing, alterations in the shape and location of rotating bands have greatly increased the range of modern projectiles, but there are critical points in each of these modifications at which improvement ceases. There are investigations under way by the Ordnance Department covering this entire subject and the Board recommends that these be continued. It is to be expected that this subject will require extended investigation and is one which can only be adequately handled by a continuing technical body.

22. The development of the mechanical time fuse should be actively prosecuted. This fuse is particularly valuable for high altitude trajectories, but the powder train fuse as now manufactured must be continued for bulk production on account of the almost negligible manufacturing capacity existing or likely to exist for the mechanical fuse.

23. The Board desires to emphasize the necessity for making fuses for high explosive shell bore-safe. The French type super-quick fuse is seriously defective in this regard. The destruction of cannon due to premature bursts during the past war has been enormous, due largely, in the opinion of the Board, to the use of this fuse.

24. It is especially desirable to reduce the types of fuses issued to any single organization. In the past war the 75 mm. shells were normally supplied with four varieties of fuse ranging from the

super-quick to the long delay. The evidence before the Board is to the effect that this is an unnecessary complication, and it is recommended that the number be reduced to two. A similar policy has been followed in all other calibers.

25. It has been considered fundamental that all guns be furnished with a type of projectile which will give the maximum range, and that all howitzers except the 105 mm. be furnished with a type of shell to carry the maximum bursting charge. It has also been considered that semi-steel (cast iron) projectiles should be supplied for production reasons in the most important calibers requiring enormous quantity production. It is considered that the semi-steel projectiles have proved efficient against animate targets and are reasonably satisfactory against materiel where burst above the ground is desired.

26. In connection with fuses, by "super-quick" the Board means a fuse which will burst the projectile above the ground without any crater whatever. By "instantaneous" is meant a fuse which will burst the projectile on the outside of a hard surface such as a concrete emplacement before penetration or ricochet. This fuse will give some crater on hard ground. By "short delay" is meant a fuse which will burst the projectile on ricochet, prerefably at a height of about 6 to 10 feet. Some crater effect will be obtained on hard ground but the fuse is desired for ricochet effect. By "long delay" is meant a fuse which will burst the projectile after complete penetration into hard ground. Obviously there will be a variation in the time element in long delay fuses required for such different types as a 155 mm. Howitzer projectile and a 16-inch Howitzer projectile in order to obtain in each case the maximum mining effect. This is a question to be determined by the Ordnance Department.

27. The Board has purposely used the term "super-charge" in

referring to the propelling charge required in the case of guns to give the maximum ranges. It cannot be too strongly emphasized that the normal charge should be used always within the maximum ranges obtainable with it and the use of super-charges must be prohibited except where necessary, otherwise the wear on the guns will become inadmissible.

28. The Board desires to point out the defects in nitro-cellulose powder. This powder takes up moisture from a damp atmosphere and deteriorates in its ballistic qualities. It requires elaborate and expensive containers and, even with the containers which have been provided, large quantities of powder have been rendered unfit for service. A powder containing nitro glycerine or similar compounds can be used in simpler containers and will tolerate adverse conditions of moisture.

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IV. TYPES OF ARTILLERY RECOMMENDED; IDEAL AND PRACTICAL.

Light Field Artillery.

29. (a) Gun. Ideal. A gun of about 3" caliber on a carriage permitting a vertical arc of fire of from minus 5 degrees to plus 80 degrees, 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; bore-safe, super-quick and selective delay fuses for shell. The high explosive shell should be of one type only. It should be designed for maximum ballistic efficiency and should contain the maximum bursting charge compatible with that object. For cheap manufacture a semi-steel shell may be furnished, provided it has the same exterior ballistics as the standard shell. 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. The ballistics of the shell and shrapnel should be the same, if practicable; the ballistics of the round of ammunition should be the same regardless of the type of fuse used. A maximum rate of fire of 20 rounds per minute is deemed sufficient.

30. Practical. For the present arm brigades with 75 mm. material, Model 1916 . . . 50%, and 75 mm. (French) . . . 50%. Continue experiments on carriage types, perfecting the split-trail carriage and studying the subject of a carriage for all round fire; continue experiments with projectiles for increase in range, power and accuracy. Our time fuse is as satisfactory as any at the present time, but a mechanical fuse should be perfected. There is no requirement at the present time for more than one variety of delay action fuse for the 75 mm. gun. For shell the super-quick and short delay fuses only are required. The present super-quick fuse must be made bore-safe. It is not satisfactory in its present form. For motorized regiments rubber tired wheels are required.

31. Transport. Ideal. Mechanical transport is the prime mover of the future. It is most important that design, experiment and test of self-propelling caterpillar types, also of caterpillar for draw-bar pull, of wheeled trailers for long rapid hauls, and of the development of similar ammunition vehicles, be vigorously pushed. For normal use a maximum speed of 12 miles per hour is sufficient. 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 vigorously carried on along these lines, as we are on the verge of changes fully as radical as the introduction of the long recoil field gun 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 universally imposed on artillery of this class. The corresponding limit in the future will probably be that imposed by pontoon bridges.

32. Practical. While there is no question that the tendency is towards complete motorization, the Board, from a result of its investigation, does not feel justified at the present time in recommending complete motorization of all division artillery. Therefore, it is thought that four regiments of 75 mm. guns, (2 regiments of French Model 1897, and 2 regiments U. S. Model 1916), should be immediately motorized; the remainder to be horsed; mechanical transport to gradually replace horse only after the tractor demonstrates its superiority in service. There are various limitations and imperfections in our present tractor equipment which it is believed can only be fully determined by a daily use of this equipment in service.

33. (b) Howitzer. Ideal. A weapon of about 105 mm. caliber 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. 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 shrapnel and shell. A maximum range of 12,000 yards will be satisfactory. Semi-fixed ammunition and zone charges should be used, otherwise the ammunition should be similar to that provided for the 75 mm. guns.

34. Practical. For the present, brigades should be armed with the 155 mm. howitzer, Schneider, but active development and test should be prosecuted on a type as stated under "Ideal" above, and with 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 artillery as recommended. In addition a split-trail carriage for this howitzer should be developed.

35. 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. For the present the 155 mm. Schneider howitzer regiments should be motorized. All testimony before the Board and all investigations of the Board emphasized the necessity of this.

Medium Field Artillery.

36. (c) 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 30 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 seperate loading ammunition parmissible. The normal charge should be established for about 12,000 yards. Propelling charge should be smokeless and flashless. The fuses should be time for shrapnel, with bore-safe, super-quick and selective delay for shell. One type of shell dosigned primarily for maximum ballistic efficiency is sufficient. It should contain as large a bursting charge as possible. A normal propelling charge for 12,000 yards should be established with a super-charge for maximum range. The proportion should be 80% of the former and 20% of the latter. A maximum rate of fire of six rounds per minute is considered sufficient. The limits of weight formerly imposed on this class of materiel by horse traction will no longer exist, and while the Board is not prepared to set a definite limit of weight for future development, it is believed that it may be safely assumed to be not less than 12,000 lbs. for wheeled vehicles or 15,000 lbs. for caterpillars. A normal maximum speed of 8 miles per hour is considered sufficient.

37. Practical. Corps artillery should be armed with the present type 4.7 inch gun, Model of 1906, except that at least one regiment should be armed with the British type 5 inch guns purchased abroad. The Board is influenced in this decision by the quantity of ammunition on hand. It would have been recommended that the bulk of the artillery be armed with the British gun except that it is believed that the large stock of 4.7 inch ammunition on hand must be utilized. In any case, as there will be a large quantity of both types of material on hand for use in an emergency for a considerable period of time, it is believed that both types should be continued in service in order that the field artillery may retain their familiarity with them. The remarks made in regard to the development of a type of carriage under the division field gun also apply to the corps gun and, in addition, it is believed that experimental work should be carried on with a view of developing a satisfactory split-trail carriage. Experiments with projectiles for increase in range, power and accuracy and development of fuses should be carried on as outlined for the division gun. The types of fuses recommended for the division gun apply also to the corps gun.

38. Transport. All corps guns should be fully motorized and wheeled trailers should be developed for long rapid hauls. Similar ammunition vehicles should be developed. The wheels for the gun carriage should be rubber tired.

39. (d) 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. It would be desirable to develop a carriage which can be used interchangeably for both corps gun and howitzer. The projectile should weigh not 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. Two types of shell

should be provided,- one for maximum bursting charge and one of comparatively inexpensive manufacture which may contaon less explosive; the ballistics of both should, if practicable, be the same. The proportion should be 70% of the former and 30% of the latter. Maximum range should be 16,000 yards. Ammunition should be separate loading, and related zone charges smokeless and flashless. Bore-safe, super-quick and selective delay fuses for shell. The maximum rate of fire should be not less than 5 rounds per minute. A split-trail carriage should be developed, interchangeable if practicable with that for the corps gun. Maximum speed the same as that of the corps gun, viz: 8 miles per hour

40. Practical. The corps should be armed with the 155 mm. Schneider howitzer referred to above. The types of fuses for shell should be super-quick and long delay.

Heavy Field Artillery.

41. (e) Gun. Ideal. A caliber of about 155 mm. on a carriage permitting a vertical arc of fire of from 0 degrees to plus 65 degrees; with a horizontal arc of fire of 360 degrees. A projectile weighing not over 100 pounds which should be interchangeable with that provided for the corps howitzer. High explosive shell only should be furnished. The self-propelled caterpillar unit offers a promising field of development for this type of gun, but a certain proportion should be retained on rubber tired wheeled mounts for rapid transportation; the maximum speed for the former type should be 6 miles per hour and for the latter type 12 miles per hour. Ammunition should be carried in original containers in trucks and tractor caissons. The conventional type of caisson is considered uneconomical and is obsolete for this caliber. The maximum range should be about 25,000 yards. A normal charge for range of 18,000 yards should be provided, with super-charge for greater ranges. The

ammunition should be separate loading and the propelling charge smokeless and flashless; with bore-safe, super-quick and selective delay fuses for shell. The shell should be of two types; a shell of maximum ballistic efficiency with fair sized bursting charge (50%); and a shell of inexpensive manufacture with as large bursting charge as practicable, inter-changeable with the 155 howitzer shell (50%).

42. 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.

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

44. (f) Howitzer. Ideal. A caliber of about 8" on a carriage permitting a vertical arc of fire of from 0 degrees to plus 65 degrees; and a horizontal arc of fire of 360 degrees. It would be desirable to develop a carriage which can be used interchangeably for the 155 mm. gun and the 8" howitzer; projectile should weigh not over 240 lbs.; the maximum range should be 18,000 yards; ammunition, separate loading; related zone charges, smokeless and flashless; shell only should be furnished which should be of two types, one of maximum capacity for bursting charge (50%), and one of comparatively cheap manufacture with fair size bursting charge (50%). For fuses, bore-safe, super-quick and selective delay should be furnished.

45. Practical. Use at present 8" material of British design which is on hand. The caterpillar treads which have been experimentally substituted for wheels are considered to be an advance and it is recommended that two batteries be so equipped for service test at once. Two types of fuses are required; the super-quick and the long delay.

46. Transport. All this material should be fully motorized. Ammunition should be carried in trucks and tractor caissons. A maximum speed of four miles per hour is sufficient.

Weapons of Greater Power.

47. (g) Heavy guns. Ideal. There will be missions requiring the use of direct fire and of a projectile weighing more than that of the 155 mm. gun referred to above. Guns will also be required having a range of more than that considered feasible for the 155 mm. gun and there should, therefore, be provided a limited quantity of guns of a caliber of about 194 mm. to 8-inches firing a projectile weighing about 220 pounds. The maximum range should be 35,000 yards. The ideal carriage for such a gun would conform in its general characteristics to those outlined above for the 155 mm. gun, and such a gun and carriage should be developed and tested until a satisfactory type is evolved. The projectile should be high explosive shell of maximum ballistic efficiency. The fuses should be super-quick and short delay. Suitable ammunition vehicles should be evolved and they should be the same as for the 8" howitzer referred to above. The type of equipment overlaps in its use the field of the 8 inch gun referred to hereafter on a railway type of mounting. The Board has in mind the development of a caterpillar carriage in this case, and while the weights involved appear large for a road type of mount, it is in the general line of development and is one which must be followed out. No gun of this power and weight has so far been arranged for road mounting by any foreign country, but the French have actually completed one of this type for their 194 mm. gun; this gun, however, is of considerably less power than the one recommended by this Board.

48. (h) Heavy howitzer. Ideal. A caliber of about 9½ inches on carriage permitting vertical arc of fire from 0 degrees to 65 degrees

and a horizontal arc of fire of 360 degrees. The carriage should be of a type requiring as little preparation for firing as possible. No type of road mount is known which is satisfactory in this respect, but the Board has in mind the development of a caterpillar type. The maximum speed need not exceed 6 miles per hour. The maximum load should not exceed 20 tons. A certain percentage should be on wheeled mounts and the loads divided so that the maximum on four wheels will not exceed 12 tons. A projectile weighing not over 400 pounds, high capacity, high explosive shell, with maximum range of 25,000 yards, separate loading, related zone, smokeless flashless propelling charges, fuses bore-safe instantaneous and selective delay. Three kinds of high explosive shell are permissible; (a) one to secure the maximum ballistic effect with as large a bursting charge as practicable; (b) one with maximum bursting charge; (c) one of comparatively cheap manufacture with fair size bursting charge.

49. Transport. Ideal. Mechanical transport, caterpillar drawn. Continue experiments on caterpillar mounts with the idea of developing a satisfactory type. Corresponding ammunition vehicles should be developed.

50. Practical. The present design of 240 mm. howitzer should be continued in service. It is unsatisfactory in the length of time required to emplace for firing, but it represents modern practice reasonably well. The super-quick and long delay fuses should be furnished.

51. (i) Super guns. In the design of all artillery of this class, it is essential that the Seacoast Defense problem be considered, since this type of artillery should be suitable not only for use in the field, but also for use along our coast against naval targets. For this reason, all carriages should be provided with means of obtaining all around fire, either from a position previously prepared, or from a temporary platform. This feature of all round fire in the case

of large guns and howitzers, will doubtless be in addition to the regular means provided for firing the mount in the field against the stationary target. The design of the carriages should be studied with the view of obtaining a universal barbette mount that could be emplaced in the present seacoast emplacements, in simple auxiliary emplacements and with trucks under it forming a railway mount.

52. Gun. Ideal. A gun of 8 inch or 10 inch, 50 calibers in length, on railway carriage, permitting a vertical arc of fire of from 0 degrees to 50 degrees, a horizontal arc of fire of 360 degrees, a high explosive projectile weighing not less than 240 pounds for 8 inch or 510 pounds for 10 inch, with a maximum range of not less than 35,000 yards. Separate loading ammunition, smokeless flashless charges, bore-safe, instantaneous and selective delay fuses. Maximum time for occupying a position under actual field conditions should not exceed one hour for the 8 inch or four hours for the 10 inch. The maximum rate of fire should not be less than one shot every two minutes.

53. Transport. Railway carriages adaptable for transportation over standard gauge track (carriages should be equipped with narrow gauge trucks, 60 cms (24")). Axle load should not exceed 17 long tons per axle. The mount should lie entirely within the International Clearance Diagram, and thus be suitable for transportation over European railways. Provision for both American M.C.B. standard couplings and the French type of couplings should be provided.

A gas electric locomotive of about 400 horse power capable of speeds up to 25 miles per hour should be developed for use with this type of artillery. Ammunition cars suitable for the storage of powder and projectiles are required. A complete repair shop should be provided. Tool equipment to be capable of making repairs on this type of artillery.

54. Practical. There are now being completed in the United States, 36 railway carriages of the Schneider type for mounting the

10 inch Seacoast guns, permitting a vertical arc of fire from 10 degrees to 55 degrees. The gun gives an estimated range of 24,000 yards with a 510 pound projectile. Also 37 - 8 inch guns have been mounted on railway mounts of the above characteristics except as to range. Range of these 8 inch guns with 200 pound projectile is 20,000 yards. Arm units with these available guns on railway mounts. An experimental 8 inch 50 caliber railway mount or 10 inch 50 caliber railway mount, should be manufactured in order that the proper type may be selected.

55. Gun. Ideal. A 14 inch gun 50 calibers long on a railway mount, permitting a vertical arc of fire from 0 degrees to 50 degrees, and a horizontal arc of fire of 360 degrees, from prepared position, or to 15 degrees when fired from curved track; a high explosive shell weighing not more than 1400 pounds with a maximum range of 40,000 yards, separate loading ammunition, smokeless flashless charges, bore-safe instantaneous and selective delay fuses. Time required for firing from prepared position not to exceed one hour. From unprepared position not to exceed 8 hours.

56. Practical. Arm units with available guns on railway mounts.

57 (j) Howitzer. Ideal. A 12 inch howitzer 20 calibers in length on carriage providing vertical arc of fire from 25 degrees to 60 degrees and a horizontal arc of fire of 360 degrees. A high explosive shell weighing about 700 pounds with a maximum range of 25,000 yards, or a 1046 pound shell with a maximum range of about 18,000 yards. Related zone charges, smokeless flashless powder, bore-safe instantaneous and selective delay fuses. Time to occupy field position not to exceed one hour, for all around fire.

58. Transport. Ideal. Same as above.

59. Practical. Arm units with available howitzers on railway mounts.

50. Howitzer. Ideal. 16 inch 25 caliber howitzer mounted

on railway mount permitting a vertical arc of fire from 25 degrees to 65 degrees. A horizontal arc of fire of 360 degrees from a prepared position or 10 degrees from a temporary position. High explosive shell weighing not less than 1600 pounds with a maximum range of 30,000 yards, related zone charges, smokeless flashless powder, bore-safe instantaneous and selective delay fuses.

61. Transport. Ideal. Same as above.

62. Practical. The manufacture of a pilot 16 inch 25 caliber howitzer on railway mount should be inaugurated.

Other Artillery.

ANTI-AIRCRAFT GUNS:

63. (k) In the recommendations of the Board under the heading "Ideal" it will be noted that the maximum elevation stated to be desirable has been made 80 degrees for the Division and Corps guns and 65 degrees for the heavier types. This is in view of the greatly increased air activity to be expected in the future and is with the expectation that the division and corps guns will be often used against airplanes and the heavier types against balloons. These ideal types are, however, not yet practical and the following special anti-aircraft equipments are necessary. Moreover, special anti-aircraft weapons will probably always be required on account of the need for a higher initial velocity than is permissible in a general purpose gun.

64. Light gun. Ideal. Caliber of about 3 inch with initial velocity of at least 2600 f.s; semi-automatic breech block, 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 rate of fire and decrease time of flight; this latter is limited only by considerations of a reasonable accuracy life for the gun.

65. Practical. Arm units with present 3-inch anti-aircraft equipment; continue experiments leading to the development of the ideal.

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

67. Heavy gun. Ideal. A caliber of 4.7 inches to 5 inches, with initial velocity of at least 2600 f.s.; semi-automatic breech block; mounted on a carriage permitting 80 degrees elevation and 360 degrees traverse; projectiles weighing not less than 45 pounds; one type high explosive shell with maximum ballistic qualities and as large bursting charge as practicable; fixed ammunition; smokeless flashless powder; mechanical fuse. In this type every effort must be made to increase rate of fire and decrease time of flight; this latter is only limited by a reasonable accuracy life to be obtained for the gun.

68. Practical. Arm units with present 4.7 inch anti-aircraft gun and continue experiments leading to the development of the ideal.

69. Transport. Ideal. Self-propelled caterpillar mount permitting sustained speed of 8 miles per hour with maximum weight not to exceed 10 tons, trailers to be provided for long and rapid hauls.

PACK ARTILLERY:

70. (1) Gun. Ideal. A caliber of about 3 inches; to use projectiles of division gun, if possible; to permit elevation of at least 45 degrees; a range of not less than 5,000 yards; to pack in loads about 225 pounds per load exclusive of pack equipment; to be equipped with panoramic sight; ammunition semi-fixed, flashless,

smokeless, with about four zones; capable of being pulled on wheels by the gun crew on normal ground, and for short distances over any ground. A shield is unnecessary.

71. Practical. Continue the present 75 mm. Vickers equipment in service. The material is, however, of an old type and it is one of the items of artillery in most urgent need of development.

INFANTRY ACCOMPANYING GUN:

72. (m) Gun. Ideal. A gun of about 2.5 inches caliber firing a projectile of about 10 pounds weight, mounted on a carriage, permitting elevation of from minus 5 degrees to plus 50 degrees and having a field of fire of not less than 6 degrees. The carriage should be designed so that it may be divided into loads, the maximum of which should not exceed 100 lbs. The gun and carriage complete to weigh not more than 300 pounds and to be arranged so that it can be readily hauled by two men over sod. The complete equipment must be capable of being man-handled in trenches. The gun should be effective for direct fire at 2500 yards. A telescopic sight should be furnished and the ammunition should consist of high explosive shell with maximum bursting capacity and instantaneous fuse. A cannon similar in general but of less power was examined in Italy and two equipments with 6,000 rounds of ammunition were ordered through the Military Attache's office in Rome.

73. Practical. Utilize the present 37 mm. guns on hand. These are deficient in the fact that the projectile is too light. In the opinion of the Board a cannon of the type described above would have the mobility of the 37 mm. gun and would provide in addition a most desirable substitute for the 3 inch Stokes trench mortar as used in the present war.

74. Transport. These equipments will be handled by men only, except on the march when they should be loaded in trucks.

TRENCH ARTILLERY:

75. (n) As stated, the Board is of the opinion that the infantry accompanying cannon can be made to serve the purpose of the light trench mortar as used in the present war. It is believed that a field exists, in addition, for a trench mortar of about 6 inches caliber firing a projectile weighing about 50 pounds and having a maximum range of about 4,000 yards. So far as known, such a mortar has not been developed. It is recommended that experiments along this line be carried on. The mortar should be fired at elevations of from 40 degrees to 65 degrees. The 3 inch Stokes mortar used in the present war is not considered satisfactory due to its lack of range and its great weight; also its type of mounting was such that a change in elevation affected the traverse, and vice-versa. The principal value of the trench mortar, in the opinion of the Board, lies in its cheapness and the rapidity with which a large number may be constructed. Therefore, the greatest simplicity in the design should be maintained.

ANTI-TANK CANNON:

76. (o) For tanks as they existed at the end of the past war a caliber 50 machine gun with a bullet weighing about 700 grains, together with the 75 mm. field gun were efficient. There was being developed armor piercing ammunition for the 37 mm. gun. In the opinion of the Board, the 37 mm. gun with armor piercing shot, the caliber 50 machine gun and the 75 mm. field gun, are suitable weapons for the attack of tanks in their present stage of development. There is, however, every reason to expect that the future development of tanks will be along the lines of better armor protection and of carrying more powerful cannon. It is, therefore, anticipated that in the future their development will be such that neither the caliber 50 machine gun nor the 37 mm. gun will be sufficient for their attack. It is believed that their armor protection will be such that it

will have to be attacked by a base fuse shell, probably of about 75 mm. caliber. For the present, it is recommended that armor piercing ammunition be issued for 37 mm. cannon for anti-tank protection, especially as this caliber will be retained for the present as the infantry accompanying gun.

V. ARTILLERY TRANSPORT

General Discussion.

77. Mechanical transport is in such a state of development in this country that there is no need in dwelling upon its numerous advantages over animal draft. It is, however, pertinent to give a brief outline of the extent of its employment by foreign governments, while stating that the United States is far in advance of all other world powers in respect to self-propelled vehicles applied to artillery transport.

GERMAN: Wheeled tractors of the farm and road repair type, with low speed, great power and extreme weight for hauling heavy weapons.

Wheeled trucks of the two-wheel-drive type with medium speed, medium power and normal weight, carrying anti-aircraft guns, directly and permanently mounted upon the chassis.

ITALIAN: Wheeled trucks, similar to the German as anti-aircraft gun mounts.

Wheeled tractors of two-wheel-drive type, medium power, speed and weight for hauling heavy weapons.

BRITISH: Rear-wheel-drive trucks, four-wheel-drive trucks, and a limited number of the heaviest American commercial farm caterpillars for hauling heavy weapons.

It is noted that these nations confined themselves, for the most part, to wheeled vehicles, which type at once limits mechanical

artillery transport almost entirely to good roads.

FRENCH: While using four-wheel-drive trucks of great power and mobility throughout the war the French finally recognized, during 1917, the necessity and advantage of cross-country mechanical transport as evidenced by their development of platform caterpillars for carrying their 155 mm. howitzer mounted on its wheeled carriage, and for towing other heavier weapons; of cargo-carrying caterpillars for ammunition and other supply purposes; and of self-propelled caterpillar gun mounts for heavier guns.

78. While these nations were employing limited motorization, the whole project appealed to them as a thing apart from animal transport and, apparently, with the possible exception of the French, who later realized the great possibilities of the caterpillar tractor, no idea existed relative to replacing animal draft by the motor driven vehicle; they considered each a valuable means of bringing the weapon to the proper place at the right time.

79. The United States approached the subject of motorization from the standpoint of obtaining a better means of transport for its artillery than offered by the draft animal. The result has been a mechanism which directly replaces the team in draft, giving at the same time a better performance, because of the fact that while animal transport, especially with lighter weapons, possesses great mobility, it does not possess a sustained or persistent mobility; exhaustion surely renders it inactive after a limited period and the time required for recuperation is fatal, if coincident with a critical point in the military operation. This question of exhaustion of animal transport is best illustrated by analyzing the mechanics of the forward push or breaking through, which is the object sought for in the struggle for a military decision. Our offensive military machine must be designed not only to fit every phase in the mission of breaking through but also to remain intact when the breaking through has been accomplished.

80. In the completest conception of an offensive, the machine starts from rest. It is at this time that the offensive mass is at its maximum. The preliminaries in an offensive combat are designed to break down the physical and moral resistance of the enemy, the opposing friction, so to speak, and to make subsequent progress as economical as possible and as rapid as desirable. Motion, or velocity of offensive progress, commences when the enemy's organized resistance begins to yield. It is at this time that the energy - that is, the mass and the movement of the offensive - expresses itself in progress toward the desired goal, namely, the break through.

81. In the second phase, we find the machine in motion. It is now that the varying rates of speed of the different combat agencies begin to impress us most particularly. It is now that the time element, more or less inconspicuous in the first phase, begins to be a dominating one. It is now that transportation - supplies, ammunition, guns, etc. - has to move. Infantry will certainly move; across country, it is the most mobile combat agency. Velocity there will certainly be in abundance as the lighter lines progress into the enemy's country, but mass and, therefore, energy will be lacking unless artillery and supplies keep up. An advance goes well enough in the area covered by artillery fire. Beyond the action of artillery, however, the enemy is unhampered in his defensive and counter-offensive dispositions. The mass of the enemy's resistance increases to a point where it is not possible to penetrate it with a rapidly diminishing offensive mass, no matter how high the velocity of the latter may be. The offensive lacks energy due to the absence of those agencies which made the original advance possible; exhaustion exacts its penalty.

82. During the phase of motion the animal is called upon for its maximum exertion, while receiving the minimum of care. Exhaustion is the natural result and, therefore, as is borne out by the analysis of

many experiences of the European War, we may say that against an organized enemy a break through is not possible with animal transport alone.

83. The difference in national ideas of animal and mechanical draft is probably due to the road conditions existing here and abroad, the European having at his disposal a vast network of excellent roads with speed as the only limitation to the horse, his idea of other transport being a fast moving vehicle whose use is merely occasional; on the other hand, the American artilleryman is confronted with roads which are little better than the untraveled cross country. The solving of the transport problems has placed us in a far better position to meet all warfare conditions than other nations because of the fact that we now need not confine our activities to the highways but have at our disposal the vast area of untraveled off-the-road terrain, leaving the roads open for the high speed motor vehicles of the supply departments.

84. In other words, we had developed the use of man and animal power to practically the limit. The use of good roads and the use of railroads is well understood, but now we are in a way to conquer the broadest field, that is, cross country, by the use of mechanical transport, allowing the great duty which was placed on good roads and the railway as avenues for artillery transport to be handled more particularly by cross country mechanisms.

Gasoline Propelled Vehicles.

85. The transportation limitations of the above can be generally stated as follows: The rear wheel drive truck and high speed motor car can be operated on good roads.

The four wheel drive truck and light motor cars can be operated on almost all classes of roads.

The caterpillar can be operated on all classes of roads and also in the open country.

MOTOR CARS:

86. The war has brought about no radical changes in motor cars. About the most that can be said on this subject is that certain commercial cars have shown greater strength of parts and ease of operation than others. They are, therefore, favored for military purposes.

MOTOR TRUCKS:

87. When motor trucks were first used for military purposes the commercial types were naturally used. The two wheel drive type was the first to appear; later, to meet a demand for utilizing to the best advantage the full power, the four wheel drive type made its appearance in the commercial world. When the two types were tested in the early days of the Mexican Expedition, real dependence was placed on the four wheel drive trucks, there being instances where whole trains of two wheel drive trucks were stalled. At a later date when the roads had dried and improved, the two wheel drive type made a better showing and came out with a better reputation.

88. However, the artillery is most interested in the type of truck that is best suited for bad road conditions. The United States Marine Corps which has had to use motorized field artillery for some of its minor operations adopted, after many tests, the four wheel drive truck to handle its artillery. Throughout the entire war, the English, French and Russian Governments purchased considerable quantities of trucks driven on all four wheels for use in their artillery service, and as late as July, 1918, the French made an urgent demand on the American E. F. for 300 such trucks. The four wheel drive truck has such power, application and weight distribution as to assure movement of the vehicle if traction can be obtained even by one wheel.

89. Up to the fall of 1917. there had not been found a type of four wheel drive truck as refined in mechanical detail as some of the higher types of two wheel drive trucks. This was natural, as the development of the four wheel drive truck came later than the two wheel drive. However, the Ordnance Department undertook the development of a four wheel drive truck that would not have any of the defects of the four wheel drive commercial types. This truck was ready for production in May, 1918, and was recommended by a board of officers from practically every department of the service for adoption as the standard type of four wheel drive truck for the United States Army (See Par. 30, S.O. 91, W.D., April 18, 1918).

In the opinion of the board, the four wheel drive two wheel steer type of truck is the only heavy cargo carrying wheeled vehicle which is adequate to meet artillery needs in the battery, battalion and the regiment as well as in the artillery ammunition train, and until definite recommendation to this effect is approved, artillery will be burdened with a heterogeneous mass of trucks whose use is confined almost entirely to good roads.

CATERPILLARS:

90. The superiority of the caterpillar over all other mechanical prime movers across country may be realized when we consider the essential features embodying its construction. The frame supporting the power plant with the necessary power transmission members is mounted upon small wheels; these wheels, instead of having direct contact with the ground, travel continuously upon a track, the rails of which are permanently mounted upon a flat, broad surface. This surface or tread corresponds with the sleepers or cross ties of the railroad, and is of such width as to secure very low unit pressures upon the ground. The track with its tread is formed into an endless belt which is driven by a sprocket identically as the bicycle chain.

The whole vehicle, therefore, may be said to constitute a wheeled mechanism which lays its own track as it moves over the ground. Further, by articulating the track and the frames or trucks which mount the wheels, the varied ground surfaces are accurately conformed to = a feature which further insures traction. Again, the power is applied in such a manner that an individual drive is assured on each of the two tracks. With such a structure movement is assured over very soft ground owing to low unit pressure, which is usually about 5 lbs. per square inch. The caterpillar can span wide gaps or ditches or climb steep slippery grades. The grip on the ground or traction is secured by cleats or grousers which project to a height of approximately three inches from the surface of the treads. With the grousers removed the caterpillars do not seriously damage hard roads. The above advantages make the caterpillar the only logical prime mover to replace the team in draft.

History of Artillery Motorization in U.S.

91. Serious and practical experiments with the caterpillar for artillery transport were started in the United States by the Ordnance Department in 1914, and the next year a commercial farm tractor of the most promising type was tested by the Field Artillery Board, resulting, in 1916, in the complete re-design of a number of such vehicles to adapt them to artillery field service, and in the actual motorization of one medium heavy battery in this country and one medium heavy regiment in Honolulu. This re-designed caterpillar still contained many small weaknesses, the elimination of which led in 1917 to the development and manufacture of the present artillery tractors.

92. The progress in artillery motorization is best indicated by the recommendations and results obtained by Boards of Artillery and

Ordnance officers; these recommendations were arrived at after long, careful study, test and investigation, not only in the laboratory but also in the field under simulated and actual war conditions. The authority in each case is given, together with the substance of the recommendations of the various boards.

93. Special Orders No. 98, W. D., 1917, par. 51, appointed a board to "consider the question of motor traction for Field Artillery." This board recommended:

(a) The motorization of the 4.7" gun,
(b) The motorization of the 8" howitzer,
(c) The use of rubber tires on all Field Artillery materiel,
(d) The formation of a pool of 30 artillery tractors for each combat division,
(e) Sending a member of the Board to France to investigate the motorization of the 6" howitzer.

These recommendations were approved by the Secretary of War, and the several supply departments were directed to put them into effect.

94. The result of the investigation in France was Special Orders No. 83, Par. 7, G. H. Q., A. E. F., 1917, appointing a board to "consider and report upon the question of motor transportation for 6" howitzer material."

This board recommended:

(a) The motorization of the 6" howitzer,
(b) The retention of the divisional tractor pool,
(c) The development of motor transport for artillery in all forms.

These recommendations were approved by the Commander-in-Chief, A. E. F., in cablegram 149, paragraph 15, to The Adjutant General, Sept. 11, 1917, and the supply departments were directed to comply.

95. Par. 69, Special Orders No. 242, W. D., 1917, appointed a board to continue the work of the Field Artillery Motor Traction Board, "to consider all questions of motor traction for Field and Heavy Artillery".

This board recommended the motorization of:

(a) The 6" howitzer,
(b) The 4.7" gun,
(c) The 9.2" howitzer,
(d) The 240 mm. howitzer.

The board further recommended:

(a) The use of wheeled trailers in certain motorized organizations for rapid transport of the tractors.
(b) The use and general requirements of the staff observation and reconnaissance cars.

These recommendations were approved by the Secretary of War, and the supply departments were directed to comply therewith.

Based upon data collected by the above boards, the General Staff drew up Tables of Organization for motorizing the 155 G.P.F., and the 5 inch and 6 inch seacoast converted guns.

96. An Artillery Board at G.H.Q.,A.E.F., after practical test recommended:

(a) The motorization of 50% of the 75 mm. gun regiments in each division;
(b) The motorization of the caisson companies of the ammunition train.

These recommendations were approved by the Commander-in-Chief, A. E. F., in cablegram No. 1771, par. 1, October 9, 1918.

Weapons of various sizes have also been placed on experimental self-propelled caterpillar mounts, namely, the 75 mm. gun, the 155 G. P. F., the 8" howitzer and the 240 mm. howitzer.

97. To date, with the exception of 50% of the 75 mm. guns in the combat divisions, the motorization of all Artillery mobile weapons has been authorized and would have been put into effect had the war lasted a few months longer, or if ship bottoms had been available during the war. At the cessation of hostilities in 1918, sufficient tractor equipment had not been delivered in France to carry out this project; this was unfortunate, for many of our artillery personnel had had experience with commercial farm caterpillars, with their serious defects and unadaptibility to artillery transport, and

had consequently formed formed erroneous opinions based on such performance. It is, however, interesting to note the reports of those artillerymen who were fortunate enough to have received even a small proportion of the adequate allowance of motor equipment in its present stage of development for artillery purposes.

Types produced by Ordnance Department.

98. The Ordnance Department has, up to the present time, accomplished the following general mechanical development with respect to artillery motor equipment:

(a) An efficient 10 ton artillery tractor for pulling heavy gun loads has been designed, tested and is in quantity production, i.e., 2800, of which 933 are in France.

(b) An efficient 5 ton artillery tractor for pulling medium gun loads has been designed, tested and is in quantity production, i.e., 4,000, of which 1018 are in France.

(c) Efficient heavy mobile repair shops have been designed, tested and put into production, i.e., 17 shops of 2 sections each, one of which is in operation in the occupied zone of Germany.

(d) An efficient artillery repair truck has been designed. tested and is in quantity production, i.e., 1332, 420 of which are in France.

(e) An efficient 3-ton four wheel drive truck has been designed. tested and adopted as standard for use in the army.

(f) Caterpillar tracks to replace wheels on certain heavy guns.

(g) The following have been designed, built and are being tested:

2½ ton tractor,
Heavy motorcycle for artillery,
Self-propelled gun mounts for various weapons,
Cargo carrying caterpillars or tractor caissons,
Cargo caterpillar trailers.

It can be stated with respect to (a), (b) and (c), that the United States is far in advance of all other world powers.

Types recommended to be developed.

99. The maximum speed for draw bar tractors should fall within a definite scale of approximately 12-8-5-3 miles per hour, with such a total reduction in each case for low gear as to provide a sure means of pulling out under all conditions. It is apparent that when good roads exist and traffic conditions are such as to allow their employment by artillery, a great loss of time is involved where long marches are necessary. The only solution is the employment of sprung, rubber-tired wheeled vehicles to transport the tractors and gun materiel, using a high speed wheeled truck as the prime mover. With such an arrangement, sustained movement over long periods at a speed of 15 m.p.h. may be economically accomplished. At the present stage of development, the trailer is the only available medium, but we can easily conceive of the application of sprung rubber-tired wheels to the tractor as an inherent part of its construction, in such a way as to permit the tractor to be quickly formed into a wheeled trailer; this, however, still requires the use of a wheeled truck as a means of transport - the next and ultimate step is to utilize the power plant of the tractor to drive its self-contained wheels. We will then have a self-propelled vehicle capable of operating as a caterpillar over cross country terrain and, also, at a moment's notice, capable of conversion into a truck operating at high speed on good roads.

100. While improving the caterpillar truck tractor, gun design will also progress; but with the weapon upon its wheeled carriage, a point will soon be reached where no improvement is possible. In all probability such a weapon and carriage will embody the split-trail feature, large angles of elevation and traverse, lightness coupled with stability and high power, but such a unit is

not the limit of progress for we have the broad field presented by the possibilities of the gun mounteed directly upon a self-propelled vehicle. Already, the self-propelled caterpillar gun mount is well along in the experimental stage and has passed to fact from fancy, and while the weights are excessive, the gun traverse limited, and slight relaying necessary, the results arrived at indicate final success in the near future. This success will be realized in a gun using, possibly, a pedestal mount, possessing perfect stability, all round fire, 90 degrees elevation, mounted upon a caterpillar truck tractor.

101. While it is readily conceivable that in the future all weapons will be so constituted and that experiment should be pushed to the utmost in this direction, it is essential that, for the present, there be developed to the minutest detail the draw-bar vehicles now existing and already in a safe state of perfection, utilizing these to the best advantage in conjunction with the weapons now at our disposal. To carry out this scheme, we must augment the existing equipment along the present lines in order that there may be a suitable range of tractors to move the weapons now in use.

TRACTORS:

102. To augment properly the existing types it will be necessary to develop the following:

(a) A small cargo carrying caterpillar without power plant, to be pulled by two men as a cart, with the tongue operating ratchets to drive the tracks when very difficult terrain is encountered; such a vehicle is primarily an ammunition carrier whose use is necessarily limited to stabilized warfare.

(b) A small unit having wheels or caterpillar treads, driven by a very light engine, the whole being operated by a man on foot, total weight being such that it can be readily man-handled by

the operator; this vehicle being used for transport of heavy machine guns, infantry accompanying guns, ammunition service, and for laying wire.

(c) A light weight tractor to fulfill the one incomplete detail lacking in motorization, i.e., the motorization of the individual man. This tractor would have a very low center of gravity, 40 inches wide over all, articulated tracks approximately 6 inches by 8 feet, with small body for carrying 2 men or 500 lbs., water cooled engine capable of operating under water and at all possible tipping angles, with speed ranges from a sure low reduction of 3, 8 direct-drive, 12 over-drive, miles per hour. This tractor to be designed for replacing the horse of individually mounted men, for use in reconnaissance, for pack transportation including machine and mountain guns, for transport of ammunition, laying wire, etc.

(d) A heavy tractor similar to the present 10 ton type, embodying long track, great power, slow speed, no armor or auxiliary front steering wheel, total weight approximately 15 tons, for pulling loads of 18 tons maximum.

103. In general, the ranges covered by the proposed and existing equipment will appear as follows:

The tractor cart, light loads up to 200 lbs.; the 1/4 ton tractor replaces the riding horse or carries loads not exceeding 500 lbs.; the 2-1/2 ton tractor replaces the six horse team or hauls loads not greater than 6,000 lbs.; the 5 ton tractor replaces the eight horse team or hauls loads up to 12,000 lbs.; the 10 ton tractor, loads of 24,000 lbs.; and the 15 ton tractor, loads of 36,000 lbs., maximum.

TRUCKS:

104. The four wheel drive truck of 3 tons cargo carrying

capacity is entirely suitable for the corps and army artillery, but due to its weight is not entirely suitable for divisional motorization; for this purpose a four wheel drive truck of approximately 1 to 1-1/2 tons pay load capacity is necessary in order to operate satisfactorily over very bad roads or unfavorable terrain. The tire may possibly be pneumatic 36" x 6", compound filled to prevent puncture, as ordinary pneumatic tires are not recommended for field service cargo carriers. The need for the development of such a vehicle has been felt for many years in connection with the motorization of the lighter weapons.

TRAILERS:

105. Sufficient wheeled trailers now exist to cover practically every requirement, but our great effort should be in the development of the caterpillar trailer. Such a vehicle with a cargo capacity of 1½ tons should be designed, tested and put into production, to replace the 75 mm. gun and light field howitzer caissons in motorized units. A 3 ton cargo caterpillar trailer is now being tested and should be perfected to replace the caissons in 155 mm. howitzer and 4.7" gun units. The horsed sections of the divisional ammunition trains should be replaced by tractors pulling caterpillar trailers.

TRACTOR CAISSONS:

106. The self-propelled cargo carrying caterpillars, while very useful, are deemed of too great weight to apply to division or light corps weapons, but may be advantageous for heavier gun equipment, especially those normally rated at a capacity of 3½ tons, which can readily maneuver over ordinary open country with a load of five tons. The heavier vehicle normally rated as a five ton carrier is thought to be entirely too heavy.

SELF-PROPELLED GUN MOUNTS:

107. While there is great promise for such mounts, those at present in existence and under test are, for the most part, excessively

heavy. The most promising at this time is the 75 mm. gun mounted on an approximation of the 2½ ton tractor. This mechanism, when carried on a 4-ton trailer and hauled by the 5-ton four wheel drive truck, is capable of going over good roads at considerable speed, and after being demounted from trailer can proceed across country under its own power. It has, therefore, important strategic and tactical uses.

108. The 155 mm. G. P.F. self-propelled mount also presents immediate possibilities, especially when we realize that to fire, the vehicle simply has to come to rest, with the power plant running, whereas, upon its present wheeled carriage, several hours are normally required to prepare the firing emplacement.

109. These two mounts, the 75 and 155 mm. guns, should be immediately developed to the utmost, paying particular attention to mobility and lightness consistent with strength and stability.

110. Caterpillar tracks replacing gun carriage wheels have been tested here and in the A. E. F. with great success, especially on heavy howitzers. At present they should be applied only to the 8 inch howitzer carriage.

Complete Plan of Artillery Motorization.

111. The following tables set forth artillery motor equipment already adopted, that being developed and that proposed to carry out the expansion of the present scheme, together with the application and general characteristics of each:

GENERAL CHARACTERISTICS.

Caterpillar Types.

Vehicle.	Draw Bar Pull Lbs.	Cargo Capacity	Speed M.P.H. Min.	Speed M.P.H. Max.	Remarks.
Tractor cart***		200 lbs.	1	4	Operated by man on foot.
¼ T. Tractor***		500 lbs.	3	12	Replaces riding horse of individually mounted man.
2½ T.Tractor**	4,000		3	11-12	
5 T. Tractor*	7,000		3	8	
10 T.Tractor*	10,000		3	6	
15 T.Tractor***	15,000		1	5	
Tractor Caisson Mark VII **		3½ T.	1½	4	Replaces caissons in heavy batteries.
Tractor Caisson Mark VIII **		5 T.			Not thought practicable due to excessive weight.

Trailers.

3 ton Caterpillar Trailer**		3 T.			Replaces caissons in medium heavy batteries.
Light Caterpillar Trailer ***		1½ T.			Replaces caissons in division artillery.

Wheel Types.

Ord. Standard 4-wheel drive*	8,000	3 T.	3	12	
Light Four Wheel Drive***		1 - 1½ T.	3	15	
Heavy Motorcycle with Sidecar.**		500 lbs.	3	50	

Trailers.

3-ton Trailer*		3 T.			
4-ton Trailer *		4 T.			
10-ton Trailer *		10 T.			Transport of 10 ton tractors etc., in heavy batteries.

* Adopted.
** Under test and developing.
*** Proposed.

APPLICATION.

Tractor Cart.***	Wire Reels Heavy Machine Guns Infantry Accompanying Gun
½ Ton Tractor.***	Misc. Pack Transportation Heavy Machine Guns Mountain Guns Replaces horse for individually mounted men. Wire Reels
2½ Ton Tractor.**	75 mm. Gun Light field howitzer Reel Carts.
5 Ton Tractor *	155 mm. Howitzer 4.7" Gun 9.2" Howitzer) breaking into 3 loads. 240 mm. How.)
10 Ton Tractor *	8" Howitzer 155 G.P.F. 9.2" Howitzer) breaking into 3 loads. 240 mm. How.) Salvage.
15 Ton Tractor ***	5" Seacoast 6" Seacoast 194 mm. Gun Salvage
Tractor Caisson- Mark VII**	Ammunition transport with battery. 155 G.P.F. tractor hauled or tractor mounted, and army artillery.
3 Ton Caterpillar Trailer**	Ammunition transport with battery, 4.7" and heavier guns and howitzers.
Light Caterpillar Trailer***	Ammunition transport with battery. 75 mm. Gun Light field howitzer.
4-Wheel-Drive Standard Truck *	Army and corps artillery. All uses.
Light 4-Wheel-Drive Truck ***	Divisional Artillery. All uses, including Ammunition Trains.

* Adopted.
** Under test and developing.
*** Proposed.

These charts indicate that certain vehicles are so closely allied that, excepting very special cases, we may follow a general principle of grouping in motorization.

The Division.

2½ ton tractor,
1½ ton caterpillar trailer,
1½ ton four-wheel-drive truck.

The Corps.

5 ton tractor,
3 ton caterpillar trailer,
3 ton four-wheel-drive truck.

The Army.

10 ton tractor,
3½ ton tractor caisson,
3 ton four-wheel-drive truck,
10 ton wheeled tractor for transport of tractors on good roads.

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112. From this general grouping of transport vehicles, is formed the following practical table for the general scheme of motorization:

Weapon	Gun Transport	Ammunition transport with firing Battery	Other battery ammunition transport.	Baggage :Rations,Fuel :Water,Misc. Supplies.	:B.C. Detail :Special Detail,&c., :Reels, etc.
75 mm. Gun Light Field Howitzer	2-1/2 ton Tractor	2-1/2 ton Tractor & 1-1/2 ton Caterpillar Trailer.	2-1/2 ton Tractor and 1-1/2 Quad Truck,1-1/2 ton Caterpillar Trailer	1-1/2 ton Quad Truck	:1/4 ton Tractor and :Caterpillar Cart and :2-1/2 ton Tractor :with Reel Cart.
4.7" Gun 155 mm.Howitzer	5-ton Tractor	5-ton Tractor and 3-ton Caterpillar Trailer	5-ton Tractor & 3-ton :Caterpillar Trailer and 3-ton Quad Truck	3-ton Quad Truck	Do.
155 mm. Gun 8" Howitzer 9.2" Howitzer 240 mm.Howitzer	10-ton Tractor	10-ton Tractor and 3-ton Caterpillar Trailer. 10-ton wheeled trailer for rapid transport of tractors & tractor trailers on good roads,pulled by Quads from reserve.	3-1/2 ton Tractor Caisson and 3-ton Quad Truck.	3-ton Quad Truck	Reconnaissance and Staff Observation :cars & motorcycles :& 2-1/2 ton Tractor :with reel cart.
194 mm. Gun	15-ton Tractor	3-1/2 ton Tractor Caisson.	3-1/2 ton Tractor Caisson and 3-ton Quad Truck	3-ton Quad Truck	Do

S P E C I A L C A S E S .

75 mm. Gun Self Propelled Mount	3-ton :Quad Truck :& 4-ton :Trailer	1-1/2 ton Quad Truck :together with (2-1/2 ton :tractor and 1-1/2 caterpillar trailer) transported by 3-ton Quad :Truck and 4-ton Trailer		1-1/2 ton Quad Truck	Do. :(2-1/2 ton Tractor & :Reel transported by :3-ton Quad truck and :4-ton Trailer).
155 mm. Gun S.P. Mount	:S.P.Mount	3-1/2 ton Tractor Caisson	3-1/2 ton Tractor Caisson & 3-ton Quad Truck.	3-ton Quad Truck	Do

Immediate application of the above plan.

113. The following recommendations are based upon experience abroad, reports of motorization boards, tests and data resulting from experiment and research, and recommendations of artillery higher commanders.

(a) The immediate motorization of all weapons larger than the 75 mm. gun and 4 inch howitzer for use as follows:

1st The Regular Service,
2nd The Reserve,
3rd The National Guard,
4th The several educational institutions.

(b) The immediate motorization of the 75 mm., 3" gun and division howitzer for use as follows:

1st The Reserve,
2nd The National Guard,
3rd The several educational institutions.

(c) The motorization when conditions warrant of:

1st The 75 mm. or 3" guns and 4" howitzers in the division,

2nd The horsed sections of ammunition trains,

employing for such motorization, vehicles having the same tactical mobility as horse drawn carriages.

(d) The adoption, as standard vehicles, with such minor modifications as war experience has indicated, of:

1st The 10 ton artillery tractor,
2nd The 5 ton artillery tractor.

(e) The adoption, to the exclusion of other types of cargo trucks, of the four wheeled drive, two wheel steer type, with some form of steel cargo body:

1st For artillery use,
2nd For artillery ammunition trains.

Special recommendations.

114. (a) That motor equipment prescribed for artillery transport must be sufficient to maintain a prolonged rapid advance and must be of the best and most suitable types.

(b) Sufficient special motor vehicles of all types should be retained in service, or contracts completed, to completely equip all contemplated regular and reserve artillery organizations.

(c) That ample reserve of spare parts for motor equipment belonging to tactical organizations be maintained, and that ample spare parts be actually carried with artillery organizations including ammunition trains to permit the attached repair facilities to function properly.

(d) That responsibility for the repair of all motor equipment within artillery organizations be definitely assigned to the Ordnance Department.

(e) That adequate repair facilities as indicated in the following table be provided to assure the proper care, repair and maintenance of both motor and gun material.

Weapon	Battery.	Battalion, normally with regimental supply company.	Brigade
75 mm. gun Light field howitzer. 4.7" gun 155 mm. howitzer	1 light repair truck	1 Art. repair truck 1 Supply Load D. 1 Supply Load B.	Mobile Ord. Repair Shop.
8" howitzer 155 mm. gun 194 mm. gun 9.2" howitzer 240 mm. howitzer 5" seacoast 6" seacoast converted.	1 light repair truck 1 artillery repair truck 1 Supply Load D. 1 Supply Load B.		1 heavy artillery mobile repair shop (2 sections).

Ammunition Supply

Unit.	Repair Facilities.
Each Ammunition Truck Company,	1 light Repair Truck
Each 2 Ammunition Truck Companies,	1 Arty. Repair Truck 1 Supply, Load D. 1 Supply, Load B.

(f) That no motor transport be definitely appro ed for artillery use without a thorough test by artillery organizations.

(g) Eliminating present artillery supply truck body, replacing it with repair body using suitable chests, cabinets, etc.

(h) That the vehicles and repair facilities supplied in time of

peace be of the types contemplated for war use.

(i) That there be manufactured immediately 150 Ordnance 3 ton model 1918 four wheel drive, two wheel steer, truck chassis, approved as standard for use in the army by board appointed by Par. 30, S. O. No. 91, W. D., 1918, to be used in motorizing one regiment of 155 mm. howitzers.

(j) Improvement in design and construction of caterpillar treads.

(k) Lowering unit ground pressure of artillery tractors.

(l) Improvement in application of grousers on artillery tractors.

(m) Noiseless exhaust of engine and production of a silent tractor.

(n) The water-proofing of artillery tractor engines to permit them to run submerged for short periods.

(o) A simple form of coupling or attachment to enable guns, tractors, trucks, etc., to be hitched in tandem for towing purposes.

As amended by minority report:

WILLIAM I. WESTERVELT
Brigadier General, U. S. Army.

As amended by minority report:

ROBERT E. CALLAN
Brigadier General, U. S. Army.

WILLIAM P. ENNIS
Brigadier General, U. S. Army.

JAMES B. DILLARD
Colonel, Ordnance Department.

RALPH McT. PENNELL
Colonel, Field Artillery.

WEBSTER A. CAPRON
Lieut. Colonel, Ordnance Department.

As amended by minority report:

WALTER P. BOATWRIGHT
Lieut. Colonel, Coast Artillery Corps.

A P P R O V E D,

By order of the Secretary of War:

P. C. MARCH

General,
Chief of Staff.

The minority report is noted and need not delay the approval of the report proper.

MARCH
C. of S.

May 23, 1919.

MINORITY REPORT

of

Board of Officers
Appointed by Par. 142, Special Orders No. 289-O,
War Department, 1918

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SUBJECT :- A Study of the Armament, Calibers and Types of Materiel, Kinds and Proportion of Ammunition, and Methods of Transport of the Artillery to be assigned to a Field Army.

WASHINGTON, D.C.,
May 5, 1919.

Although it has been the endeavor of the Board to keep as free as possible from questions of organization in its discussion of types, the report shows that this could not be done entirely. Types of artillery are dependent on missions to be performed and missions are interwoven with organizations. A reading of paragraphs 11, 12 and 13 might lead to the impression that a field army should include organic army artillery and that a reserve of artillery for reinforcement and special missions should be organized as a thing apart from the organic army artillery.

This does not bring out the views of the minority on one of the most important artillery developments of the European War. The inadvisability of forming organic army artillery has been evidenced on all sides. The opinion of our higher artillery officers in France was opposed to organic army artillery; in fact, no expression of any views favoring such an idea were heard in any of the conferences which the board had in Europe. To go further, considering the organization of European Armies and the opinions of many of our own officers, organic corps artillery is of questionable value. While the army artillery of our First Army was organic and without the reserve principle, except latterly for railroad artillery, the consensus of opinion of those officers who were immediately connected with the Army artillery, as a result of the experience, is opposed to organic army artillery and is in favor of an Artillery Reserve.

The views of the minority of the Board on this whole subject are in brief as follows:

In addition to the assignment of division and corps artillery there must be additional artillery available; there must be a surplus of division and corps types, properly transported, for strategic reinforcement of divisions and corps during such times as the allotment to such units may be insufficient, and also for replacement of disabled units of these types; there must be heavier guns and howitzers for the missions of interdiction, neutralization and destruction which require greater

power and range, or either, than the capabilities of the normal corps or medium field types; there must be artillery of special purpose,- trench artillery, pack artillery, anti-aircraft artillery and super-guns and howitzers. Whether there be one or more field armies this additional artillery should constitute the Artillery Reserve. It should be a complete organization, with proper staff and all the necessary facilities for organizing, equipping and training artillery units as well as for the repair and replacement of units that have been used up in combat. The High Command should assign a certain amount of this artillery to the army or armies as the necessities of the general situations demand, and as the High Command views the relative importance of these situations; such an assignment to any particular army constitutes the Army Artillery.

From the assignment made, the Chief of Artillery of an army is prepared to assign to divisions and corps, such units as the general artillery plan demands; and with such super-guns and howitzers as he may have, he is prepared to undertake, through his own staff, missions of interdiction and destruction which fall beyond the corps artillery's activity or cover zones of adjoining corps and which could, therefore, be better handled for the general good under his immediate orders. When units are used up or are no longer needed, or the plans of the High Command demand a rearrangement of the reserve artillery, these army units should be sent to the Artillery Reserve for repair, reequipment, replacement and general refreshing, or to some other theater of action, as the case may be. First of all, this method permits the most economical use of artillery and facilitates upkeep and replacement; and second, it relieves an army from the burden of unnecessary artillery and of much of the large administration, supply and repair problems that such units involve.

Under the foregoing the Artillery Reserve should contain properly organized and trained units of the following:

Trench mortars.

Pack artillery.

Anti-aircraft artillery.

Guns and howitzers of division and corps types.

Guns and howitzers of types heavier than those in corps artillery.

Railroad artillery.

In the composition of large forces there is always the danger of being led astray by the attractions of symmetrical organizations which are not based on the requirements of the battlefield. There is a variety of missions that might be given to an army of the United States; and in the organization of such a force to fit the necessities of the case, there would be greater variations from any normal assignment, in what are known as army troops than in any of the lower subdivisions of the army. Perhaps in no case would this be more true than in the Army Artillery. In some cases almost no heavy artillery would be needed; in others, the heaviest available might be required. Therefore, whatever may be the plan of military preparedness, the Artillery Reserve, though a thing not considered in our pre-war ideas of organization, should be organized and developed to a high state of efficiency. From the wide range of artillery that such a reserve would contain, the high command, guided by the general mission, could select and assign to an army the tactical units of the appropriate types that should constitute its army artillery.

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