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# HISTORY OF ANTI-AIRCRAFT GUNS IN CONNECTION WITH THE EUROPEAN WAR.

## INTRODUCTION.

Without imagination no one would have been of much service in the anti-aircraft artillery development during the present war, save in the working out of specific problems which had been visualized and definitely stated by others. Likewise the problems presented came so rapidly, and were at such variance with familiar fields of artillery practice that the inventive faculty was stimulated, and a high order of intelligence and engineering knowledge and ability demanded.

The whole subject was new and development of the artillery matériel, the ammunition, and the fire control was necessary.

In field artillery practice, range problems had been presented in connection with mortars, howitzers, and guns which would cover almost the entire scale of elevation, but the results to be accomplished and the problems in connection with each of these weapons were quite different. The previously provided elevation of the guns was small, while the muzzle velocity of some of the howitzers and all of the mortars was comparatively low, and the traverse of all three of the weapons was limited. The target was usually stationary, and maps were available for establishing its position and ample time was available in which to figure its range. Observation of the point of fall of one shot would serve as a guide in correcting the range for the next shot. Frequently it was possible to choose the atmospheric conditions under which the weapon could be employed and assisting or opposing longitudinal windage, or driftage due to side windage, could be calculated with the aid of wind gauges.

For anti-aircraft service the problem is entirely different. The single weapon must be able to cover the elevations of all three of the field artillery weapons and preferably have a traverse of  $360^\circ$ . These wide variations in elevation introduced serious recoil problems, and the difference in the traverse problem may be to some extent illustrated by reference to the fact that the total traverse of the 75-millimeter French, model 1897, field gun is only  $6^\circ$ .

Instead of a stationary target there may be presented one whose speed is one-sixth of the speed of the projectile itself and whose

course can in no wise be forecast by road direction or terrain formation and whose position may be at any vertical or horizontal angle. The possible altitude and speed of airplanes were increased from time to time during the war, making useless the earlier basic data to be employed in the design of protective matériel. Under certain conditions of airplane approach the range must be calculated on the instant and there is no choice as to atmospheric conditions. As the target is not stationary, range corrections are difficult to estimate by observation. While gauges may indicate the direction and force of the wind at the altitude at which they are set, they furnish no indication of air currents existing at other altitudes through which it might be necessary for the anti-aircraft projectile to pass. With the flat trajectory of a fieldpiece at but few degrees elevation, the density of atmosphere through which the projectile must pass is largely uniform, while at high angles of fire with anti-aircraft guns the projectile passes through atmospheres of different rarefactions and hence different resistances to the passage of the projectile. These influences affect the trajectory of the projectile, the rate of travel of the projectile, and the time element of the burning of the fuze. It will be seen that a time-fuze setting for a given linear distance at low angle of fire will not be applicable for the same linear distance of high angle of fire both on account of variations in rate of travel due to action of gravity and to density of atmosphere and to variation in rate of fuze burning due to the rarefaction of atmosphere. A clockwork fuze element may dispose of part of the difficulty. With field artillery shrapnel is employed with both a time fuze and an impact fuze, and high-explosive shell with impact fuze only, but anti-aircraft disrupting projectiles must be fitted only with time fuze, as otherwise a projectile which has missed its aerial mark will be apt to cause damage within friendly lines through impact explosion on reaching the ground. Consideration is being given to a fuze with both time and sensitive impact element, but with a safety device to insure detonation before reaching the ground. Attention is given to the effect of anti-aircraft-gun fire upon the morale of the aviator as well as to possible physical damage to aviator or plane, and in explosive projectiles high-explosive shell has almost entirely superseded shrapnel.

As there is practically no position which is entirely free from the possibility of aircraft attack, and as there is no means of determining the direction from which such attack may come, ready mobility of anti-aircraft guns is most desirable and as opportunity to reach the target is frequently only momentary, rapidity of sighting and of firing is essential. The gunner fires at something that isn't there, in the expectation or hope that the target will reach the in-

semifixed mount; or on an auxiliary circular pedestal for a four-wheel or caterpillar tread trailer; fitted with stops if required for the auto mount, would allow all of the top carriage, including leveling device, traversing, and elevating mechanism, and gun and recoil, as well as instruments, to be standardized."

"Every effort should be made to cut weight by improved design and by use of stronger materials, but without sacrificing stability and strength."

"The carriage should be designed for night lights."

"The stability of the carriage must be absolute. The American 75-millimeter truck mount and American 3-inch trailer as at present designed have not the necessary stability. This feature should be corrected on the 3-inch trailer by a different type of outrigger."

#### "INSTRUMENTS."

"All anti-aircraft artillery units should be fully equipped with modern instruments so that either the angle of approach or the tachymetric method may be used at any time."

"An instrument whereby the battery commander's station can secure and deliver to the gun crew firing data, thus eliminating several instruments from the gun carriage, has been devised but never used under battle conditions by American batteries. This instrument, called the corrector R. A., can be used for direct or indirect fire. With direct fire, a telescope on the gun follows the target, and from the corrector R. A., information given to the gun layer is the vertical deflection correction, the lateral deflection correction, and the future fuze-setter range to target. The vertical and lateral deflection corrections are set on the gun by the use of mil scales.

"The future fuze-setter range being given from the corrector R. A., the turning of the fuze-setter range dial beneath a pointer moved radially across its face as the gun is inclined, allows the automatic setting of the super-elevation. For indirect fire the corrector R. A. gives the gun the future azimuth and future angle of sight to target, and these are laid off on the mil scales of the gun. It also gives future fuze-setter range.

"At present greater accuracy and quicker action can be secured by direct fire. If efficiency can be secured by this method, it is preferable as delicate instruments are removed from the gun, and one instrument will often answer for a battery."

"Actual battle practice shows that it was necessary to allow 8 seconds dead time and fire every 4 seconds. Accurate firing could not be secured at greater speed than 15 shots per minute."

"In the 75-millimeter French auto cannon were furnished with Puteaux altimeter, tachyscope, angle of approach telescope, wind drum, horizontal telemeter, Brocq double-sight corrector, gun telemeter, and fuze-setter range dial."

"In the 75-millimeter French trailer mount the sights can be held on the target while the gun is offset, and this method should be adopted."

"The tachymetric method of fire control was used for approximately 85 per cent of the shots fired from the two 75-millimeter French auto cannon mounts."

"All anti-aircraft personnel should be equipped with gas masks having specially large glasses and constructed so that talking is easy. The American box respirator is unsatisfactory."

"A searchlight with each battery would be of great assistance. It should be under the control of the battery commander. A 150-centimeter light with hand control throughout and with open mirror has been designed for transportation and operation on a Cadillac chassis and weighs no more than the former 90-centimeter light."

"A machine gun with high-angle tripod should also be furnished with each unit."

"In any war of movement the question of mobility of the artillery is of great importance."

"The automount is thought best for all front-line work."

"Trenches, shell holes, mud or soft ground, bridges down, light pontoons, location of guns known to the enemy, the necessity of repeatedly changing front, and for considerable distances, the relocation of ammunition dumps, camps, etc., all make it necessary that anti-aircraft artillery be extremely mobile.

"This means exceptional design to eliminate weight. It means that the pressure per square inch on the ground should be very low and at the same time the permissible speed of travel should be high."

"It has been necessary during a night to move anti-aircraft artillery 30 miles over muddy and broken roads to be emplaced ready for firing at daylight."

"The 75-millimeter French anti-aircraft auto mount has a speed of over 30 miles per hour on a fair road, can be leveled ready to fire in four minutes, and is extremely stable."

"The design of an auto mount should closely follow that of the French 75 millimeter, improvements being attempted to secure complete azimuth by changing shape of chassis and by increasing the ground bearing surface, the construction allowing the use of a standard interchangeable base ring with simple locking means for holding the top carriage.

"Plenty of space should be provided for tools, extra tires, gasoline and oil, and spare parts. It is recommended that the semifixed mount be supplanted by a trailer with four separate short caterpillar treads and carrying a steel platform on which would be mounted an auxiliary circular base, at the top of which would be the interchangeable base ring for the standard top carriage. This platform should be low, with folding extensible side platforms, and be equipped with beam outriggers carrying jacks to give extreme stability without the use of spades."

"The trailer mount should have heavy brakes, steering mechanism, seats, mud guards, springs, axle snap hooks, spare parts and tool chests, and with standard trailer couplings and hooks for hauling by horses."

"A standardized 3-inch auto mount for front-line work and a standardized caterpillar tread trailer for the rear areas, having the same top carriage and gun, if properly designed, should cover most of the anti-aircraft work."

"Above all, the design of these two mounts should be started immediately."

#### "75-MILLIMETER FRENCH AUTO CANNON MOUNT."

"The following is a summary of the reports received from the officers who have handled this mount in the field."

"Two mounts, type FZ, and two caissons, type G. O., have been at the front for five months and are now owned by the United States. The guns are No. 15935 and No. 14225, tube No. 3382 and No. 2612, recoil mechanism No. 198 and No. 199, carriage No. 208 and No. 209; total rounds fired, 3,880 and 4,500."

"These guns were manned by the Battery B, First Anti-aircraft Artillery, now the Twenty-third Battery, First Battalion."

"Firing was between 3.50 a. m. and 9.30 p. m. No night firing by this battery because of lack of personnel."

"Other French autocannon batteries were manned by American personnel, alternating with the French. The French furnished 50 per cent high explosive and 50 per cent shrapnel. High-explosive 24/31 maximum horizontal range 9,000 meters."



"The French have since made high-explosive 24/31 a maximum horizontal range of 9,000 meters, known as type A. Shrapnel was used only because of insufficient range of high explosive furnished."

"Ammunition furnished was very accurate. Battery B had a total of about 25 misfires out of 8,380 shots. These misfires were attributed to primers set too far down in reloaded shells, 17 occurring in one morning."

"Very few shells were stuck in gun. Shells should be cleaned and tried before time of using and a coat of lard oil or graphite put on the rotating band."

"When stuck, the shells are removed by a rammer with hollow head, so that the blow comes on the ogive and not on the fuze. The loader and firer should have a careful training with dummy shells of the same weight as the standard. Shells are often stuck by too rapid movement of the breech block."

"Battery B had the rear end of one caisson shot away. Repaired at mobile ordnance repair shop in two days."

"The gun firing-pin spring frequently breaks and the breech-locking device was broken four times in the latch. It was thought that this was caused by wear. Extras could be carried and changes made in three minutes."

"In operating the breech mechanism the right hand was used to open and close the breech and the lanyard was pulled with the left hand. The leather lanyard frequently broke where it passed through the eye, and a very short lanyard was necessary."

"Very little trouble was experienced from coppering. The guns were cleaned with cold water, dried, and greased after every 100 rounds or less, and also every morning and night. At night a coating of heavy grease was put on and removed in the morning. Grease and oil are a good protection against the effects of gas."

"All gears, roller paths, and moving parts should be dust proof. Shells landing near guns have often put them out of action until they could be cleaned."

"The carriage can be put in readiness to fire in about four minutes and ready to move in about three minutes. At Le Bruil, southwest of Dorman, the guns were located by German artillery and were moved out under fire in two minutes. Heavy rains also frequently make it necessary to move the guns."

"The guns can be depressed to  $-3$  inches and elevated to  $+70$ ."

"The trailer mount, in the opinion of the officers experienced in its use, is superior to the truck in the following points: It has complete movement in azimuth. Its breech is higher from the ground and therefore easier to load. It is possible to give the gun deflection without moving the sights off the target."

"The truck mount is admittedly superior as to mobility, and traction must be furnished the trailer which can not be traveled at much greater than 8 miles per hour because of the effects, very detrimental, of jolting and bouncing. It was hauled by a Latil tractor."

"More men and their equipment can be transported on the autocannon mount. The trailer mount has greater road pressure per square inch."

"The trailer mount is satisfactory as to stability, the four large spades aiding greatly, although it is thought the ground pads should be larger."

"The trailer mount requires about 15 minutes to get in position as against 4 minutes for the auto mount, and about 20 minutes to get out as against 3 minutes for the auto mount."

"The spades occasionally break when locked for travel, and the forgings should be strengthened. The spades do not greatly interfere with loading."

"The gun elevation is from 0° to 73°."

"It is recommended that anti-aircraft artillery for defense of rear areas, such as ammunition dumps, aircraft or balloon hangars, be designed to set above ground without the necessity of digging pits. It generally required a week or more to emplace a semifixed mount."

"Defense at Colombey-les-Belles, sector No. 10, consisted of six American and two French semifixed mounts. Two American semifixed were mounted as designed by the Ordnance Department, in pits with 2 by 4 cribbing, the other four being mounted on a wooden octagonal frame, 6 feet 6 inches from ground to top of the base ring, the platform being suspended in the standard manner. (Photographs of this mount are attached.) Maj. R. R. Robertson, who set these, states that it requires two weeks' average time to mount one gun in pit, and if frames were cut and bored for bolts, the above ground mount can be completed in one day. The French 75 millimeter can be put in pit in four days. The American mount takes longer than the French, because of extra depth and because of piling which must be leveled on top of base ring."

"The lack of head room on American mount makes it necessary that the loader and firer stand on a lower platform, and as constructed they are in an extremely dangerous position. The changed American semifixed frames were never received at the front."

"The maximum depression was 10° and maximum elevation 78°, which is not sufficient."

"The guns at Colombey-les-Belles were mounted in three groups, Group A having four guns about 150 feet apart, Group B and Group C having two guns each. The battery commander's station was about midway and slightly back of most likely line of fire. The Ordnance Department station was generally about 200 yards away with telephone connection."

"The four gun groups did most of the firing. On October 30 planes came down Nancy Road and dropped 22 bombs east, west, and north to field but none nearer than 1 kilometer, making three trips from 6 p. m. to 10.30 p. m. Battalion A fired 537 shots; Battalion C, 60 shots. On October 28 a single large plane dropped 7 bombs at 6 p. m., doing no damage. Battalion A fired 34 shots and Battalion C fired 21 shots. On October 18, at noon, Battalion C fired 26 shots at two Fokker planes."

"Both the American and French semifixed mounts are very crude and hardly satisfactory for the accurate work required of anti-aircraft artillery. The American mount is difficult to serve and to emplace, and it is recommended that no more be made. Insufficient space is provided for personnel. Three men were sent to the hospital with broken ear drums, and the heat from explosions sometimes singed their hair. The space for the gun loader and the firer is cramped and dangerous, and the deflection setter has to work in an awkward position. No ladders were provided for the men to reach their position. The American mount is too heavy. Eight men can mount the French piece in one-half day, and 12 men need one and one-half days to mount the American piece. The traversing required 2 men."

"This mount consists of a standard 75-millimeter French gun and recoil mechanism fastened securely to a steel frame carrying two sets of trunnions and steel trail. One set of trunnions is for road travel of the gun and frame on detachable wheels. When mounted the other set of trunnions rests in bearings carried by side frames fastened to a V-shaped platform, which can be split in the middle for transportation and erection. The gun and recoil mechanism being fastened to the trail, elevation is given by a cable fastened to the trail and carried over a drum with a counterbalancing weight on the opposite side and a handle on the drum to give elevation. Traversing is secured by a cable

and hook, which by vertical shaft and worm and gear pulls the platform around on rollers running on top of circular steel ring."

"The French 75-millimeter has 0° depression and 82° elevation, but when mounted in pit was not fired below 18°."

"One gun mounted near Soppe-la-Maut was struck by a German shell, thought to be 155-millimeter, and completely wrecked, and in one case a round of 30/55 shrapnel tore and cracked the tube at the muzzle end of the gun, the shell going on. Exact cause is not known, but thought possibly caused by steel in rotating band. Shell did not burst. Abnormal recoil was noted."

"Gun at Manonville had fired 7,000 rounds and was still apparently in good condition."

"French furnished shell with special rotating band of steel color, possibly graphite, which was used to clean copper, 21 shots being fired in one case. French also had a solution which was fairly satisfactory for removing copper."

"The breech threaded sectors sometimes caused trouble by chipping, particularly if breechblock was loose. Firing pin occasionally break."

"One recoil mechanism was smashed by direct hit and one had to be sent to repair shop because of excessive leakage at piston end. Occasionally a gun failed to return to battery, thought to be caused by overcompression of air. The gun was returned by removing plug."

"Screw filler was satisfactory."

"The traversing rollers often slip when the rail is wet or muddy and the rails get out of line. The roller-path key works loose. The carriage jumps about one-half inch on firing at high elevations. The American mount does not do this."

"HEADQUARTERS ANTI-AIRCRAFT SERVICE,

"AMERICAN EXPEDITIONARY FORCES,

"December 3, 1918.

"Memorandum for Chief of Artillery, American Expeditionary Forces.

"The number of troops in the anti-aircraft Service at the time of the armistice was about 12,000. Comparatively few of these were on the front, but the results actually obtained by those that were on the front are so remarkable and unprecedented that it is recommended that they be published in commendatory orders by the commander in chief. The following outline is suggested:

"The results obtained by the American Anti-aircraft Service with our armies from July 17, 1918, at Chateau-Thierry up to the time of the armistice are so remarkable as to warrant publication.

"The results of these batteries which brought down one or more planes during this period are as follows:

"Average number of shots per plane, 605. The average number of shots per plane for all anti-aircraft batteries serving in our army area during this period, including those batteries sent for instruction, is 1,003. These results far surpass all expectations, one plane for 8,000 shots being heretofore considered good average. Machine-gun records are as follows:

Organization.	Number of shots fired.	Planes brought down.
Fifth Anti-aircraft Battery .....	520	1
Twenty-second Anti-aircraft Battery .....	2,116	2
Twenty-third Anti-aircraft Battery .....	5,062	9
Twenty-seventh Anti-aircraft Battery .....	1,028	3
Twenty-eighth Anti-aircraft Battery .....	1,517	2
Total.....	10,273	17

*First Anti-aircraft Machine Gun Battalion.*

Organization.	Dates.	Planes brought down.
Company A, First Anti-aircraft Machine Gun Battalion .....	Sept. 6-Nov. 11 ...	2
Company B, First Anti-aircraft Machine Gun Battalion .....	do.....	5
Company C, First Anti-aircraft Machine Gun Battalion .....	do.....	9
Company D, First Anti-aircraft Machine Gun Battalion .....	do.....	8
Company A, Second Anti-aircraft Machine Gun Battalion .....	do.....	5
Company B, Second Anti-aircraft Machine Gun Battalion .....	do.....	4
Company C, Second Anti-aircraft Machine Gun Battalion .....	do.....	7
Company D, Second Anti-aircraft Machine Gun Battalion .....	do.....	1
Total.....		41

"Total number of shots fired by anti-aircraft machine-gun companies during periods stated, 225,115.

"Average number of shots per plane, 5,500.

"A comparison of the number of planes brought down by all anti-aircraft machine guns on our army front warrants a conclusion of relative efficiency of about 300 to 1 in favor of those of the Anti-aircraft Service.

"Anti-aircraft machine-gun troops and anti-aircraft searchlight troops have carried on their work with an aggressiveness and with results which are phenomenal and unprecedented.

"The following specific instances are of special interest:

"At Cherery, October 13, 1918, eight Fokkers were chasing one American plane back to our lines; Battery A, Second Anti-aircraft Battalion, First Lieut. T. J. Bell, Coast Artillery Corps, commanding, brought down two of these enemy planes.

"At Jaulny, November 5, 1918, five Fokkers were returning from destroying an American balloon; the First Platoon of Company B, First Anti-aircraft Machine Gun Battalion, First Lieut. J. C. Mickle, Infantry, commanding, brought down two of these enemy planes.

"At Esnes, October 29, 1918, the Twentieth Anti-aircraft Searchlight Platoon of Company A, Fifty-sixth Engineers, Second Lieut. H. R. Davis, Corps of Engineers, commanding, brought down an enemy plane with machine guns.

"JAY F. HOPKINS,  
Colonel, Coast Artillery Corps,  
"Chief, Anti-aircraft Service."

"MEMORANDUM FOR INTERALLIED ANTI-AIRCRAFT COUNCIL.

"12 DECEMBER, 1918.

"ANTI-AIRCRAFT MATÉRIEL.

"Guns.—Caliber: Gun's caliber to be as large as rapidity of loading will permit. Rapidity of loading can not be sacrificed because the loss in dead time in loading would more than compensate for gain in reduction of time of flight.

"Velocity.—Velocity should be very high. A few hundred rounds of ammunition cost no more than a gun tube. Tubes should be supplied so that they can be expended freely. The gain in efficiency will more than compensate for this policy.

"Projectile.—Should be of high ballistic efficiency, filled with high explosive, and provided with a time fuze, probably clockwork, which must be reasonably accurate.

"Mount.—All-around fire and as mobile as possible.

"*Pom-poms*.—Probably of larger caliber than any now designed in order that the projectile may contain a reliable fuze. Its mount to be all-around fire and sufficiently mobile to insure its keeping up with infantry.

"*Machine guns*.—To be of larger caliber than at present in order to obtain increased range. Bullets in proportion, one tracer, one armor-piercing, and three ordinary is satisfactory at present.

"*Searchlight*.—150-centimeter searchlight, with hand control throughout and with open mirror, has been designed which can be transported and operated on our Cadillac chassis. It is scarcely heavier than the former 90-centimeter light, and very satisfactory.

"JAY F. HOPKINS,  
"Colonel, Coast Artillery Corps, Chief Anti-Aircraft Service,  
"American Expeditionary Forces."

"HEADQUARTERS ANTI-AIRCRAFT SERVICE,  
"FIRST ARMY, AMERICAN EXPEDITIONARY FORCES,  
"19 December, 1918.

"Memorandum for Design Section, Chief Ordnance Officer, American Expeditionary Forces, Paris.

"The following French anti-aircraft matériel has been in use under my direction and observation:

"(a) 75-millimeter cannon on semifixed carriage.

"(b) 105-millimeter cannon on semifixed carriage.

"(c) 75-millimeter cannon on auto mount.

"(d) 75-millimeter cannon on trailer mount.

"The semifixed carriage should not be depended upon for any way of movement, though it can be used for defense of fixed sensitive areas; the great argument for its being so employed being its cheapness.

"The auto mount has proved more mobile than the trailer with present methods of traction, and for shifting from one part of the front to another quickly, will continue the better for work of that nature.

"The mobility of both auto mounts and trailers was reduced by bad roads, and this condition will probably always be met in any war of movement anywhere, and especially in the United States.

"The difficulty may be at least partially met by furnishing caterpillar traction for the trailers, but this will not insure the passage of the trailer, as at present designed, over all the bad places that will be encountered.

"It is reported that the Germans made considerable use of the horse-drawn matériel.

"Another difficulty for the heavy anti-aircraft guns is the passage of temporary bridges (including pontoons).

"The present matériel (French) is good, but the anti-aircraft artillery needs a mobile gun of greater range and shorter time of flight, the carriage should be able to stand traction over rough roads and soft roads, and if necessity arises, off the roads.

"All anti-aircraft artillery should be able to use indirect fire whenever it is desired to do so.

"If an accurate, self-contained range finder can be developed, it should be provided; until it is found, accurate instruments for use with base line of about 500 meters (1,000 meters at the outside) should be furnished.

"R. W. COLLINS,  
"Colonel, Coast Artillery Corps."

"HEADQUARTERS ANTI-AIRCRAFT SERVICE,

"AMERICAN EXPEDITIONARY FORCES, FRANCE,

"21 December, 1918.

"A. *Mobile mounts.*—(1) Zero degrees minimum angle of elevation. In recent firing from 70 to 80 per cent of firing was below 25°. (2) Eighty-five or preferably 90° maximum angle of elevation. All dead angles should be avoided if possible. (3) Balance: The gun should be so balanced that it can be easily elevated and depressed, and so that it can be traversed without great effort by pushing on the carriage, the latter effected, possibly, by a disengaging clutch between the traversing-gear train and the carriage. (4) No horizontal dead angle. Mobile mounts are liable to be used in fixed defenses where the field of fire is not predetermined. (5) Separate control for laying in elevation and azimuth. (6) Absolute mobility. The gun should be capable of being brought from the road to the firing position, and conversely, in a minimum of time. Spades and extra trusses above the number on the French automount (four jacks and two buttresses) defeat this end. (7) A compound elevating mechanism for the gun whereby the separate elevation movement will not affect the movement of the vertical sight, as in the case of the French autotrailer mount. (8) The setting mechanism for all instruments and scales should be so arranged that the movements may be continuous, easy, and smooth. A small handwheel, instead of the knobs at present on the 1917 model auto mount, United States, would probably accomplish this purpose. (9) Semiautomatic or full-automatic breechblock. (10) Seats for the manning detail that have sides and backs. The seats on the present auto mount, United States, are impractical.

"B. *Semiautomatic mounts.*—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, ditto. (11) The mount whatever its design, should be so arranged that it can be jacked onto the running gear and moved from place to place intact, as in the case of the British Mark IV pedestal mount. In case of emergency, such a mount can be easily moved overland to the point of emergency.

"*It is recommended.*—(1) That a common gun, from base ring up, be designed for all types of mounts. (2) That this gun be of high muzzle velocity—2,400–3,000 foot-seconds. (3) That all guns be equipped to fire with both angle of approach and tachymetric methods of fire control. (4) That shrapnel be abolished from anti-aircraft artillery. (5) That the value of the illuminated explosive shell (as the Italian), the phosphorus shell, tracer shell, and the illuminating shell be determined by experiment. (6) That a light caterpillar tractor mount be attempted.

"BENJAMIN J. HARMON,

"Captain, Coast Artillery Corps."

From another overseas report on "Anti-aircraft Artillery Matériel" the following abstracts are taken:

"Much of the advance so far has evented because of a knowledge of the capabilities and limitations of modern optical, mechanical, and electrical instruments. An even more specialized knowledge of these matters is essential for future progress.

"With the design of more powerful guns, naturally, is embraced that of a fuze capable of withstanding all of the detrimental effects of gunfire under every condition. The mechanical fuze appears to be the only logical solution."

"The best protection against airplanes flying below an altitude of 2,500 and a range within 4,000 meters is the pom-pom, a 1 or 2 pounder gun firing at the rate of about 120 rounds per minute. No gun of this type has been success-

fully designed and constructed. The necessity of using ammunition having a supersensitive fuze with back time protection adds to the problem of gun design. Machine guns of larger caliber, if possible, at least with increased range, should fulfill effectively the requirements within a zone of action of altitude 1,500 and range 2,500 meters."

"Because of the important field played by aerial sound-detecting apparatus, searchlights, and telephony, including wireless, any future progress in the design of anti-aircraft artillery matériel should not be undertaken before having a complete knowledge of these subjects. With the perfection of airplane motors and their interconnected functioning apparatus, the design of aircraft, and the art of flying, other factors upon which the design of artillery equipment should likewise be based, enter into the problem. A thorough coordination of all these details is absolutely necessary."

"Anti-aircraft gunnery differs from other forms of gunnery, such as field-artillery problems. It is a new subject, one more complicated than any other artillery problem, and consequently one which essentially demands new methods and modes of measurement."

"Its rôle is only beginning. It is hardly possible to estimate how great will be the future importance of the perfection of the country's aerial defense from a strategic point of view. The value of every advance made during the war is therefore more than doubled, for it will be of permanent value in time to come. Aviation as an offensive arm will remain the principal arm. Anti-aircraft artillery, as a defense branch, will play opposite it the part that coast artillery plays to the naval squadrons of the seas. An arm which will continue to increase with the progress of aviation."

It will be observed that in the responses to the questionnaire no mention is made of corrector V. S., as described on pages 31 and 32, and it may be that the field officers generally had not had opportunity to familiarize themselves with this fire-control development.

Star shells are mentioned on page 69, and possibly there is opportunity for more elaborate development in this connection, for assistance during night attack, by perfecting an illuminating element of great intensity, long burning, and which would be sustained aloft for a lengthy period by parachute or other device, and which could be projected from an anti-aircraft gun.

## CHAPTER IX. SUMMARY.

Any attempt to summarize the history of anti-aircraft guns, with more in mind than a simple summarization of matériel produced, must take into account a number of viewpoints.

It must be recalled that the whole subject of anti-aircraft gunnery is limited to the present European war, and that material progress in what might be termed the science of anti-aircraft gunnery was largely limited to the first year of the war.

At the beginning there were no established principles, no matériel, no organization, and such progress as was made was made **under** stress and entirely as the result of conditions developed in actual combat. Those who carried on their labors at a distance from the zone of action were dependent upon those within the active zone for a statement of needs and an outline of the most promising method of development.

It seems very probable that the information in the hands of many of those outside of the zone of action was far from being up to date and that the mental picture of the actual process, as involved in the physical handling of equipment which brought forth the best results, was not always clear. Certain it is that the knowledge of what was being accomplished from week to week was confined to comparatively few.

As an example of the impression that might be conveyed to those who obtained their impression solely from figures, it is unnecessary to go further than the American Expeditionary Forces' weekly statement of the artillery situation as of record November 16, 1918, five days after the signing of the armistice, as issued from the office of the Chief Ordnance Officer, American Expeditionary Forces, Requirements Division. A copy of the figures from this report, which would seemingly convey information as to the total amount of anti-aircraft artillery, both from United States sources and from the French, which was in the hands of the American forces at the time of the signing of the armistice is reproduced below:

Type of matériel.	From—	Quantity ordered.	Total delivered in France.	In reserve.		Total with troops.	
				With troops.	Service of Supply.	Advance area.	Train area.
3-inch anti-aircraft guns .....	United States...	612	0	0	0	0	0
75-millimeter anti-aircraft truck mounts.	.....do.....	51	18	0	17	2	59
75-millimeter anti-aircraft improvised mounts.	.....do.....	50	50				
75-millimeter anti-aircraft mounts .....	France.....	4	4				
75-millimeter anti-aircraft guns .....	.....do.....	66	66	0	23	2	59
Do.....	United States.....	65	18				



An inspection of this tabulation would lead one to believe that the only anti-aircraft artillery, from any source, in the combat of the American troops, consisted of two 75-millimeter anti-aircraft truck mounts and two improvised mounts fitted with French 75-millimeter field guns, or four units in all, distributed among three American armies. The "Statement of anti-aircraft situation" dated October 12, 1918, as included in the confidential report of October 10, 1918, from Chief Ordnance Officer, American Expeditionary Forces, to Chief of Ordnance, Washington, "Review of United States Artillery Program," showed "a great shortage of anti-aircraft matériel," but there was more protection and more opportunity to judge by American troops in the handling of anti-aircraft guns than these tabular figures might lead one to believe.

These figures are doubtless correct as a matter of statistical record, but it is known that two type FZ 75-millimeter French auto cannon were at the front for five months, in the hands of Battery B, First Anti-aircraft Artillery, now known as the Twenty-third Battery, First Battalion, and that other French auto cannon batteries were manned by American personnel, alternating with the French, and that at Colombey-les-Belles, sector No. 10, there were six American and two French semifixed mounts.

The number of troops in the Anti-aircraft Service at the time of the armistice was about 12,000, and although comparatively few of these were at the front, the following organizations are referred to as those which actually brought down enemy planes:

- Fifth Anti-aircraft Battery.
- Twenty-second Anti-aircraft Battery.
- Twenty-third Anti-aircraft Battery.
- Twenty-seventh Anti-aircraft Battery.
- Twenty-eighth Anti-aircraft Battery.

The anti-aircraft machine-gun organizations which are listed as having brought down planes are:

- Company A, First Anti-aircraft Machine Gun Battalion.
- Company B, First Anti-aircraft Machine Gun Battalion.
- Company C, First Anti-aircraft Machine Gun Battalion.
- Company D, First Anti-aircraft Machine Gun Battalion.
- Company A, Second Anti-aircraft Machine Gun Battalion.
- Company B, Second Anti-aircraft Machine Gun Battalion.
- Company C, Second Anti-aircraft Machine Gun Battalion.
- Company D, Second Anti-aircraft Machine Gun Battalion.

It is also of record that the American troops handling anti-aircraft guns obtained remarkably good and constantly improving results.

As to what was accomplished in the furnishing of anti-aircraft artillery matériel prior to the signing of the armistice, the figures of the United States production are not imposing, but it is well to

airplanes, and for this the "pom-pom" has been suggested. In conversation with an overseas officer he made the statement that he had seen four of our observation balloons brought down inside of 10 minutes.

Reference has been made to the use by the enemy of "flaming onions" for the protection of their own observation balloons and of their deterrent effect upon our own aviators.

While operations during the time of war were carried on under stress, nevertheless development at such time took place under conditions which it is impossible to reproduce with the same effectiveness in time of peace. Page 44 refers to difficulties encountered in the provision of suitable target conditions for training purposes.

A brief reference is here made to the general routine of aircraft activities during the European war.

Enemy Zeppelins and bombing planes provided a means for attack upon England against which its mighty fleet provided no protection. On page 28 reference is made to the new branch of service which was built up to meet this emergency. The part played by small incendiary projectiles is referred to on page 33. The thought may arise as to whether aerial incendiarism will be further developed by the shell discharge of long streamers of flaming material which would catch upon the wings of airplanes or otherwise act effectively, or to any possible use of quick acting gas, or of shell discharge of gas or liquid which would produce a large burst or shower of flame for the disabling of aircraft operators. At present we have no device corresponding with the "flaming onions," which disconcerted our airmen in attacks on enemy balloons.

As far away as the United States is from the scene of the European war, it will be recalled that provision was made against aircraft attack, even at a time when the sea was free from enemy ships, and the danger from enemy aircraft attack in the United States could apparently be brought about only by the release of aircraft from submarines, unless the thought was entertained at that time that it was in the range of possibility for aircraft to cross the ocean. At the present time this possibility seems quite probable.

Attention must be given to possibilities attached to use of helium or other light noninflammable gases, in connection with lighter-than-air machines.

On the battle front in Europe the customary practice was to establish the observation balloon beds about 7 kilometers behind the front lines and each morning to tow the balloons by motor-driven winches mounted on motor trucks to a distance about 5 kilometers behind the front lines and to hold them there through the day unless attacked. The winch trailer carried six machine guns and their crews, and on arriving at forward station, these machine gunners distributed

themselves in favorable position in the vicinity of the winch, for the protection of the balloon and the winch against enemy airplanes. The balloon was usually set at an altitude of 4,000 to 4,500 meters, depending upon the atmospheric conditions, and if attacked by airplanes, was drawn down until the balloon was at a height which would bring the enemy airplanes within range of the machine gunners. The official record of planes brought down by these machine gunners is four, and it is understood that the total actually disabled was considerably greater. Pom-pom fire has been suggested as a better protection for observation balloons.

On page 43 reference is made to the descent by parachute of observation balloon men and their views concerning the use of automatic rifles from the balloon basket, in the event of the balloon being attacked by airplanes. In the event of enemy gunfire from the ground, the balloon was towed out of range by means of the motor truck which can tow at the rate of about 10 miles per hour.

Attention is called to the vulnerability, not only of the balloon, but of the motor winch truck, and also of the balloon beds or filling stations, which are subject to airplane attack or map firing from field artillery. Regarding the latter condition it will be remembered that the balloon beds are 7 kilometers behind the lines and the enemy artillery would be a considerable distance behind their own lines. Enemy field artillery attack upon balloon beds can be attempted only by long-range guns. This is in a measure true of similar attacks upon observation balloons, and the winch trucks when in their customary position of 5 kilometers behind friendly lines, although they are sometimes inadvertently gotten close to a front-line position. It is understood that on the British front observation balloons were subject to enemy fire from guns of as large a caliber as 155 millimeters, using explosive shell with clockwork fuze, which provided for the necessary range; but no concentrated attack of this nature has been reported on the American front.

It will be held in mind that for reasons indicated on page 18 it is intended to operate against aircraft back of the enemy lines as well as against enemy aircraft over friendly territory. This means long-range guns to reach observation balloons or airplanes operating behind enemy lines in positions which permit of their occupants observing and reporting on conditions inside friendly lines.

The general operations of the enemy aircraft and of our aircraft are, to some extent, similar, and a description has been given of the manner in which our own observation balloons are handled. A brief outline of the methods of operation of our own airplanes may assist in visualizing the opportunity for attack upon and defense against enemy airplanes, with the use of anti-aircraft guns, as well as the possibility of assistance to our own airplanes.

In general, airplane routine is divided into pursuit, observation, and bombing.

Pursuit planes as a rule are one-man planes, of light and speedy type, equipped with fixed machine-gun armament. These are planes which operate singly or in groups, in regular patrol, or in response to alarms and in which the individual acts largely upon his own initiative in judging the opportunity and method of attack upon enemy aircraft, and in the evolutions performed either in operation against enemy aircraft or in his own defense. The altitude at which the pursuit plane flies largely depends upon the objective of the moment, but on the Marne his patrol work was done at about 3,000 meters, in the Argonne at about 600 meters, and around Toul at from 3,000 to 6,000 meters' altitude. He is, therefore, subject to all kinds of enemy fire, both from the air and from the ground.

He is constantly hunting for trouble, and frequently our own anti-aircraft artillery helps him to find it. From the air it is difficult for one pilot to discern an enemy airplane at any considerable distance, and when he notes the explosion of shells from our own anti-aircraft artillery his attention is called to the presence in that vicinity of enemy aircraft, and he immediately directs his flight to the scene of the aerial burst of these shells. This will make clear the necessity for high-powered telescopes or field glasses in the hands of our own anti-aircraft men, to provide against their firing upon friendly airplanes when they approach to take a hand in the attack upon enemy planes. This will also bring out the need for effective liaison between our own searchlight men and our own airplanes, in connection with night attacks by the enemy. If our searchlight men can pick up an enemy airplane over our lines, they can hold their light upon him, and in some cases so blind him as to cause him to lose his sense of location, while in the meantime a friendly plane may keep without the focus of the searchlight and maneuver into a position favorable to attack. From the ground we are able to discern the proximity of an airplane through the noise of its engine, but the enemy airplane pilot is prevented from hearing the noise of another airplane through the noise of his own engines.

The observation plane usually carries two men—a pilot and an observer—and is somewhat slower than the pursuit plane. It has the fixed machine-gun armament at the disposal of the pilot and, in general, flies at its "ceiling," or the maximum height to which the plane is adapted, save when on some direct objective. In good weather, clear photographs may be obtained from a height of 5,000 meters, and the average photograph is taken at about 3,500 meters. This plane is therefore, in the main, subject to ground attack from enemy artillery only and not from machine guns, and it does not maneuver and dodge about to the extent of the pursuit plane, as it

has a definite accomplishment to perform, such as map making and other observation of the disposition of enemy location, formation, and transportation.

It has, however, other definite duties, such as trench observation, artillery regulation, and infantry contact, which again holds it to a more or less definite course, but does subject it to machine-gun fire. The artillery regulating consists of flying over the enemy lines and observing objectives or the nearness of arrival of friendly shells to these objectives, for the purpose of checking or correcting field artillery fire. Infantry contact consists of the following up of our own infantry during attack and reporting back to our own artillery the exact position of friendly infantry during an advance, to provide for the proper regulation of friendly artillery fire as well as for the information of infantry maneuvering headquarters.

Bombing planes are large and heavy and carry two or more men. Their operations are carried on either by day or by night; they fly in a fixed formation—usually in the form of a triangle, with the apex leading—and, as a rule, proceed with one objective and a prompt return, following release of bombs over that objective. The pilot has at his disposal fixed machine guns, shooting directly forward, and other machine guns—usually double Lewis—are provided for operation by another man, in any direction which will clear his own plane. Bombing formations usually fly high and do not maneuver, as they depend for their protection against enemy airplane upon their fixed guns for protection straight ahead and upon their free mounted guns and large volume of fire for protection in other directions, or upon the protection of accompanying pursuit planes.

It will be seen then that the anti-aircraft gunner's activity may include either artillery or machine-gun fire against the pursuit plane or the observation plane, but is confined to artillery against the bombing plane. It will further be observed that anti-aircraft machine-gun fire with its stream line of projectiles, including its fire-correcting tracer bullets, is the most effective against quick-acting planes which are free to maneuver and are constantly changing both course and altitude, provided the altitude and distance bring the plane within the machine gun's range. The called-for development of the larger-caliber machine gun would increase this effective range and the provision of an artillery shell with a wider range of burst than the present, or of an artillery projectile which would release "flaming onions" or irregularly moving, wide area covering disconcerting elements, would permit of anti-aircraft guns giving increased assistance in this field.

Against bombing planes artillery alone is effective, and as these fly at increasing altitudes, increasing range from anti-aircraft artillery has proved necessary. They, together with dirigible balloons,

being of large carrying capacity, involve the greatest physical destructive menace from the air, and as they fly in formation and usually along a definite course and at a more or less maintained altitude, they form a more promising target for the anti-aircraft artillery, which is slower in maneuver than the anti-aircraft machine gun.

A higher-speed projectile is desirable both on account of accomplishing increased range and the decrease in error due to variables, through the reduction of the time of flight. The wider area of burst is more desirable for the purpose of increasing the effectiveness through shock or fragmentation, and the mechanical fuze is essential to the elimination of previously mentioned fuze difficulties. Noise of burst is also desirable, as well as smoke and, to some extent, incendiary effect, although an airplane is usually set on fire only by puncturing its petrol tank.

The psychological side of anti-aircraft fire seems to be worthy of considerable attention, for while the reduction of enemy personnel or of the enemy aircraft is the primal object, the experience of our own aviators makes it very evident that noise or flaming objects have a decidedly deterrent effect, even when the known record of physical damage through certain agencies is small. In conversation with the ordnance liaison officer attached to Military Aeronautics, he stated that during his stay in France, and his close association with the first pursuit group, consisting of 84 planes, and extending over a period of eight months, he knew of only one American flyer whose plane had been destroyed by enemy anti-aircraft fire, and of one other flyer whose engine had been damaged by an enemy shell, which had failed to explode, but who was able to land within friendly lines. Questioned as to the statistics regarding casualties among observation and bombing planes, he was unable to find definite records.

This brings out the point that pursuit flyers were offered steel seats and also steel sides to protect them from machine-gun fire and apparently it was left optional with them as to whether they wished to accept this protection with its handicap of additional weight.

There were, of course, many flyers brought down, but they were brought down by enemy aircraft and apparently not to any large extent by enemy anti-aircraft fire. It likewise seems clear that the enemy anti-aircraft fire had a very decidedly deterrent effect and from several sources indications have been given of the deterrent effect of the enemy "flaming onions."

In view of the above, the record of enemy planes actually brought down by American anti-aircraft fire, as referred to in official communication quoted on pages 74 and 75, is the more worthy of attention.

## CHAPTER X.

### ADDITIONAL NOTES.

#### FRENCH 105-MILLIMETER ANTI-AIRCRAFT TRAILER MOUNT.

In an appended report from American Expeditionary Forces, dated February 28, 1919, there appears a description of the above matériel, but this description is confined largely to the fire control in connection with the apparatus.

The fundamental characteristics of the 105-millimeter Schneider matériel is described as being the suppression of the laying by direct sighting on the objectives and the putting in operation of semiautomatic telepointing which requires only relatively simple mechanisms not likely to require readjustment.

One of the advantages noted with reference to the employment of this indirect firing is the elimination of the danger of confusing objectives.

As has been previously stated, this matériel is so arranged that it is fired from a platform resting on the ground, when in battery, but capable of being rapidly put on wheels by means of jackscrews, which likewise facilitate its being put into battery.

The breech mechanism is automatic and is effected by the action of a special recuperator functioning upon the return of the gun into battery. The breech of the eccentric screw model assists in ramming the projectile home. The ammunition is placed on a revolving loading tray equipped with a mechanical device for fuze setting.

#### FRENCH SIGHTING AND FIRE-CONTROL EQUIPMENT.

Appendix 16 and Appendix 19 from American Expeditionary Forces, and dated February 1, 1919, describe in detail the mechanical or electrical construction of anti-aircraft fire-control and sighting apparatus, and the text is accompanied by numerous illustrations.

#### GERMAN ANTI-AIRCRAFT ARTILLERY.

In Appendix Report 15 from American Expeditionary Forces, dated February 20, 1919, is contained a compilation of information on enemy equipment, which compilation is believed to cover all types of matériel employed by the Germans during the entire period of the war.

Attention is first devoted to the fire control. For fire in still air, the values for the different corrections of the moment were given by

tables in function of the mean temperature of the powder, and the weight of a liter of air on the ground, at the battery position.

It is a matter worthy of note that for the permanent corrections of fire, the Germans distinguish between a new gun and a worn gun. The Germans reason that the influence of wear of the tube is of the same nature as the influence of a variation in the temperature of the powder; that is, a variation in muzzle velocity.

(REMARK.—The fact that the Germans make their ballistic corrections by merely changing the distance by a constant quantity with the resulting obligation of accepting certain theoretical inaccuracies in order not to complicate the giving of orders is obviously the consequence of their having neither fuze setter nor corrector.)

Further note is made that it does not appear that the Germans have developed to any extent study of wind corrections.

In the German instruments, no instrument seems to exist for measuring velocity, the same being estimated according to the type of airplane, and probably with an allowance for the wind.

Apparently the angle of the route is estimated either by the operator of the telemeter, or by the officer commanding the fire, and called out at intervals of 30°, relative to the figures on the dial of a watch. For instance, an airplane "Going 0" is indicated as 12, an airplane "Coming 60" is indicated as 4.

The shell used is principally high explosive. Shrapnel is only exceptionally employed and never for ranges beyond 4,000 meters.

The fire is conducted by zones, the regulation is about 100 meters, the dimensions of the zone swept and the direction in which it is swept depends upon the number of guns, the number of rounds per gun, and the route of the airplane. The Germans consider only a coming plane, a going plane, and a crossing plane. In the first case the fire is regressive; in the second and third instances it is progressive. The number of rounds to be fired by each gun depends upon its rapidity of firing and loading, and the danger apprehended from the objective. Fire is opened at the following commands: "Number of rounds, progressive or regressive, range, vertical deflection correction, lateral deflection correction, fire!"

The Germans do not make any range adjustment. They employed no distant observers. From the first rounds are estimated the lateral and vertical deflection corrections. German batteries fire three rounds and then wait to observe the three bursts before continuing the fire.

Photographs of instruments and blue-print diagrams to illustrate the text description of fire control methods are included in the report.

The principal matériel of the German anti-aircraft artillery may be classified as follows:

*Light*.—Sections of two pieces, 37-millimeter guns, either a revolving gun or the automatic type, horse drawn.

*Semifixed*.—Sections or batteries of naval 77-millimeter or 88-millimeter guns; also 90-millimeter guns.

*Automobiles*.—77-millimeter automobile gun (isolated singly or in section).

*Trailer*.—80-millimeter and 88-millimeter guns (battery of two guns).

*Horse drawn*.—This is comprised of a certain number of emergency equipments used only occasionally against aircraft. French 75-millimeters transformed, 77-millimeter Schmetzler carriage, model 1914, and 100-millimeter guns.



In addition, the Russian gun of 76.2 millimeters on pedestal mount (battery of three or four guns), concerning which is given a more detailed description, this gun being one of the best known and the most generally used in the German Army.

### LIGHT MOUNTS.

#### 37-MILLIMETER REVOLVING CANNON.

The carriage is fixed on a wooden platform equipped for firing from legs or props. The rigid part of the mount consists of a cast-iron column on which the movable part can turn freely. The gun is composed of five barrels held together by two collars. The shells are placed in a slide and are successively forced into the tubes by means of a rammer, as the tubes are successively rotated into the proper position for the entrance of the shell. Each round is fired separately, and it is stated that a friction primer is employed. The empty cartridge case is ejected before the barrel it occupied again comes opposite the loading slide.

#### 37-MILLIMETER AUTOMATIC CANNON.

This mount is supported by a carriage having two wheels, and a trail, and is fired from the mount. The gun is fundamentally a large Maxim machine gun. Range, 3,000 meters; weight of projectile, 6.450 kilogram. Two shells provided—one loaded with black powder, and the other a tracer shell, leaving a green trail.

### SEMIFIXED MOUNTS.

#### 88-MILLIMETER GUN.

(Length, 45 calibers; muzzle velocity, 750 to 765 meters per second.) This is a German naval gun on a Krupp and Eberhardt pedestal mount. Range, 9,150 meters; weight of projectile, 9.60 kilograms; time fuze.

Different arrangements of platforms are shown. The general mount is composed of a framework of beams used as outriggers from a central bed on which is bolted a cast-iron circular plate. To this plate is bolted a stationary column on which the whole of the movable part turns. This mount is also used by the Germans as a trailer type, the entire unit above the circular bed plate being identical with that used with the semifixed mounts. The semifixed mounts themselves, together with the guns, are transported from place to place on motor trucks.

An accompanying photograph shows five rounds of ammunition packed in a steel drum or barrel, fitted with sleeves or diaphragms to receive them. These drums may be rolled, instead of being dragged or lifted, in moving short distances.

## AUTOMOBILE MOUNTS.

## 77-MILLIMETER GUN.

No jacks are employed for putting it into battery; this is done by locking the springs.

The photograph which accompanies the report shows a flat-bodied truck with gun so mounted as to apparently permit of all-around fire. The front wheels of the truck have rubber tires and the rear wheels have double rubber tires, but a point worthy of note is that on both front and rear wheels there is a cleated rim extending beyond the rubber tires and at smaller diameter. During the passage of the machine over hard roads the rubber tires only would come in contact with the road surface, while in mud or soft ground, not only would a wider wheel surface be presented to prevent the weight of the vehicle forcing the wheels deeply into the ground, but the cleats on the extension rims would provide traction between the wheel and the soft or slippery ground surface.

## TRAILER MOUNTS.

## 80-MILLIMETER GUN.

(Length, 45 calibers; muzzle velocity, 715 meters per second.)

The frame consists of channel iron sections on which rests the platform supporting the gun. The placing in battery is accomplished by locking the springs and lowering two outriggers to insure lateral stability. The gun and recuperator cradle is trunnioned to the rear of the center of gravity of the combination, and equilibrating springs are located beneath the cradle at the center of gravity. The gun with its recoil mechanism is raised and lowered by means of a pinion and segment gear; a separate gear mechanism being supplied for superelevation. The cast mount has an all-around traverse on the channel-section frame; being adjusted by worm-screw mechanism.

The principal characteristics of the gun are:

Total length of tube.....	3.22 meters (45 calibers).
Total length of bore.....	3.38 meters (42 calibers).
Total length of rifling.....	2.78 meters (35 calibers).
Grooves:	
Number.....	24.
Angle.....	6° 10'.
Pitch.....	Constant.
Amplitude of elevating mechanism.....	70°.
Maximum range.....	13,000 meters.

The ammunition consists of a brass cartridge case with an explosive shell and a three-ring time fuze. The complete round weighs 12.265 kilograms. The explosive projectile is solid forged with two rotating bands, and with its fuze weighs 7.920 kilograms. The fuze,

which is a time fuze only, may be graduated from 3 to 29 seconds. The fuze weighs 465 grams, and the threaded diameter of the fuze body is 50 millimeters. Attention is directed to the fact that German projectiles with a fuze hole threaded to the same diameter are found only in their naval artillery.

#### 88-MILLIMETER GUN ON TRAILER MOUNT.

This matériel is similar to that of the German 88-millimeter semi-fixed mount. Its characteristics are:

Bore, 88 millimeters. Length, 13 feet.

Breechblock, horizontal sliding.

Elevation, 0° to 70°; azimuth 360°.

Circular base with auxiliary leveling pintle and screws at bottom.

Height from steel platform to trunnion, 55 inches.

Height from face breechblock to trunnion, 18 inches.

Length of cradle, 51 inches.

Height from top of platform to ground, 30 inches.

Frame, 10-inch channel; 18-inch wide folding platform extension each side.

Wheel base, 13 feet 8 inches; tread, 72 inches; wheels, 3 feet diameter, with two 4-inch steel shoes flexibly mounted on each rear wheel and one on each front wheel.

Double seat with steering wheel and brake at the front.

Four built-up steel T sections, 8 feet 6 inches long, are slipped, two on each side, under frame over rollers when in firing position. These tees carry 4-inch diameter screw jacks with 19-inch diameter plates with webs for support. An auxiliary screw is located at the top of these jacks.

Platform 6 feet wide extended by folding platforms to 9 feet wide between wheels, and is 38 inches wide between wheels at ends.

Traversing and elevating handwheels located on both sides.

Both ends have eye coupling and hooks for traces.

Above gun is a 6-inch diameter by 52-inch long recoil cylinder, and underneath is a 4-inch diameter one.

Double elevating racks are provided. On the left side and fastened to the trunnion is a pointer and scale giving elevation in degrees.

On the right side and fastened to the trunnion is the sighting apparatus bracket.

The traversing and elevating of this gun is very easy, the gun being well balanced. All parts are rugged in construction. A removable travel lock is provided so that the gun is transported on the road with muzzle to the front. Equilibrating spring is inside of pedestal.

#### HORSE-DRAWN MATÉRIEL.

##### FRENCH 75-MILLIMETER FIELD GUN.

Transformed and rebored to 77-millimeters. (Length, 35 calibers.)

*Tube.*—Only the part behind the breech housing is utilized. It is screwed on a tube of the same length as the 75-millimeter bored to 77-millimeters, reinforced by a steel sleeve of almost the same exterior dimensions as the bronze jacket of the 75-millimeter.

For the recoil, the traversing rollers are replaced by the sliding blocks. The rear blocks are carried by the breech housing, the front and intermediate ones by special hoops. The rollers at the muzzle became unnecessary and therefore no longer exist.

*Cradle.*—The interior parts have been retained completely with the exception of the square bronze scale for which the chambered section of the brake has been modified by the addition of one plate of brass flanged and riveted.

The drum of independent sight has been adapted to the firing of the 77-millimeter and provided with an adjustable zero clinometer.

*Rocker.*—The length of the segment rack of the aiming cradle has been increased.

*Carriage.*—The trail of the 77-millimeter carriage has been cut to about one-third its length from the pintle end.

The part carrying the trail spade and the pintle is fixed at the extremity of the flask of a German howitzer trail. The whole constitutes the trail of the new carriage.

The part in front of the carriage of the 75-millimeter has been changed by omission of the axle, axle plates, and the part constituting the road brake, all of which have been transferred to the flasks of the light howitzer. The rear part has been equipped with trunnions which permit angles of elevation on the howitzer carriage.

*Counterbalance.*—The counterbalancing of all oscillating parts, consisting of tube, cradle, carriage of 75 millimeter, and gun shield, is maintained by means of a strong helical counterpoise spring.

This mass, due to this counterbalancing, may be elevated and depressed with ease. The system can be placed in two fixed positions on the carriage of the howitzer. To lock it in each of these positions the cradle has been equipped with a front sector having two stops, into which a large steel latch engages. This sector is carried by the howitzer carriage and operated with ease from an eccentric crank shaft. The corresponding angles of fire are shown in the following table:

	Low position.		High position.	
	Maximum.	Minimum.	Maximum.	Minimum.
First matériel.....	37 20	0 40	61 15	23 15
Second matériel.....	28 20	10 15	50 20	14 40

The 75-millimeter carriage set in field firing position, the apparatus functions as in the regulation 75-millimeter gun. The scale, the drum, the collimator, the graduation for the angles of site, and the lever perform their usual parts. A footboard fixed to the left flask

of the carriage indicates that the pointer operates the sight in a standing position.

The 75-millimeter carriage set in anti-aircraft firing position, the pointing is direct and the pointer causes the cradle to follow all the vertical movements of the objective. In some cases, for anti-aircraft fire, the Germans had replaced the French collimator by a slightly different design of sight.

The wheels of the carriage are often set in a circular traversing track which is fixed either in concrete or securely held to the ground. The carriage is traveled in this track for large angular displacements and to the smaller movements by axial sliding, the amplitude of which is 72-millimeters.

The central transom of the howitzer carriage carries a movable shaft which is fastened by means of a bolt to the head of the pivot and transmits to the latter the reaction of the recoil.

The trail spade is supplied with a wooden shoe which gives to the rear of the carriage a strong point of support on the ground, and permits with facility lateral pointing in all azimuths.

The shield of the 75-millimeter also protects the pointing mechanism. On one of these mounts, the collimator has been placed about 60 centimeters back to the right by means of a special bracket.

Sight has remained independent, both for field and anti-aircraft fire. The dials, however, have been slightly modified.

The sight drum has three graduations: The first, F (probably Feld), bears the division 0 to 4,700; the second, L (probably Luft or Luftfahrzeug), also bears divisions 0 to 4,700 but apparently in different progression; the third, H and L, carries the divisions 4,500 to 6,700.

These graduations are probably used as follows:

- (a) Graduation F, for field fire at low ranges.
- (b) Graduation L, for anti-aircraft fire at low ranges.
- (c) The mixed graduations for either, firing at high ranges.

In order to correct the trajectory deformation, the Germans have assembled a sight compensator which simultaneously moves the reference marks of the three graduations. The compensator handle is marked "higher" and "lower," and in each of these directions the compensator graduation runs from 0 to 10 (one division equals about one-fourth degree).

#### MODEL 1914, 100-MILLIMETER GUN.

(Length, 35 calibers.) Range, 11,050 meters; weight of projectile, 18 kilograms; time fuze.

This gun has not been especially designed for anti-aircraft service. It has no particularly interesting points except its pointing apparatus, which has already been described.

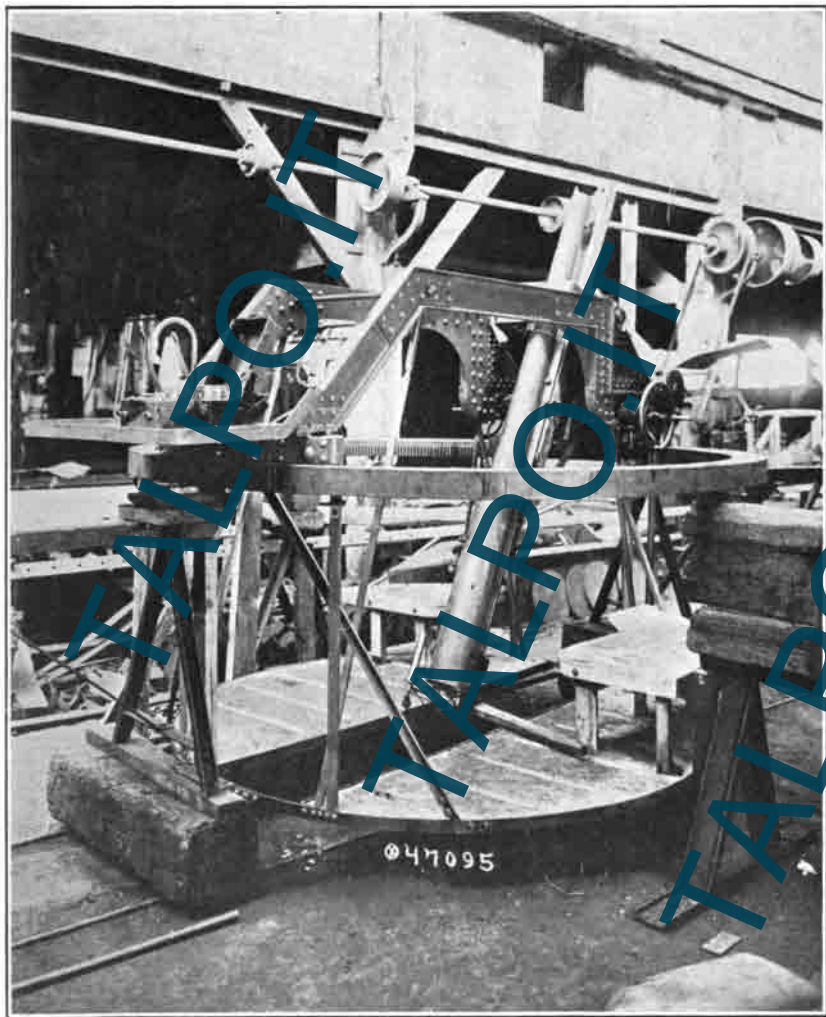
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CHAPTER XL  
PHOTOGRAPHS.

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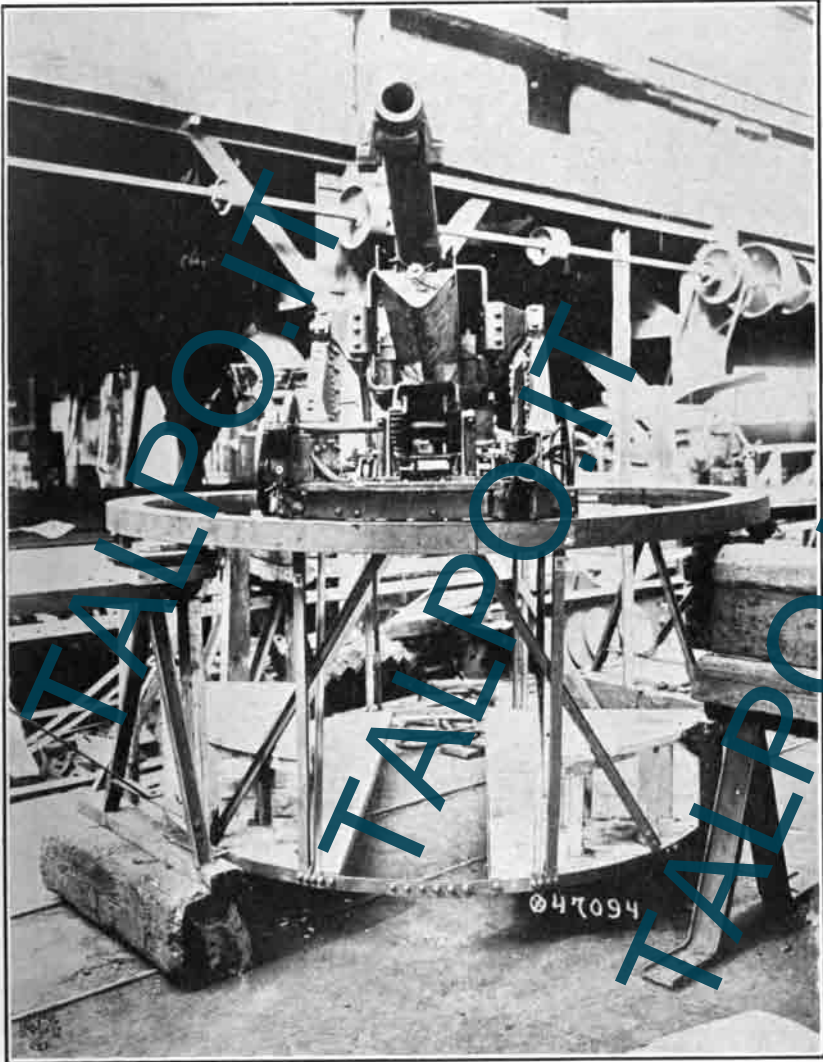
AMERICAN IMPROVED ANTI-AIRCRAFT CARRIAGE.

Model of 1917, after it had been changed and equipped with 75-mm. French model 1897 field gun in French shop. Note changes in platform and change of horizontal supports to riveted U frame to provide better space for loading. (See p. 45.)



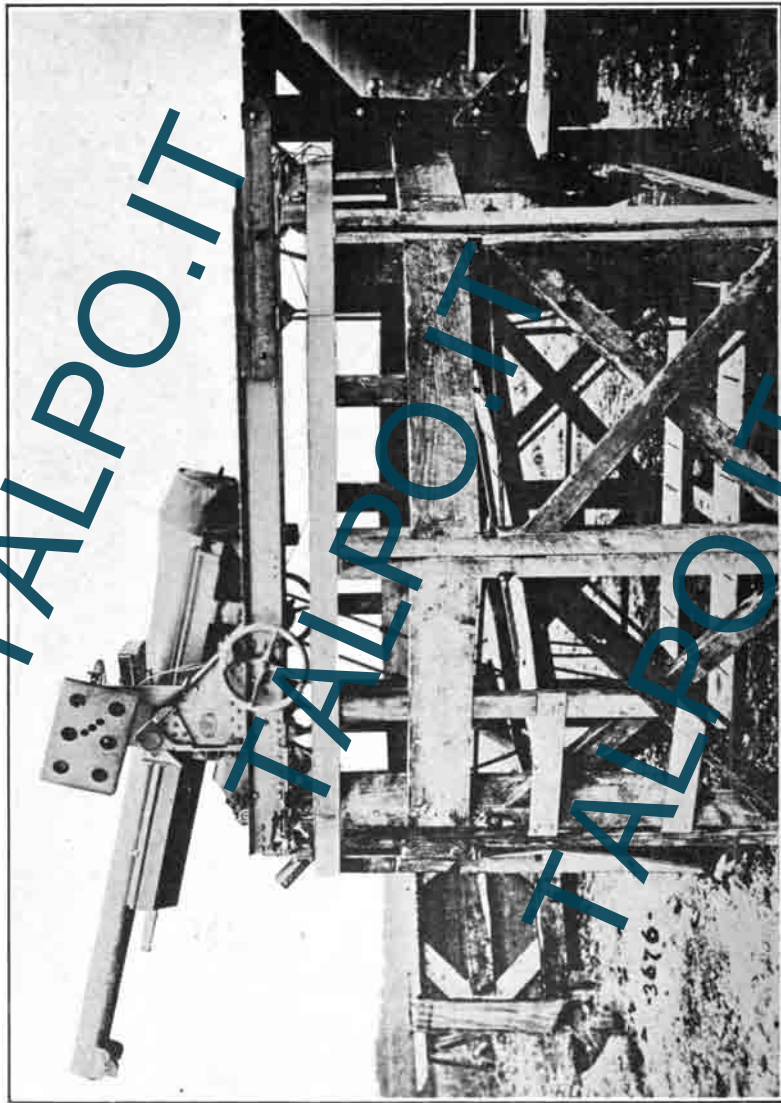
AMERICAN IMPROVED ANTI-AIRCRAFT CARRIAGE, MODEL OF 1917, AFTER IT HAD BEEN CHANGED AND EQUIPPED WITH 75-MM. FRENCH MODEL 1897 FIELD GUN IN FRENCH SHOP.  
Note changes in platform and change in horizontal supports to riveted U frame to provide better space for loading. (See p. 45.)



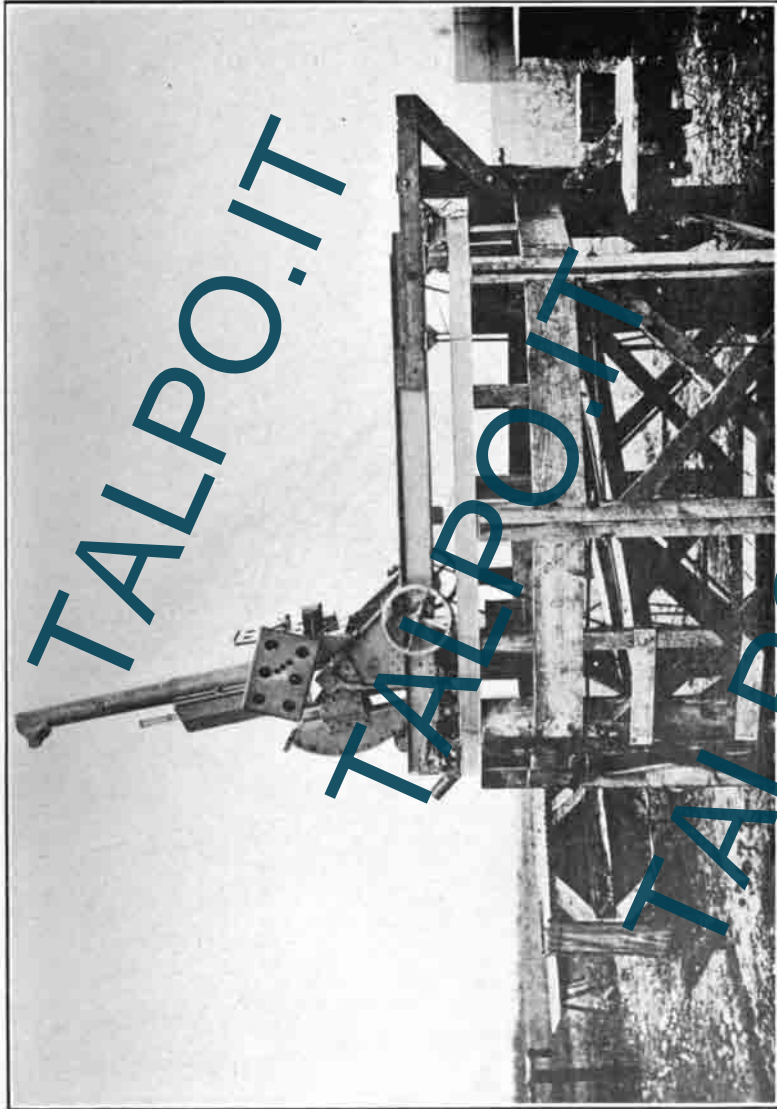


AMERICAN IMPROVISED ANTI-AIRCRAFT CARRIAGE, MODEL OF 1917, AFTER IT HAD BEEN CHANGED AND EQUIPPED WITH 75-MM. FRENCH MODEL 1897 FIELD GUN IN FRENCH SHOP.

Note changes in platform and change of horizontal supports to riveted U frame to provide better space for loading. (See p. 45.)



75-MM. FIELD GUN, FRENCH MODEL 1897, WITH PUTEAUX RECUPERATOR, FITTED WITH AMOURTISSEUR ON AMERICAN IMPROVED PLATFORM MOUNT, FOR ANTI-AIRCRAFT SERVICE.



75-MM. FIELD GUN, FRENCH MODEL 1897, WITH PUTERLIX RECUPERATOR, FITTED WITH AMOURTISSEUR ON AMERICAN IMPROVISED PLATFORM MOUNTING, FOR ANTI-AIRCRAFT SERVICE AT MAXIMUM ELEVATION.

PLATE VI



AMERICAN TROOPS OPERATING AMERICAN 75-MM. IMPROVED MOUNT EQUIPMENT FOR ANTI-AIRCRAFT SERVICE.

Note arrangement of fuze punch, sighting apparatus, position of men on overhanging seats and inside of mount structure.



AMERICAN TROOPS OPERATING AMERICAN 75-MM. IMPROVED MOUNT  
EQUIPMENT FOR ANTI-AIRCRAFT SERVICE.

Note fuze punch.



75-MM. ANTI-AIRCRAFT TRUCK MOUNT. TRAVELING POSITION. (See p. 46.)



75-MM. ANTI-AIRCRAFT TRUCK MOUNT. FIRING POSITION WITH GUN ELEVATED AT 80°. (See p. 46.)

PLATE X



75-MM. ANTI-AIRCRAFT TRUCK MOUNT. FIRING POSITION. (See p. 46.)

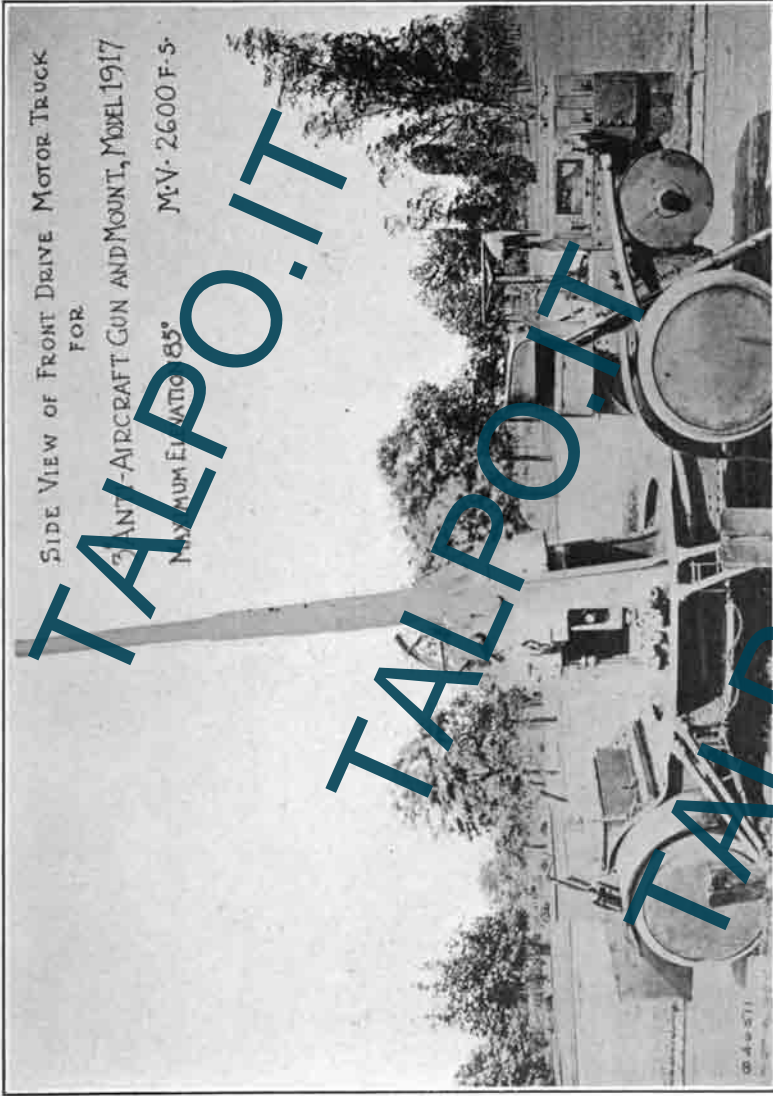
28702





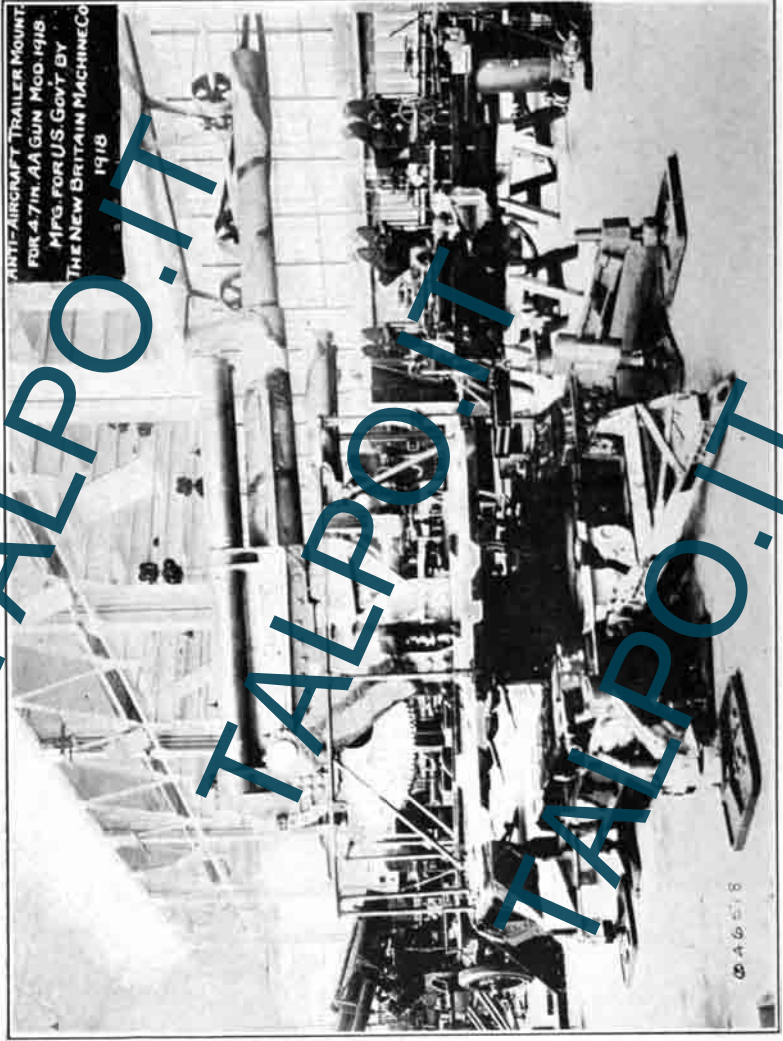
GROUP OF 75-MM. ANTI-AIRCRAFT TRUCK MOUNTS AT FACTORY, NEW BRITAIN, CONN. (See p. 46.)

TALPOIT  
TALPOIT  
TALPOIT



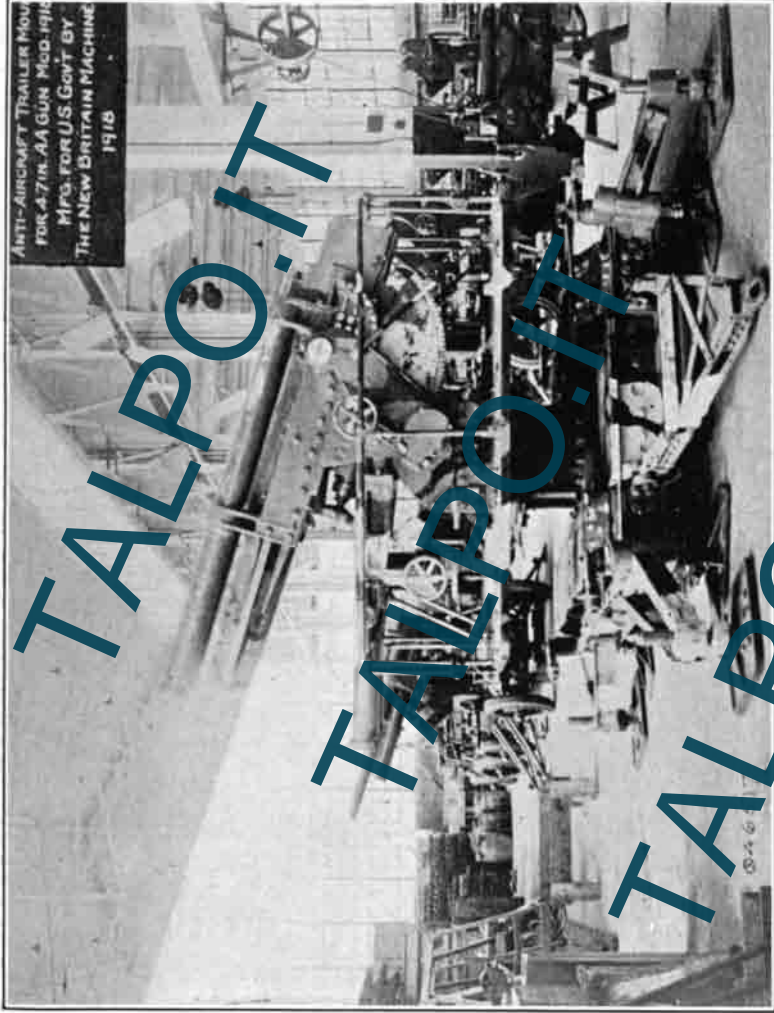
SIDE VIEW OF FRONT DRIVE MOTOR TRUCK  
FOR  
3-INCH ANTI-AIRCRAFT GUN AND MOUNT, MODEL 1917  
MAXIMUM ELEVATION 85°  
M.V. 2600 F.S.

3-INCH ANTI-AIRCRAFT GUN, MODEL 1917, SEA COAST TYPE, MOUNTED ON 4-WHEEL TRUCK—IN FIRING POSITION, WITH JACKS AND TRIGGER SET. (See p. 48.)



4.7-INCH ANTI-AIRCRAFT GUN, MODEL 1918.

Note horizontal spring cylinder and chain with cams for balancing weight of gun and recoil mechanism in trunnions. (See p. 51.)



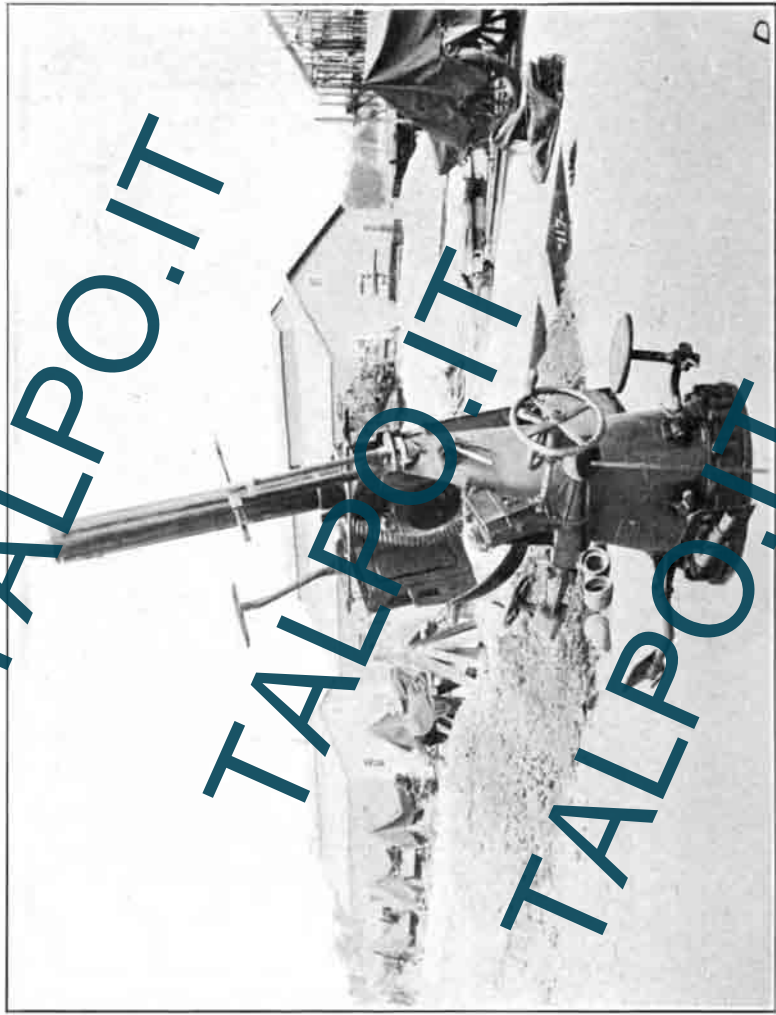
4.7-INCH ANTI-AIRCRAFT GUN, MODEL 1918, MOUNTED ON CATERPILLAR TRAILER, IN SHOP AT NEW BRITAIN, CONN.

Photo shows jacks and outriggers. (p. 46.)

PLATE XXII



75-MM. ANTI-AIRCRAFT AUTO CANNON, MADE IN FRANCE.



40-MM. VICKERS 2-POUNDER ANTI-AIRCRAFT GUN FORWARDED FROM ENGLAND TO BE TESTED AT ABERDEEN PROVING GROUND.

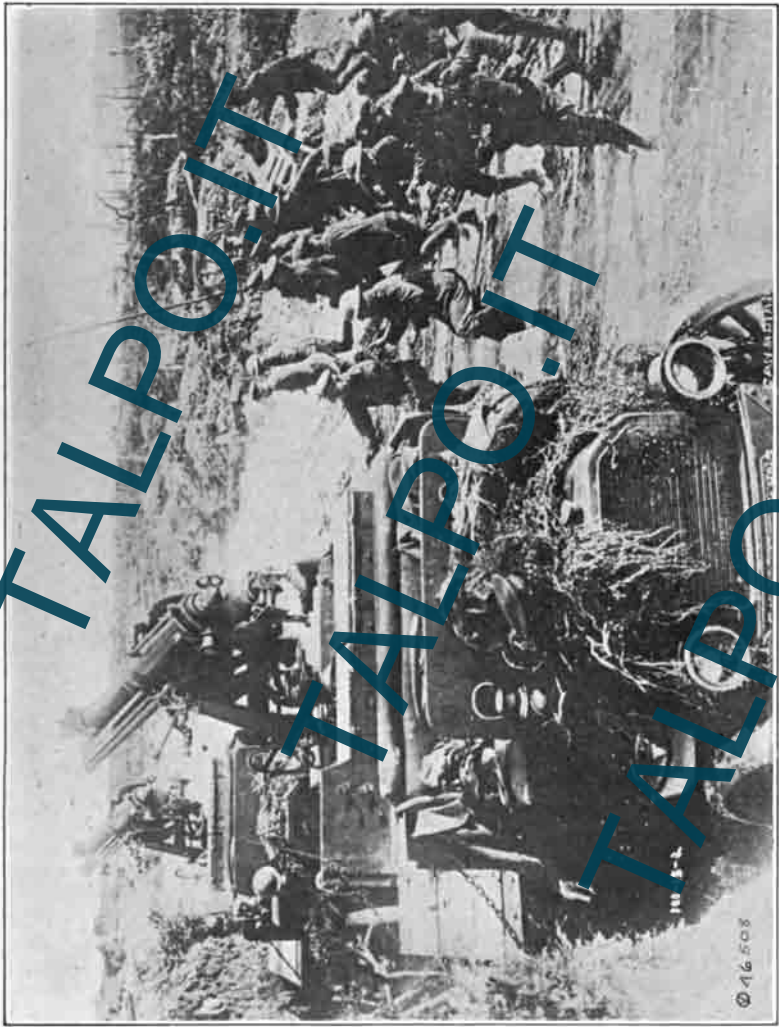


40-MM. VICKERS 2-POUNDER ANTI-AIRCRAFT GUN MOUNTED ON TRAILER. SIDE VIEW.  
Gun sent from England and tested at Aberdeen Proving Ground.

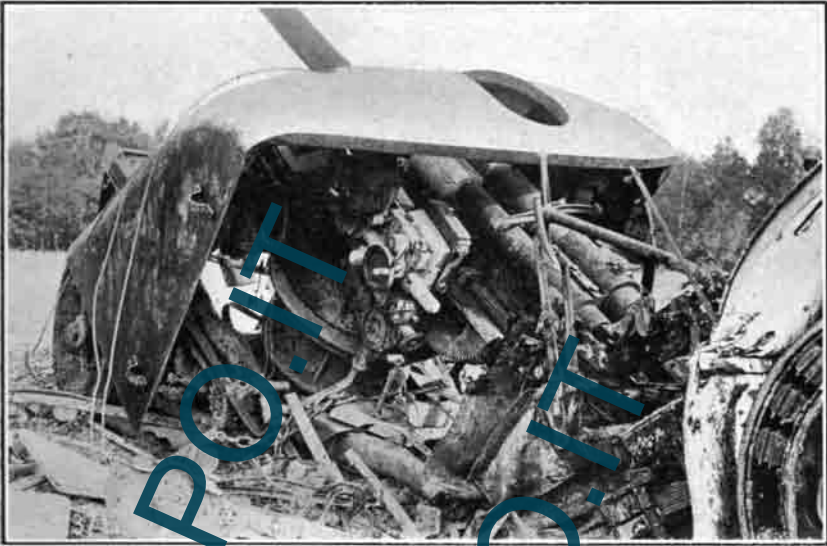


40-MM. VICKERS ANTI-AIRCRAFT GUN MOUNTED ON TRAILER. REAR VIEW.  
Gun sent from England to be tested at Aberdeen Proving Ground.





CANADIAN ANTI-AIRCRAFT GUN MOUNTED ON AUTO TRUCK IN ACTION. 13-Pounder (9 CWT.)



GERMAN TRUCK USED FOR TRANSPORTING SEMIFIXED 88-MM. GUN FOR ANTI-AIRCRAFT SERVICE.



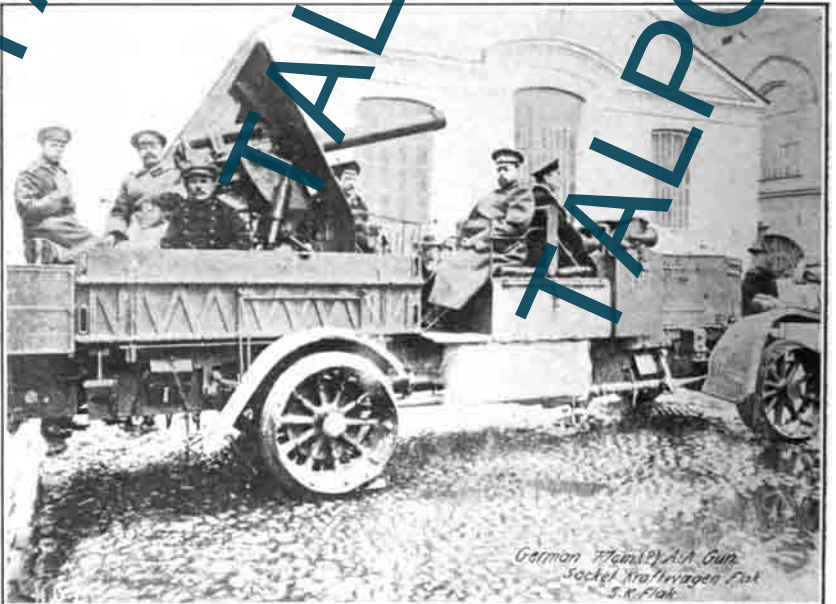
GERMAN SEMIFIXED MOUNT FOR 88-MM. GUN FOR ANTI-AIRCRAFT SERVICE.

Note ammunition and transportation drums for same at side of photo.

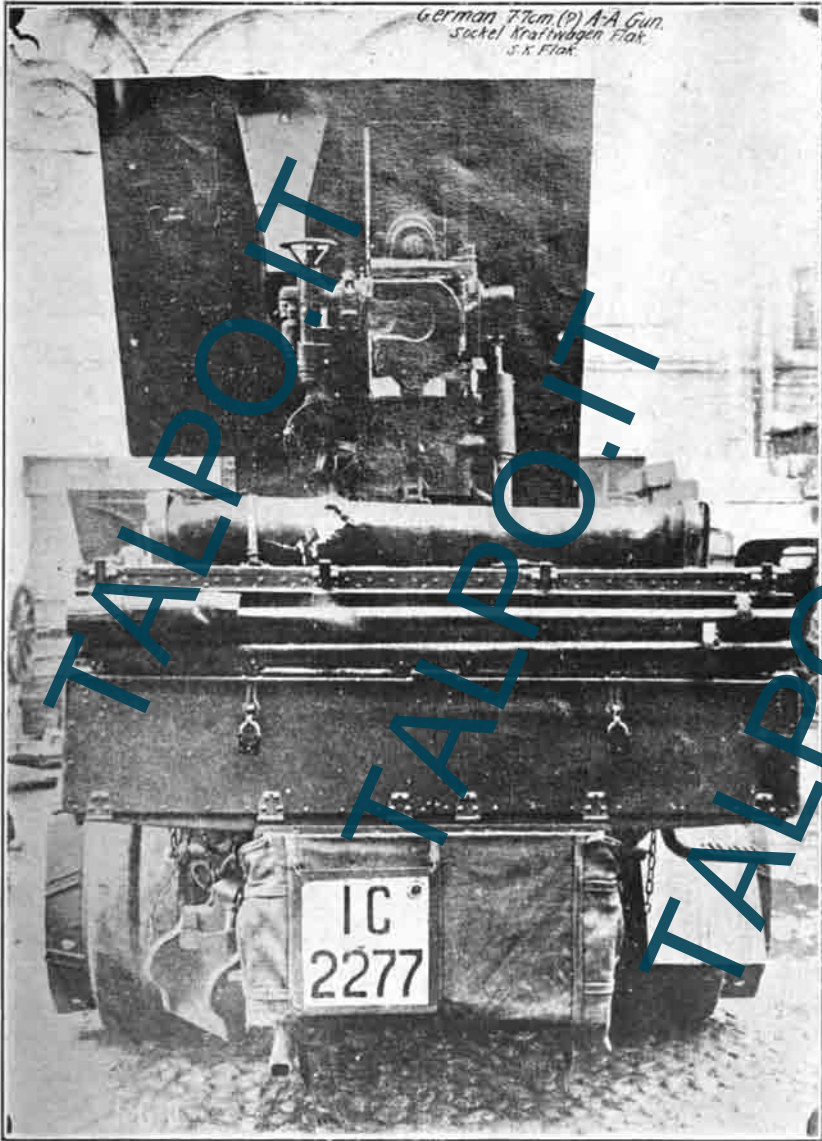


GERMAN SEMIFIXED MOUNT FOR 88-MM. GUN FOR ANTI-AIRCRAFT SERVICE.  
Note radial bracing from central pedestal mount.

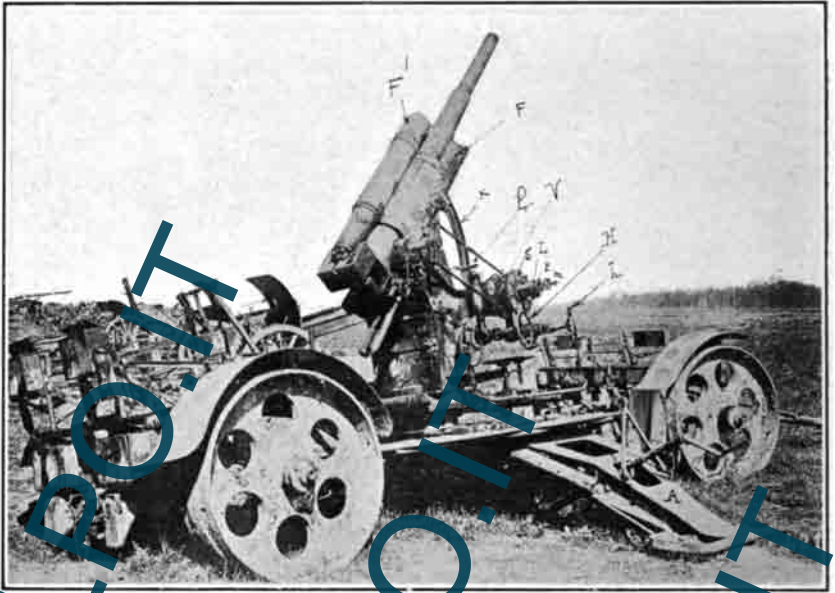
LATE XXVI



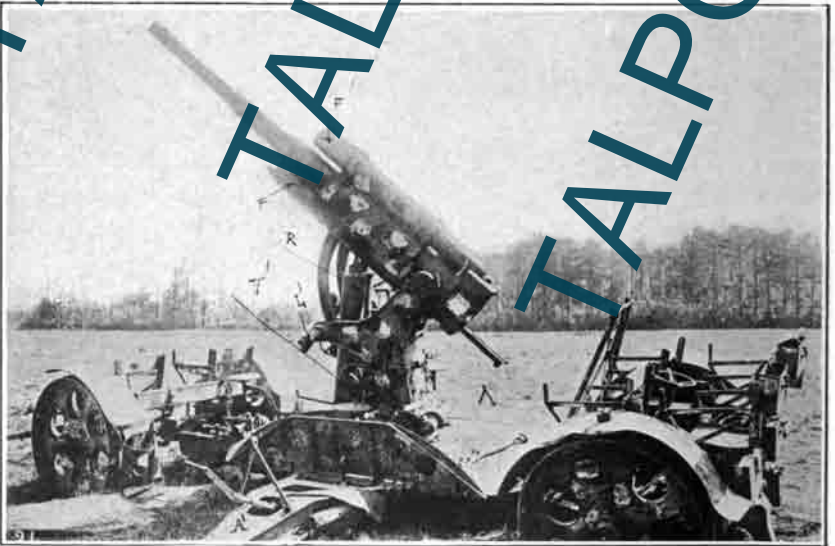
GERMAN AUTOMOBILE MOUNT, 77-MM. GUN, FOR ANTI-AIRCRAFT SERVICE.



GERMAN AUTOMOBILE MOUNT, 77-MM. GUN, FOR ANTI-AIRCRAFT SERVICE.



GERMAN TRAILER MOUNT, 88 MM. GUN, FOR ANTI-AIRCRAFT SERVICE.



GERMAN TRAILER MOUNT, 88-MM. GUN, FOR ANTI-AIRCRAFT SERVICE.



GERMAN 88 M.M. ANTIAIRCRAFT GUNS MOUNTED ON TRAILERS.

Captured near Conflans and Ville Au Montois and sent to Mehus with recommendations that they be forwarded to Aberdeen Proving Ground. These guns not fired by A. E. F., but give indications of excellent design and stability.

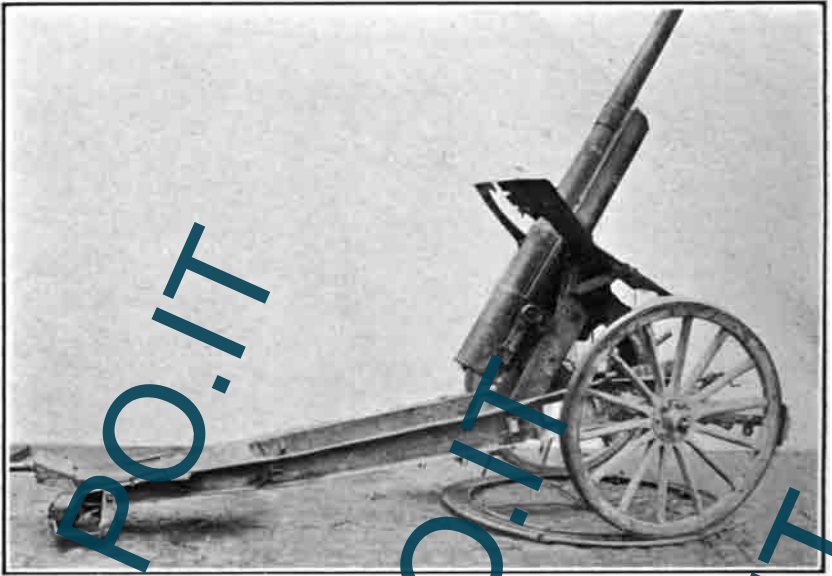


CAPTURED GERMAN 88-MM. ANTI-AIRCRAFT GUN MOUNTED ON TRAILER.  
Wheels have steel tires. When set for firing, weight of truck is supported on jacks, and steel outriggers are set at the sides of truck.

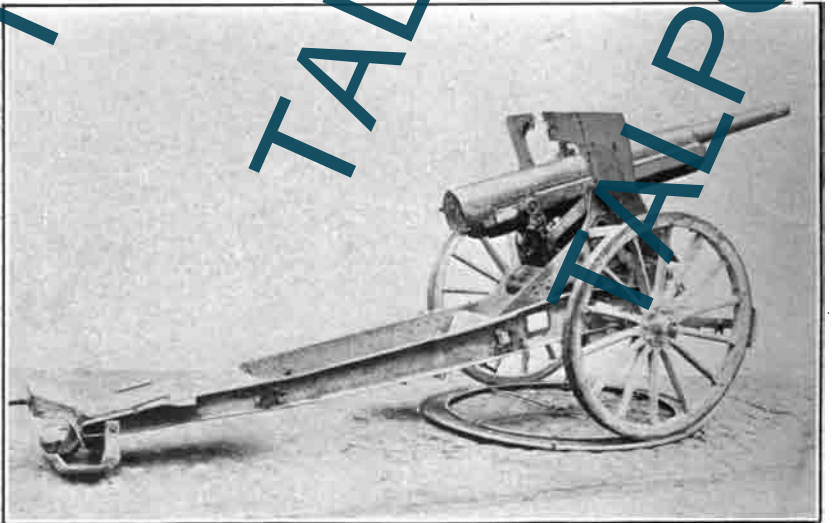


REAR VIEW OF CAPTURED GERMAN 88-MM. ANTIAIRCRAFT GUN MOUNTED ON TRAILER.





GERMAN TRANSFORMED 75-MM. FIELD GUN, FRENCH MODEL 1897, REBORN  
TO 77 MM., USED FOR ANTI-AIRCRAFT SERVICE.

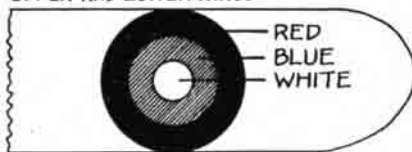


GERMAN TRANSFORMED 75-MM. FIELD GUN, FRENCH MODEL 1897, REBORN  
TO 77 MM., USED FOR ANTI-AIRCRAFT SERVICE.

DIAGRAM TO SHOW DISTINCTIVE MARKINGS OF AIRPLANES  
AS USED IN PRESENT WAR, 1918

U.S.

UPPER AND LOWER WINGS



BRITISH

LOWER WINGS



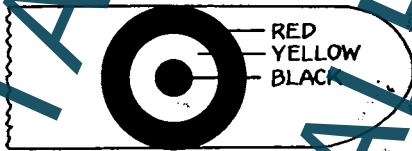
FRENCH

LOWER WINGS



BELGIAN

LOWER WINGS



ITALIAN

LOWER WINGS



GERMAN

LOWER WINGS

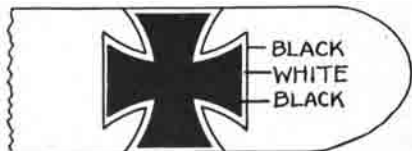
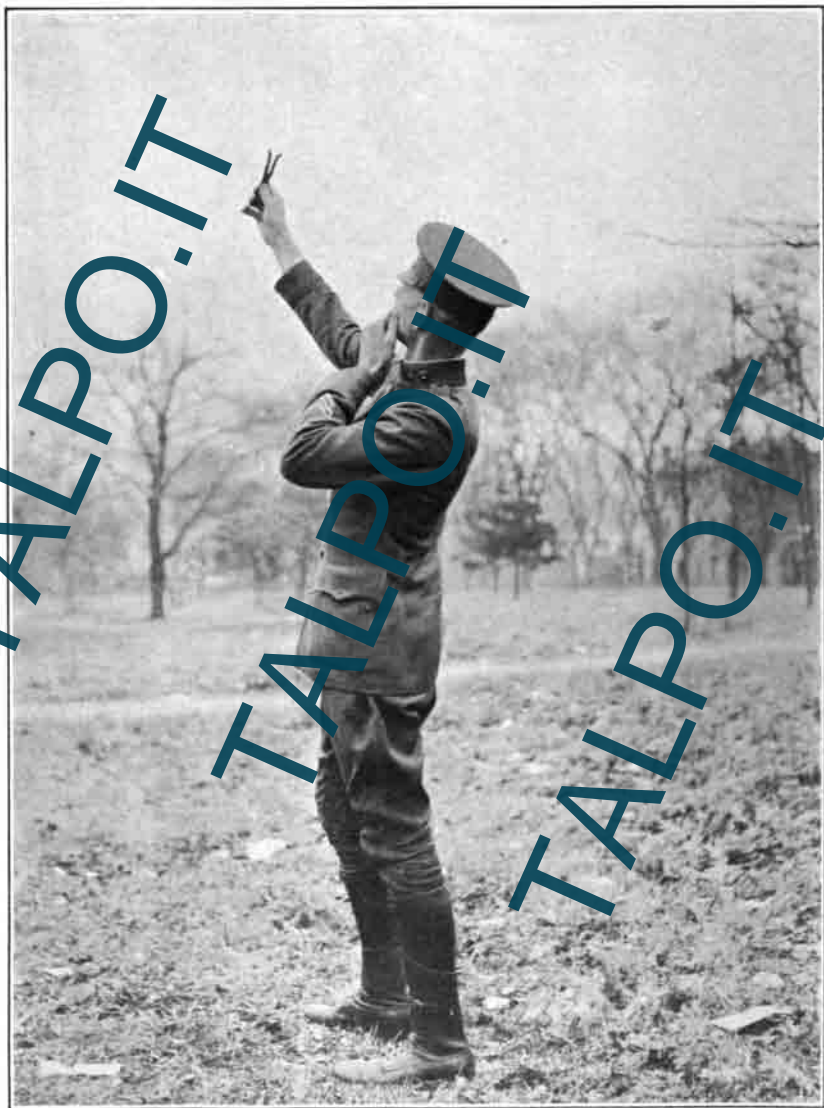


PLATE LII



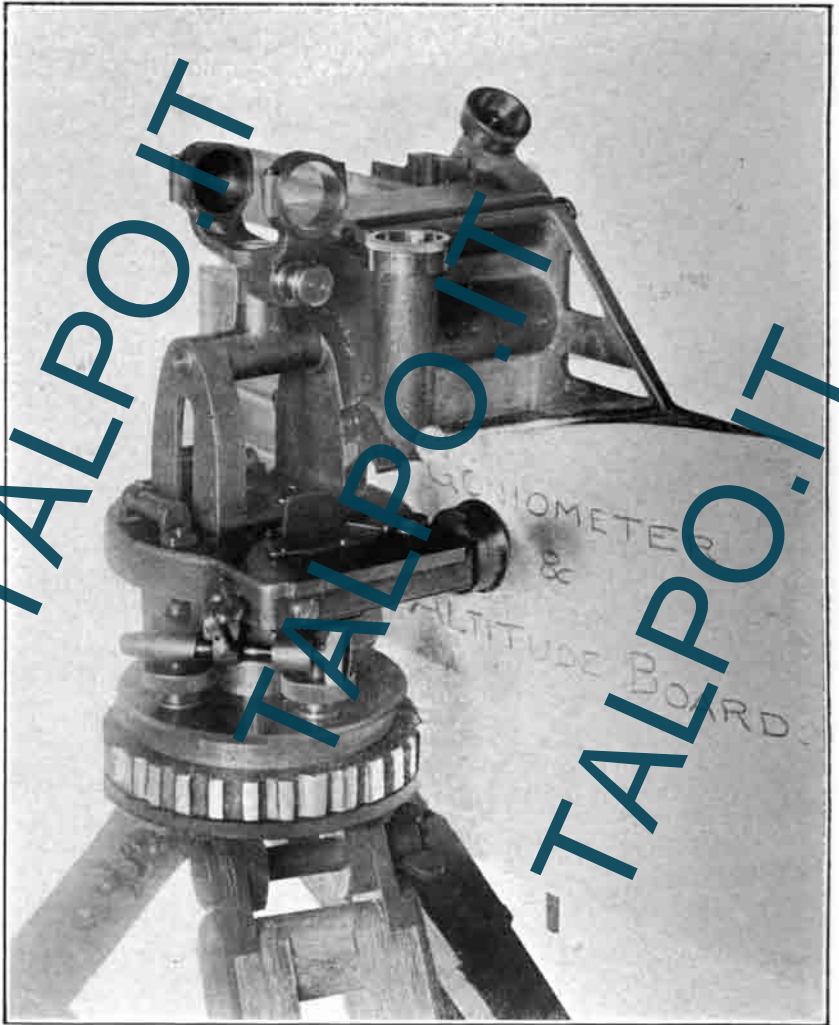
THE STADIA, PEYCRU, COMPLETE AND SEPARATE VIEW ILLUSTRATING APPEARANCE OF AIRCRAFT AS VIEWED THROUGH STADIA



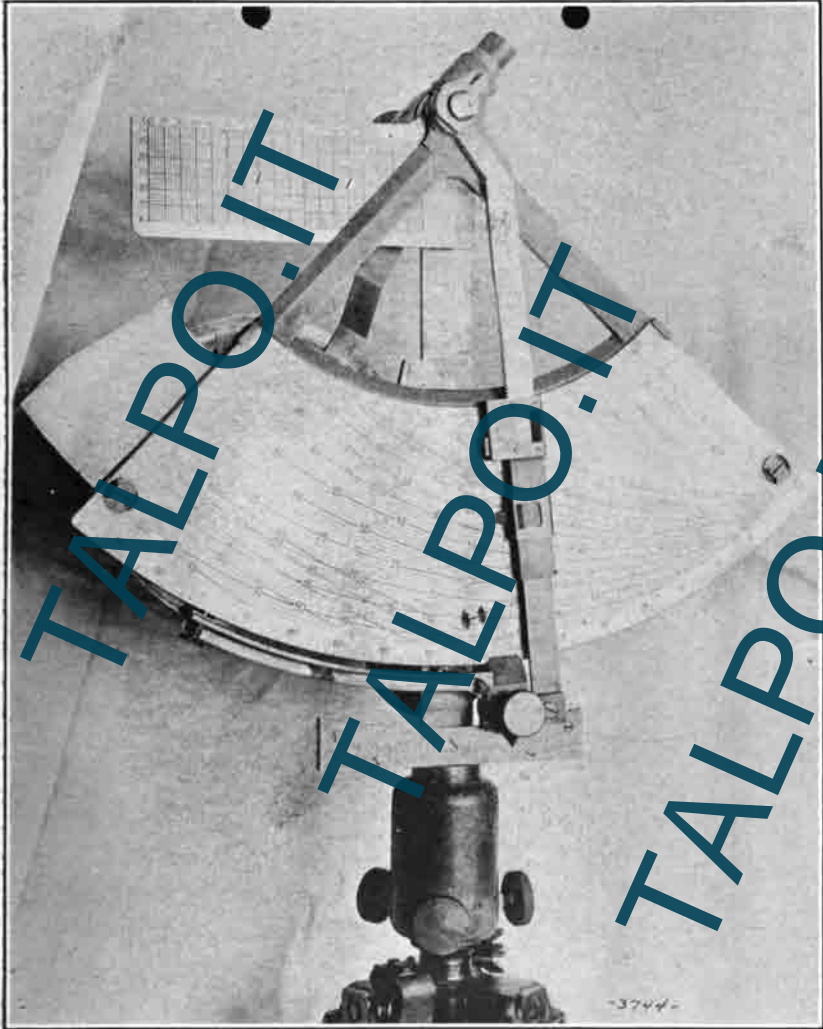
OFFICER APPROXIMATING DISTANCE OF AIRPLANE BY MEANS OF THE STADIA.



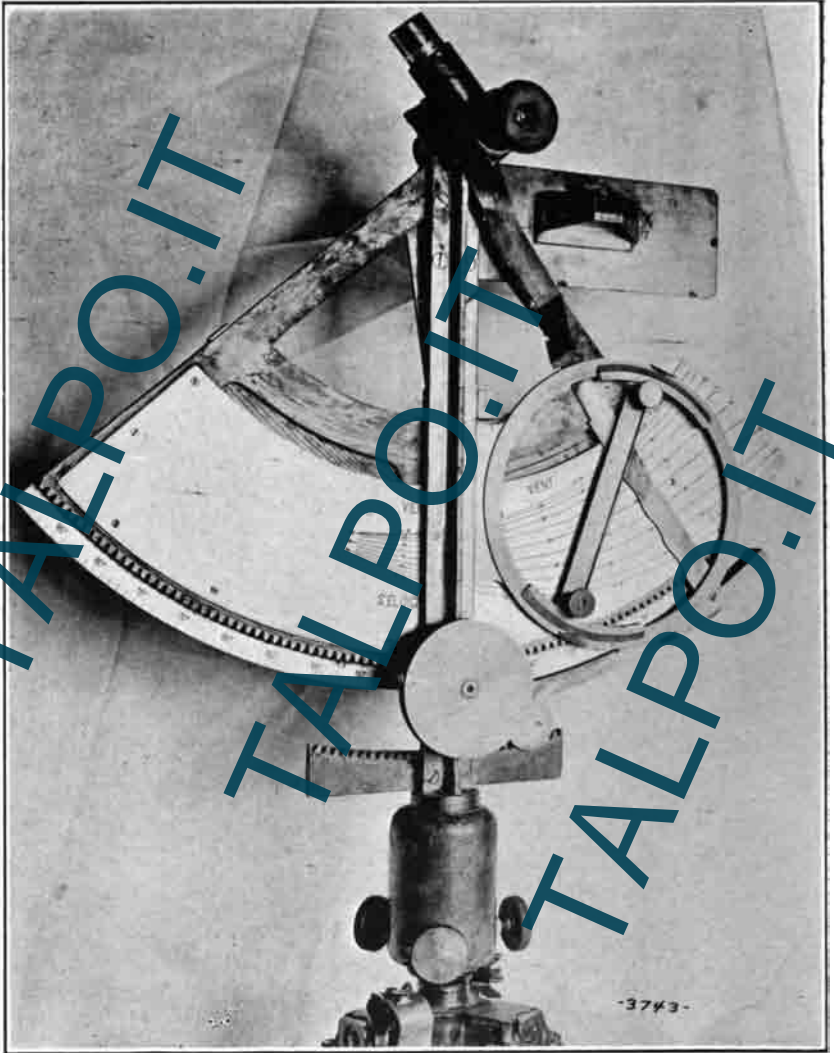
ALTITUDE BOARD, MODEL OF 1917, OF GONIOMETER.



GONIOMETER AND ALTITUDE BOARD.



ALTITUDE TELEMETER, FRENCH TYPE. FRONT VIEW.



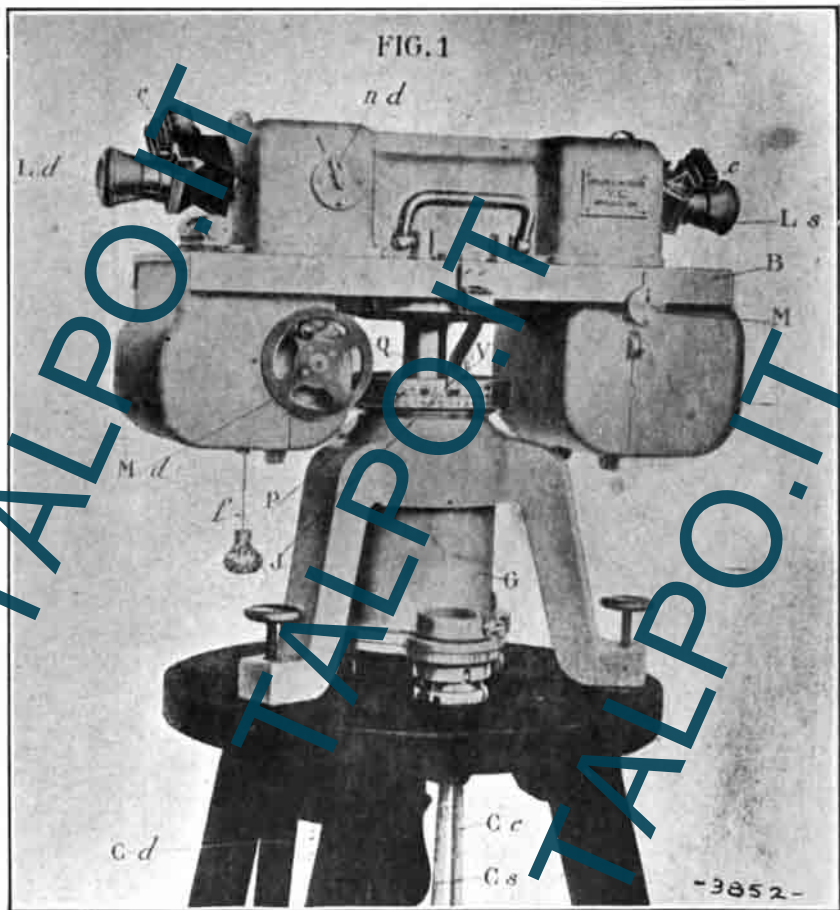
ALTITUDE TELEMETER, FRENCH TYPE. REAR VIEW.



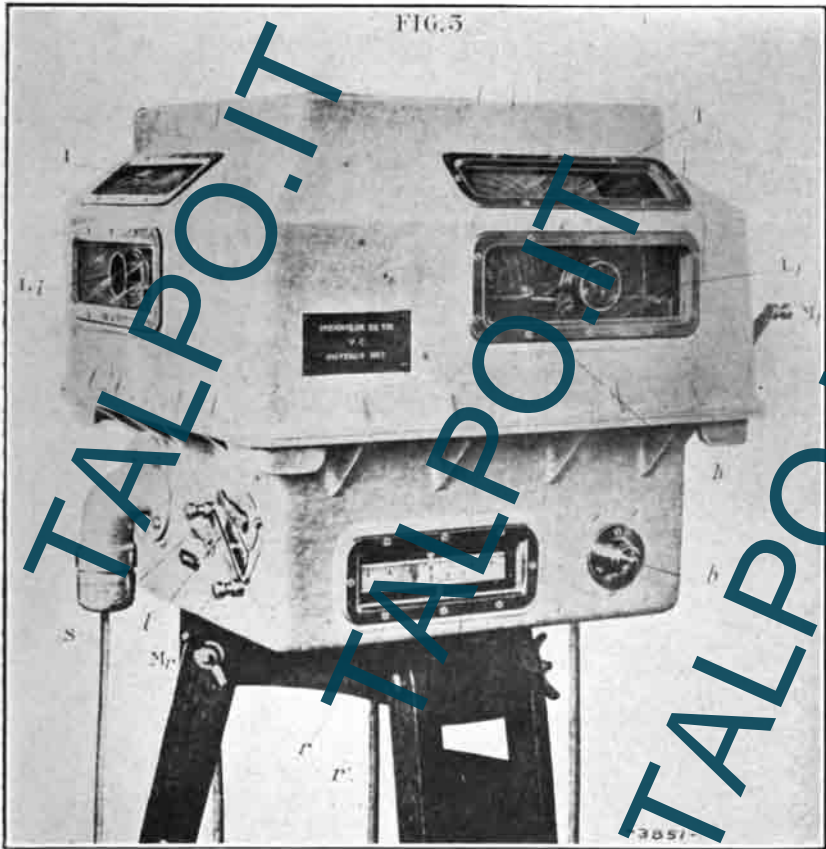


STARTING WITH THE TACHYSCOPE.

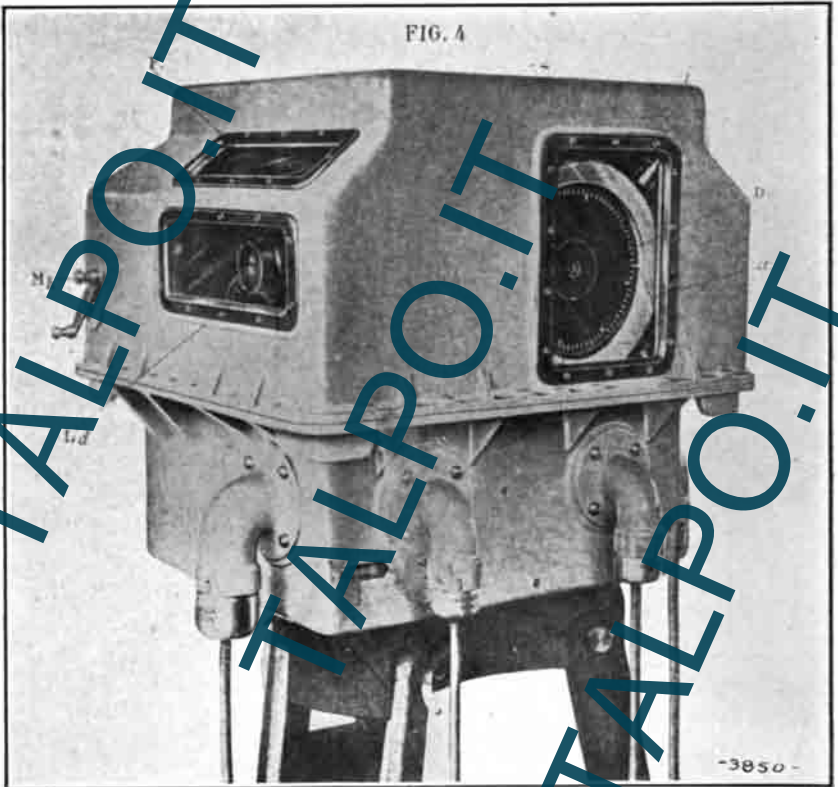
This instrument registers speed of target and direction in which it is bound.



CORRECTOR V. C. OBSERVER'S STATION INSTRUMENT.



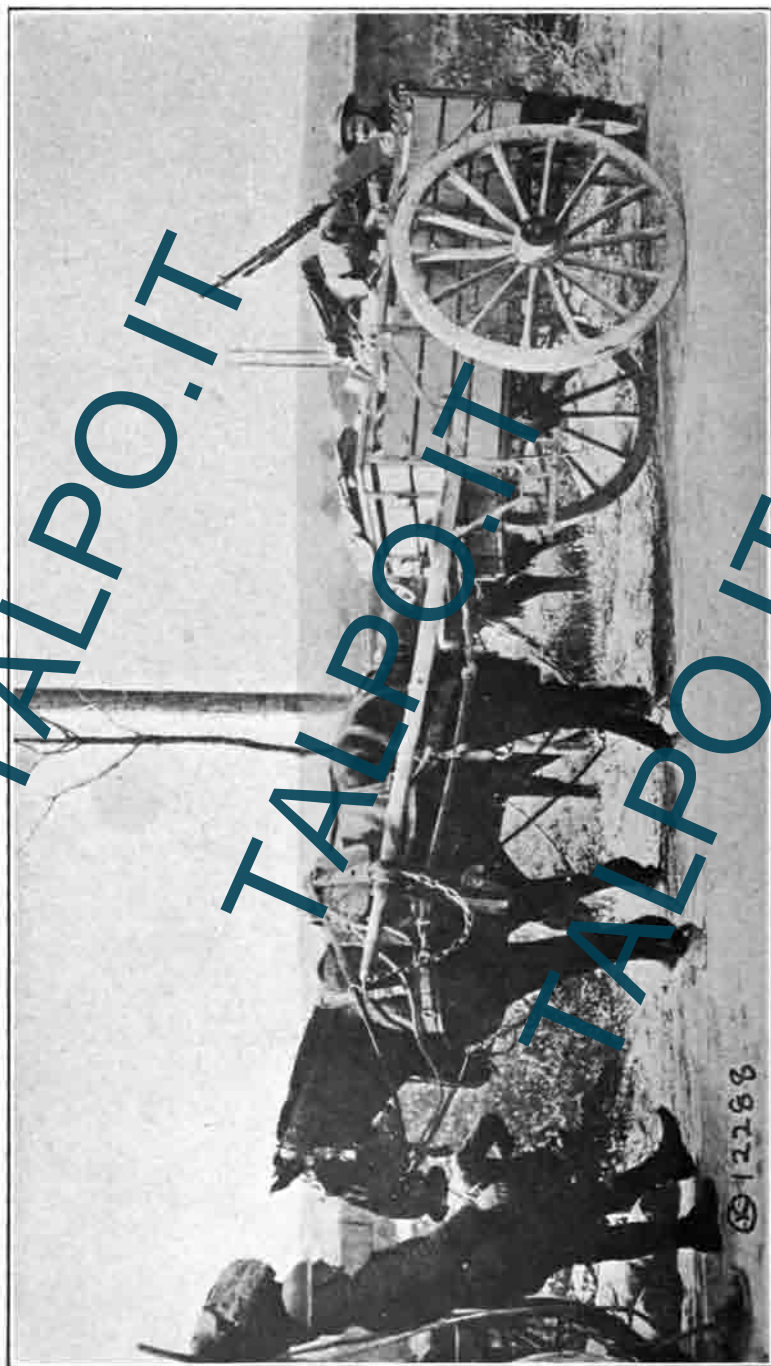
CORRECTOR V. C. CENTRAL STATION INSTRUMENT.



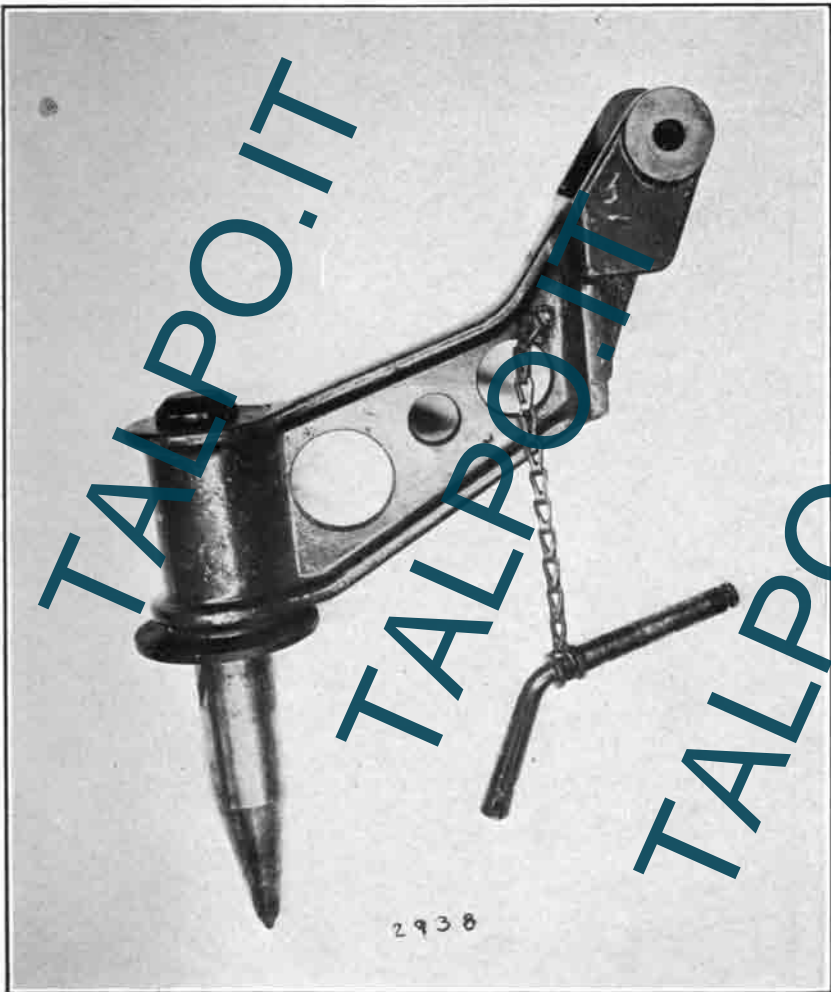
CORRECTOR V. C. CENTRAL STATION INSTRUMENT.



HOTCHKISS MACHINE GUN WITH SERVICE SIGHT, MOUNTED ON RIM OF WAGON WHEEL WITH VERTICAL AXIS. COMBINATION USED AS TEMPORARY EXPEDIENT FOR ANTI-AIRCRAFT WORK, BATTERY E, 6TH FIELD ARTILLERY, MENIL-LA-TOUR, FRANCE, FEBRUARY 17, 1918.

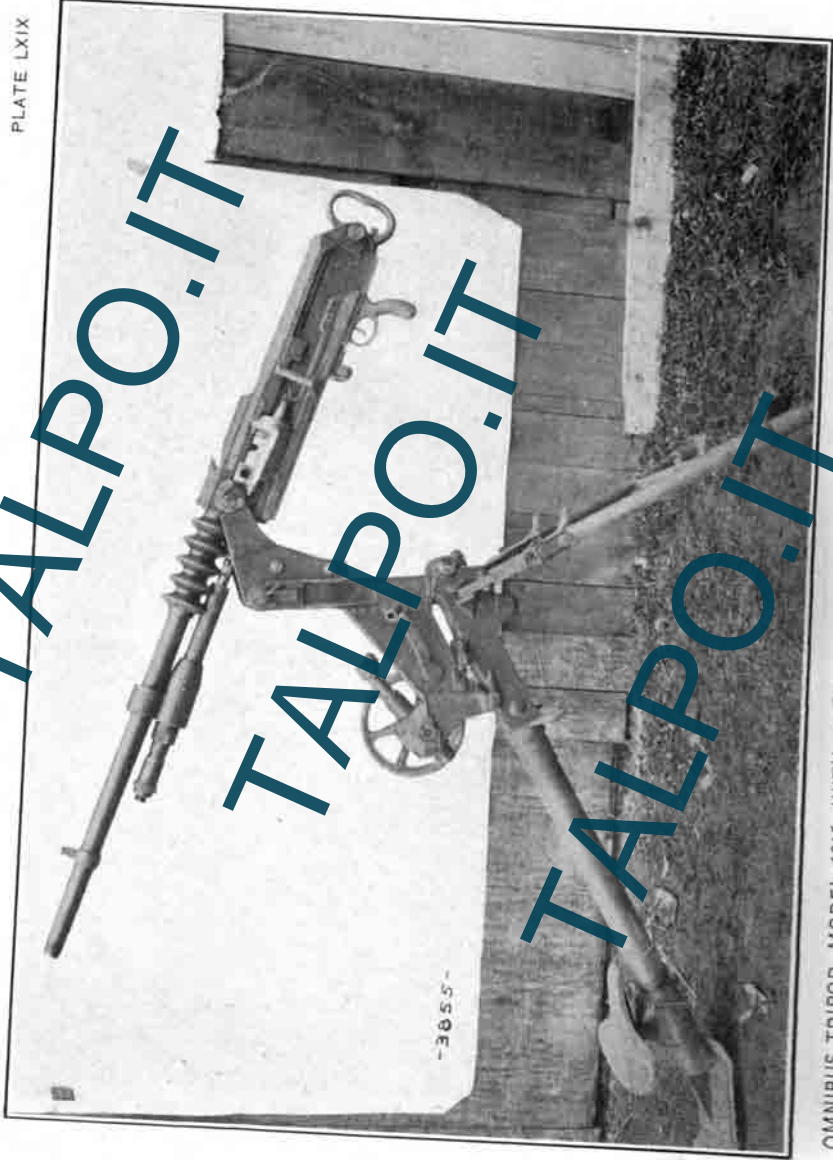


HOTCHKISS MACHINE GUN MOUNTED ON REAR OF HORSE CART, FOR ANTI-AIRCRAFT SERVICE, CHENEVIERES, FRANCE, APRIL 26, 1918, 1ST BATTALION, 149TH REGIMENT, FIELD ARTILLERY.



ANTI-AIRCRAFT IMPROVISED POST MOUNT, ASSEMBLED.

PLATE LXIX

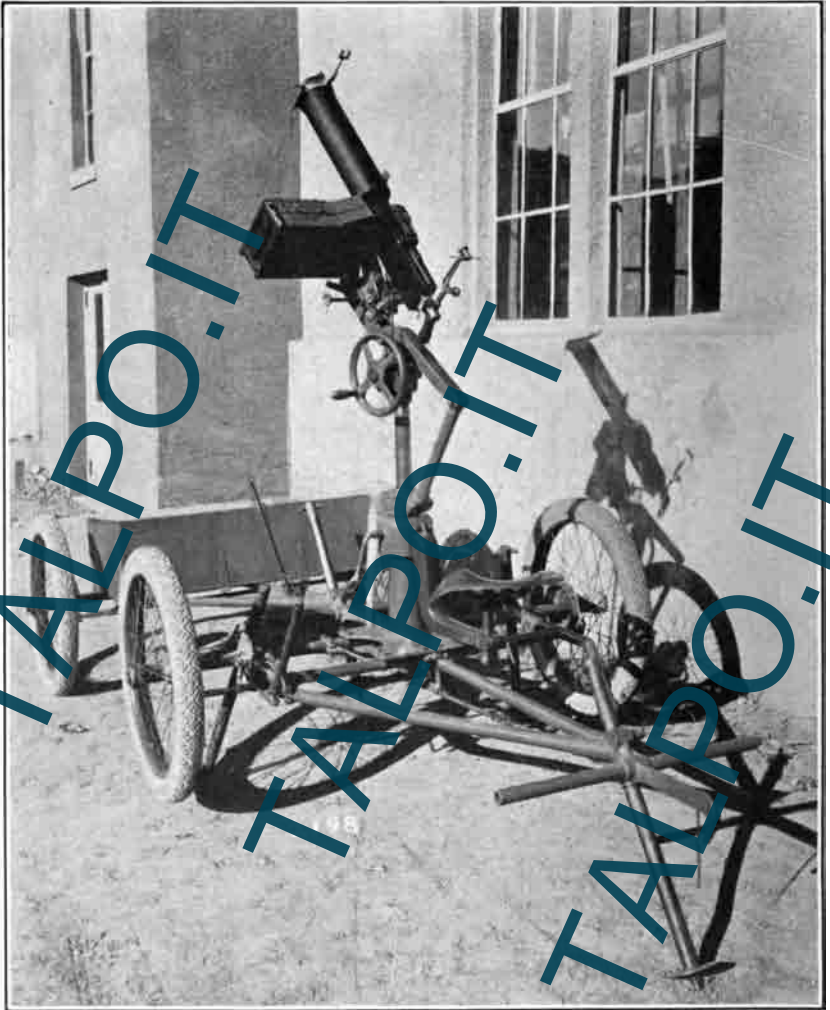


OMNIBUS TRIPOD, MODEL 1915, WITH ANTI-AIRCRAFT ADAPTER (FOREIGN DESIGN AND MANUFACTURE)  
AND HOTCHKISS MACHINE GUN.





HOTCHKISS MACHINE GUN, TRIP FOLD, MOUNTED IN TRENCHES, FOR ANTI-AIRCRAFT WORK. SERVICE TRIPOD WITH ADAPTED SOLDER TO TRIPOD HEAD TO PERMIT HIGH ELEVATION. OPERATED BY SOLDIER LYING ON GROUND UNDER TRIPOD, WITH ANOTHER SOLDIER ATTENDING TO THE CARTRIDGE STRIPS. (SERVED BY COMPANY C, 129TH MACHINE GUN BATTALION, FORMERLY 2D BATTALION, 2D REGIMENT, INFANTRY, MISSOURI NATIONAL GUARD, CAMP JORDAN, NEAR AMPHERSBACH, ALSACE, AUGUST 30, 1918.)



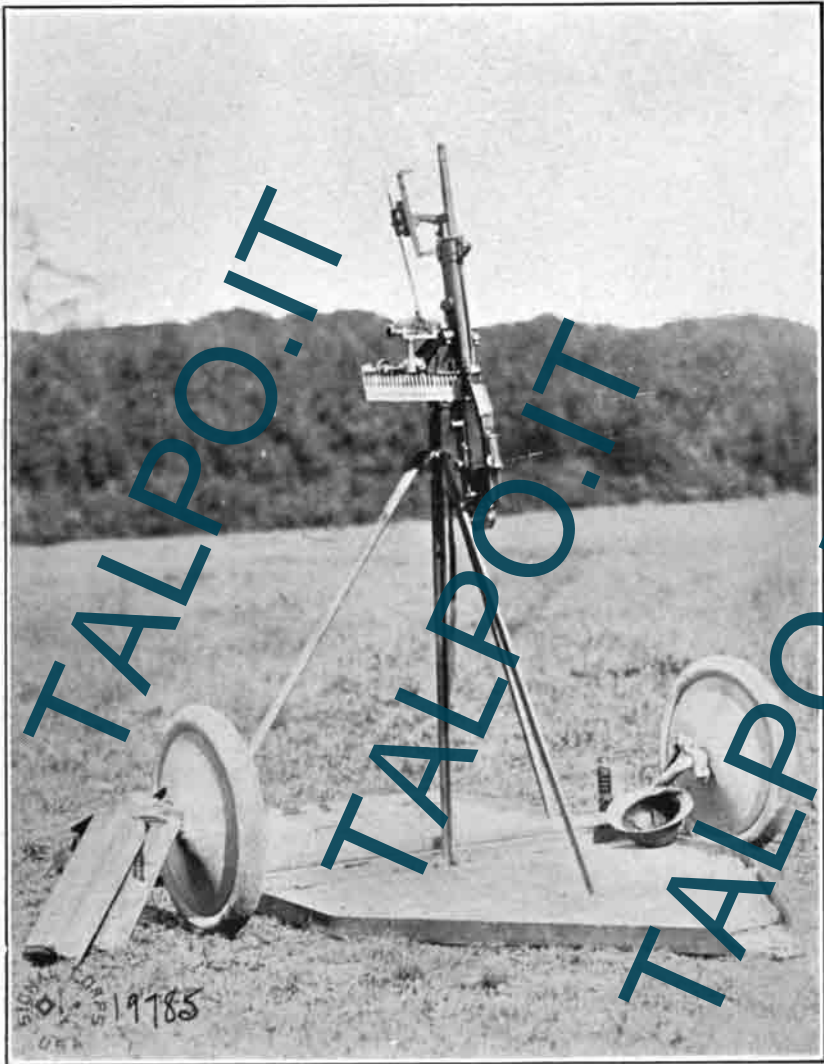
ANTI-AIRCRAFT MACHINE GUN MOUNT, CYGNET TYPE (THIS MOUNT HAS BEEN IMPROVED) ON TRAILER WITH AMMUNITION TRAILER, SHOWN WITH BROWNING MACHINE GUN WATER-COOLED, MODEL 1917, WITH P. B. AIM CORRECTOR SIGHT (NOW DISCARDED IN FAVOR OF PEYCRU SIGHT), EXPENDABLE AMMUNITION BOX, MARK I, AND CARTRIDGE-BELT GUIDE ON BOX.



ANTI-AIRCRAFT MACHINE GUN TRAILER, MODEL 1918, SECHLER TYPE, WITH ANTI-AIRCRAFT MOUNT, CYGNET TYPE, AND ANTI-AIRCRAFT MACHINE GUN TRIPOD, MODEL 1918, WITH FRENCH ADAPTER AND WITH MACHINE GUN CHEST AND SPARE PARTS CHEST.


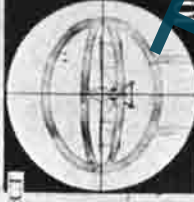
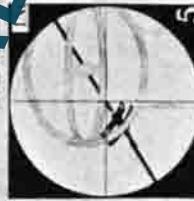
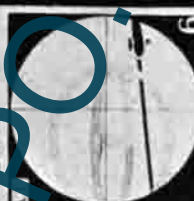







THE ANTI-AIRCRAFT MACHINE GUN TRIPOD, MODEL OF 1918, SECHLER TYPE. Body view. Showing also mounted thereon anti-aircraft machine gun tripod, model of 1918 (this mount has been improved), with Marlin tank machine gun, trench light, shoulder stock, Browning ammunition box, cartridge-belt guide on same, and anti-aircraft mount, Cygnus type, with Browning machine gun, model of 1917, and P.B. arm corrector sight (now discarded in favor of Peyrou sight), expendable ammunition box, Mark I, with cartridge-belt guide. View shows gun chests and spare parts chest.



FRENCH MACHINE GUN IN ALSACE SECTOR, WITH FRENCH, JULY 30, 1918.  
HOTCHKISS TYPE GUN, STRIP FED, WITH AIRCRAFT SIGHT USED FOR ANTI-  
AIRCRAFT WORK.

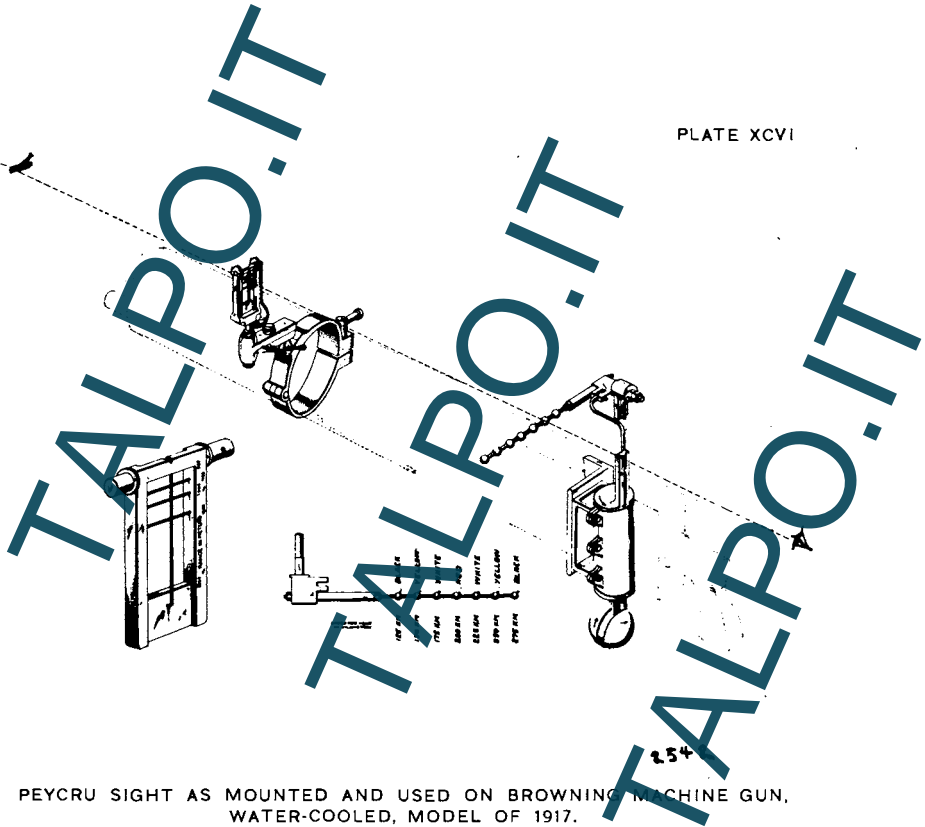
Gun mounted on folding tripod, set on platform trailer with offset axle, which has been inverted and used as platform for firing.

<p><b>A. A. SIGHTS</b> CORRECT</p>  <p>9</p> <p>THE OUTER RING OF THE LINE OF FLIGHT CHIPS THE APERTURE. THE HEAD IS ON THE CENTER OF THE APERTURE. THE INNER RING OF THE LINE OF SIGHT IS ON THE CENTER OF THE APERTURE.</p>	 <p>10</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	<p><b>A. A. SIGHTS</b> CORRECT</p>  <p>5</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	 <p>6</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	<p><b>A. A. SIGHTS</b> CORRECT</p>  <p>2</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	 <p>3</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	 <p>11</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	 <p>7</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>	 <p>4</p> <p>THE OUTER RING OF THE LINE OF FLIGHT IS ON THE LINE OF FLIGHT AND THE INNER RING OF THE LINE OF SIGHT IS ON THE LINE OF SIGHT. THE HEAD IS ON THE CENTER OF THE APERTURE.</p>
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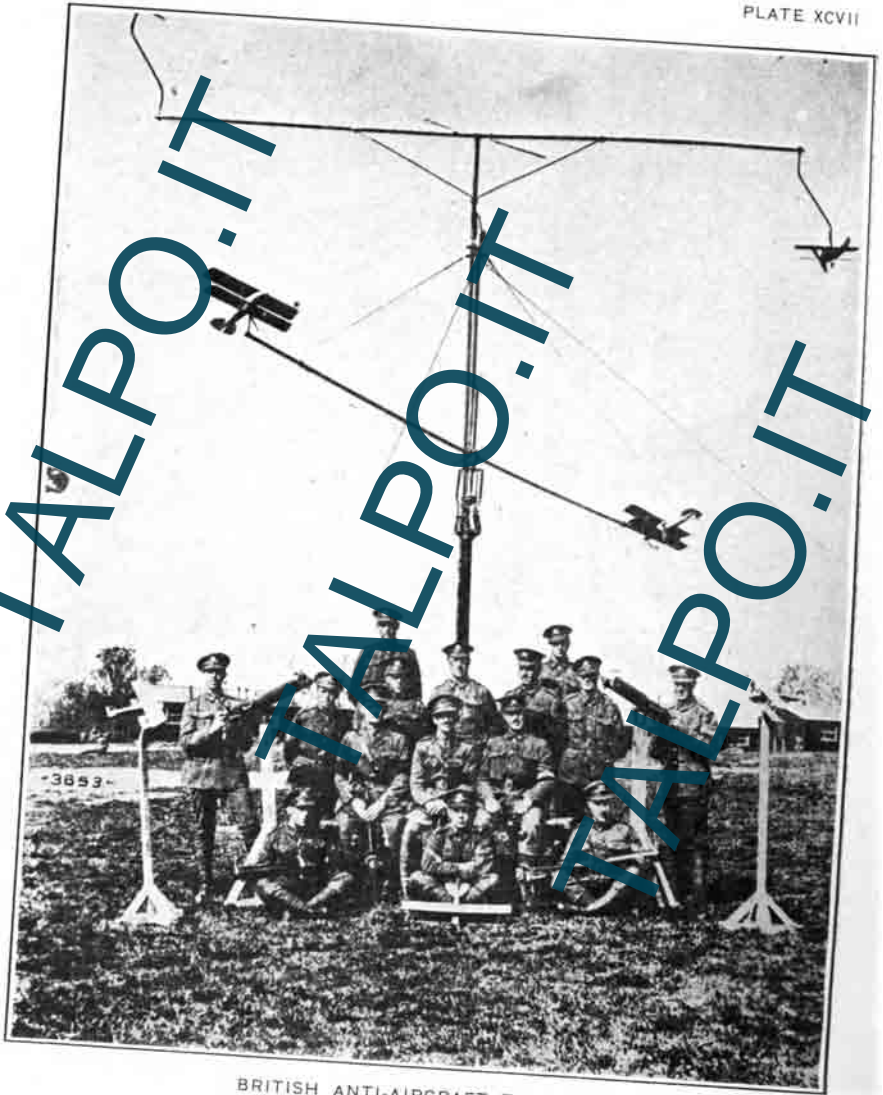
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DIAGRAM SHOWING CORRECT AND INCORRECT SIGHTING BY MEANS OF TRENCH SIGHT OR FORWARD AREA SIGHT FOR MACHINE GUNS.

PLATE XCVI



PEYCRU SIGHT AS MOUNTED AND USED ON BROWNING MACHINE GUN, WATER-COOLED, MODEL OF 1917.



BRITISH ANTI-AIRCRAFT TARGET.