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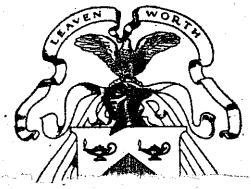

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Office of The Adjutant General.

WAR DEPARTMENT,
WASHINGTON, *July 18, 1917.*

The following Field Artillery Notes No. 6 are published for the information of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

TASKER H. BLISS,
Major General, Acting Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

WAR DEPARTMENT,
THE ADJUTANT GENERAL'S OFFICE,
Washington, June 19, 1917.

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By order of the Secretary of War:

H. P. MCCAIN,
The Adjutant General.

ARTILLERY INFORMATION SERVICE.

1. The organization of the important service of artillery information in the French service is of comparatively recent date. It is officially known as the *Service des Renseignements de l'Artillerie,* and is referred to in orders and circulars as "*S. R. A.*"

2. *The object* of the service is to furnish accurate information as rapidly as possible covering the following:

(*a*) Hostile batteries, including their emplacements, the degree of activity, and the number of pieces.

(*b*) Other hostile dispositions, including defensive and offensive works, observation stations, telephone lines, railways, paths, bivouacs, depots of ammunition, and other matériel, etc.

3. *The facilities given the service* include the following:

(*a*) Artillery observation stations, posts of commanding officers, etc.

(*b*) Special observation stations pertaining directly to the service itself. These are referred to as pertaining to the *Service des Renseignements Terrestres.* ("S. R. T.").

(*c*) Sections for the identification of targets by sound, referred to as *Sections de Repérage au Son.* ("*S. R. S.*").

(*d*) The information obtained by aerial observation and aerial photography.

(*e*) Information received from neighboring army corps and from the second bureau of the general staff.

(*f*) All information received from artillery and infantry troops concerning hostile batteries or dispositions. This information ordinarily is given by means of a daily bulletin or by telephone.

4. *The distribution of information* is provided for by the issuing of bulletins distributed to all commanders, including battery commanders. These bulletins are issued as often as once a day during periods of active operations and less frequently at other times. In urgent cases the information is transmitted to commanding officers concerned by telephone, but

in such cases every precaution should be taken in order that useful information is not communicated to the enemy. As a general principle important telephone messages are avoided or are sent in cipher.

5. *Organization.*—The service of artillery information is a function of the Army Corps. It is supervised by the general or colonel performing the duties of chief of artillery. The following personnel pertain to his staff and are charged with the details of the service:

One captain, in charge.
One lieutenant, assistant.
One adjutant (warrant officer).
Two privates, draftsmen, and clerks.
One telephonist.
One motorcyclist.

In the corps headquarters visited all the work of this service was done in two very small rooms, one of which was used as an office and one as a drawing room. Economy, simplicity, and efficiency were noticeable in all arrangements.

Both the officers and men worked almost uninterruptedly from 8 a. m. to 11 p. m. daily. In no other way could they have produced the amount of valuable information which they prepared each day.

6. Referring to paragraph 3, the facilities given to this particular corps were as follows:

(*a*) All the artillery observation stations of the two divisions and one Russian brigade comprising the corps. These included not less than 20 stations scattered along a front of 23 kilometers.

(*b*) Three permanent stations of the service itself. (S. R. T.). The personnel for these stations is permanent and both officers and men become experts in observation and interpretation of reports. In addition to the ordinary optical equipment of an observation station, which included binocular "scissors" instruments and monocular observing telescopes, the stations were provided with very simple range boards for the horizontal base position-finding system, and a very complete set of carefully prepared panoramic sketches of their own and neighboring sectors. They were connected with the artillery telephone system, and also had a private system which connected the three main stations and the secondary stations depending upon them.

In each main station there was an instrument consisting of four small electric lights, each covered with ground glass set in a small frame. The ground-glass squares were numbered from 1 to 4. The lights were lighted by pressing a button in any one of the secondary stations. If a button in No. 1 secondary station was pressed, the light under "No. 1" in the main station was lighted.

The lighting of a light was a notification that the secondary station concerned had made an observation. The lighting of more than one light at the same instant indicated that probably two stations had seen the same thing. The observations were then sent in to the main station at once by telephone and the position of the objective located by the intersection of angles as in any horizontal base system. If the lights had not been lighted simultaneously there was naturally some doubt as to both or all three observers having seen the same thing. The use of the lights seemed to be an extremely simple and useful device.

(*c*) Secondary observation stations: Each main station had either three or four secondary stations depending upon it. Their equipment was much like that of the main stations except that instead of the lights their equipment consisted of the operating key, which lighted the light in the main station.

All observation stations were strongly constructed and well-camouflaged. They would have resisted anything except heavy calibers. The construction of observation stations will be treated in a separate report.

In addition to the observation stations of the corps itself, it could depend upon cooperation from the stations of neighboring corps.

(*d*) The corps visited was supplied with three stations for the identification of targets by sound. ("S. R. S.").

This is a newly developed service, which is constantly giving better and better results. The details of the system employed will be described in another report from the mission.

Until recently these stations could locate satisfactorily only the position of low-velocity guns because of the fact that there was a confusion of sound waves in the case of high-velocity guns; but at present results which identify the position of both guns and howitzers within 50 yards are frequently obtained.

In the case of a new hostile gun or battery being reported the officer in charge of the artillery-information service at once

makes a careful study of the aerial photograph of the locality. If he can not identify the gun or battery he has a new photograph made. During the visit to the corps referred to the location of a heavy German minenwerfer was discovered by the sound and the position definitely located in an aerial photograph. The locality had previously escaped the scrutiny of the officer in charge, but when his attention was drawn to it by the report from the sound station he found indications which became unmistakable in later photographs taken specially of the locality in question.

Although still in a stage of development, the use of sound in the location of targets is being used daily in the allied armies and is given serious consideration by all concerned.

(*e*) For aerial reconnaissance and photography one of the two aerial squadrons pertaining to the artillery of the corps was used. It consisted of 12 biplace caudrons. They were unarmored and were considered too slow for the work. The other squadron consisted of 12 triplace armored caudrons and was used principally for the ajustment of fire; but this line was not strictly drawn, and both squadrons adjusted fire and made reconnaissances.

Aerial photographs are constantly becoming more and more important and more and more satisfactory and clear. The information they contain is far more exact than the report of the observer himself, although often the report of the observer completes the photograph or vice versa.

But aerial photographs are of little value unless they are properly read and interpreted. The officers charged with this work at army headquarters and the artillery information officers at corps headquarters become very expert in it and can see things in the photographs which are completely hidden from the inexperienced person, no matter how good his eyesight may be.

The entire front of a corps (which amounted to 23 kilometers in the corps visited) is carefully photographed each month as a part of the reconnaissance routine of the aerial squadrons. This work is done over the whole depth of the front which contains any enemy works of importance and involves the taking of about 300 photographs. In addition to this regular work, the squadron is constantly charged with the taking of special photographs necessary to establish the location of suspected

batteries, to keep track of new emplacements being constructed, and to record the result of friendly artillery fire for demolition or for the preparation of the infantry attack.

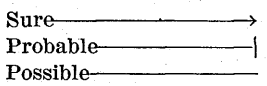
Such details of aerial photography as have been obtained will be made the subject of a separate report.

(*f*) In addition to the aeroplane reconnaissance there was one balloon engaged in constant observation of the front and in the recording of all enemy activity. The results of this information came regularly to the officer in charge of artillery information at corps headquarters. He stated that during active operations seven balloons would be engaged on this work for a corps front.

6. *Filing of information.*—Information obtained from the foregoing sources was filed either on maps, in tables, or in individual files covering hostile emplacements and positions.

(*a*) Maps: The basis of the map information was the 1/10,000 map kept constantly up to date by the officer in charge himself. It might be called the "current-information map." This map is kept for a period of 15 days. At the conclusion of this period the information collected is recorded and distributed and a new current-information map is begun. The basis of each new map is, of course, the information obtained from the preceding map.

The current map showed batteries of 77 mm. as small green circles, batteries of 105 mm. and medium calibers as small blue circles, and heavy batteries as small red circles. In each circle was stuck a large pin; and a small green, blue, or red streamer was added to each pin each time the battery in question was reported as active. As a result of this practice, at the end of the 15-day period, or at any intermediate time, it was very easy to see the relative activity of the hostile batteries without having the map littered up with lettering. A line was drawn from each battery position to the targets usually fired on by the battery concerned. Depending upon the reliability of this information the lines terminated as follows:



At the end of the 15-day period the current map is filed. The pins are removed and a small legend is placed near each bat-

tery position showing the number of times it has been active as indicated by the number of small streamers found on the pin.

The information thus obtained is made up in the form of a map with a 1/50,000 scale and furnished to army headquarters. Based on this map, army headquarters issues what is called the *Canevas de Tir* each month.

At corps headquarters the information is also marked on the 1/20,000 firing maps or *Plan Director de Tir*. These are furnished to batteries.

No lithographed or printed maps are actually made at corps headquarters. All such work is done at army headquarters.

Special maps at scales of either 1/10,000 or 1/5,000 are prepared at corps headquarters by mimeograph for use in special operations.

In addition to the foregoing the artillery information service prepares shaded outlines on tracing paper indicating the areas hidden from observation stations and protected from fire from batteries. By having one sheet of tracing paper for each station and each battery, when information is required as to what battery can fire on any given target, the appropriate sheet of tracing paper is placed on the map and the capabilities and limitations of the battery in question are evident at once. This obviates the necessity of marking a map too much or of having too many maps.

(*b*) Tables: Tabular information consists of corps artillery bulletins prepared at corps headquarters in mimeograph usually every five days. In active periods this bulletin is issued daily. They are furnished to all higher commanders, to group commanders of light artillery, and to battery commanders of heavy artillery. About 60 copies are required. These bulletins include information concerning the activity of hostile batteries, their objectives, and all data about new emplacements or works.

In addition to the bulletins, each 10 days the chief of artillery of the corps prepares an artillery program including all the counterbattery and fire for destruction work which he wishes carried out. This is, of course, based on the needs of the corps as shown by the bulletins and maps.

(*c*) Individual information files: Each hostile emplacement or observation station was recorded by means of an individual file which consisted of a description of its exact location by map coordinates, its caliber, number of guns, etc., copies of the last

aerial photograph, with the interpretations thereof marked on a small section of a 1/20,000 map. On the back of the form was a record of each time the battery had been active and all fires for adjustment of destruction which had been directed at it by friendly batteries. Filed with the card was a copy of all other pertinent information. By the use of this record, the information officer at corps headquarters was in a position to give immediate information concerning any enemy emplacement. This information was often called for by the chief of artillery for the corps who wished it for his work in connection with the regular artillery program and for any special work which he had in mind. Copies of this file, without photographs, were furnished all batteries. Copies of files concerning batteries opposite or opposed to them were furnished to battery commanders with photographs. The form of the individual file can be seen by referring to figures 3 and 3a accompanying the report submitted under date of March 16, 1917, by O 6 on "Aerial Observation in Liaison with Artillery."

7. *Artillery information service in divisions.*—Although not regularly organized with special officers detailed for the work, divisional artillery commanders and group and battery commanders all have a service of information which cooperates with the corps service of artillery information. An officer at each divisional artillery headquarters and in each group of artillery is charged, in addition to his other duties, with the furnishing to the officer in charge of artillery information at corps headquarters with all artillery information received in the sector and with the interpretation and distribution of information received from the corps. Each time a hostile battery fires on a friendly battery the number and caliber of the projectiles is reported; and each observation from a battery or group observation station which would be of interest to the corps is also reported to corps headquarters through divisional artillery headquarters.

8. *Supervision of artillery preparation.*—One of the most important duties of the artillery information service is the supervision of artillery preparation. This falls to the officer at corps headquarters charged with artillery information. He follows the preparation with aerial photographs and reports and is able to furnish the chief of artillery or the commanding general with photographs of the zone subjected to the preparation taken within 30 minutes of the time delivered. Based on these the

commanding general is able to make an estimate of the progress of the preparation and thus intelligently determine upon the "jour J" and the "hour H" which play so important a part in the delivery of all modern attacks. (See report of O 6 on "Barrage and Accompanying Fire," dated Mar. 23, 1917).

9. By every possible means the requirements of mobile warfare have been anticipated; and every provision has been made for the continuance of this service when the Army moves. This conforms to a fundamental principle of all French organization.

INSPECTION AND CARE OF ARTILLERY MATÉRIEL.

1. During a recent visit to a battery of 75 mm. guns in position on the western front the following notes on the inspection and care of matériel were obtained:

2. *General care and condition.*—The condition of the guns and carriages was uniformly excellent. This applies not only to the battery with which the observer was stationed, but also to the nine other 75 mm. batteries and two 120 mm. gun batteries, four 155 mm. gun batteries, and two modern rapid-fire St. Chamond, 1916, 155 mm. howitzer batteries seen during the tour.

The elevating and traversing gears, the recoil guides, and the breech mechanism were cleaned and oiled daily. For this purpose 3 kilograms of lubricating oil were kept on hand with each piece and 10 kilograms in store in the battery wagon. In addition there was 1 kilogram of coal oil with each piece and 18 kilograms in the battery wagon.

The bore was cleaned and oiled after each firing. For this purpose water and ammonia were used. (See detailed instructions on this subject submitted as appendix to this report).

3. *Care of recoil mechanism.*—The quantity of oil in the cylinder is always shown by the position of the small gauge at the rear of the cylinder. When the gauge is flush with the edges of its recess the oil supply is correct. When the gauge recedes it is an indication of insufficient oil; on the contrary, when it projects it is a sign of too much oil.

For the purpose of filling the cylinder there are two filling plugs and two pumps. One small screw pump is furnished with each piece and is applied to the rear filling plug. One battery pump is furnished for each battery which is larger, more easily used, and is used at all times when available. Its general design may be seen from the figure 1 submitted with the original of this report only. The pump is screwed to the right-hand side of the carriage before being used. Much thicker

oil is used than in the United States service. It takes one man one minute to fill a cylinder. Cylinders are verified and filled every day in intense action, two or three times a week in ordinary active sectors, and once a week in quiet sectors. Although leaking is referred to as a possibility in official publications, no signs of oil were seen under any guns and no leaking was reported by any of the officers or men questioned. Each emplacement was carefully inspected for signs of leakage, and every opportunity to be at the guns during and after firing was taken advantage of.

The group commander, who was a member of the Technical Commission at Bourges before the war, stated that he had been with 75-mm. guns since August, 1914, and had never seen a recoil mechanism out of order except as the result of hostile fire or inexcusable neglect. The official records of the group showed that at Verdun eight guns fired 6,000 rounds in one day, one gun had fired 1,000 rounds during a day, and that carriages with a continuous record of 13,000 rounds were in excellent condition. During one day on which the observer was with one of the batteries it fired 1,800 rounds in four hours, and the recoil mechanism was functioning perfectly at the end of the day, and the gauge showed no signs of lost oil.

4. *Care of accessories and small parts.*—In contrast with the excellent care given to guns and carriages, spare parts and accessories were in disorder in the battery visited. The chiefs of section were always able to produce the parts called for, but no two kept them in the same place or in the same way. Boxes and cases provided for their care were in poor condition. All leather portions of cases were stiff and badly cared for.

5. *Inspection of matériel.*—All artillery matériel is under the supervision of a general officer as inspector for the armies. At each army headquarters there is an assistant inspector, with the rank of commandant, charged with the matériel of his army. In the army visited, pieces are normally inspected about once in two months and oftener whenever special inspections are asked for. The observer was present at a normal inspection. The assistant inspector for the army arrived without previous notice. He was accompanied by one mechanic. The inspection of the battery required about one hour and a half and consisted of visiting each piece, star-gauging the bore, and measuring the chamber and core with the Manceron device.

No play was found in sights or gears. The pieces in the battery varied from a new piece, which had fired only 250 rounds, to a piece which had been in service since the war and had fired 8,000 rounds. The new gun was found perfect, the guns of average use showed a wear which did not exceed $\frac{1}{10}$ mm., the old gun showed wear varying from $\frac{2}{10}$ to $\frac{6}{10}$ mm., but, as the wear was uniform and the piece reported as still accurate, it was continued in service.

The individual record of each piece was submitted to the inspector by the chief of section. The inspector examined it and noted the fact and results of his visit. He afterwards had the chiefs of sections and gunners assembled and lectured them on the necessity of careful compliance with the note from general headquarters, dated September 3, 1916, on the care of guns during and after firing, referred to below.

6. *Instructions for the care of matériel.*—There is submitted as an appendix to this report the note of September 3, 1916, and an older note of November 19, 1915, and existing regulations for the care of matériel. It is believed to be of considerable value to the Ordnance Department as a recent authoritative statement based on the experience of two years and a half of war and the expenditure of several million rounds of ammunition. Their source should not be divulged, but no reason is known to exist which should prevent the Ordnance Department using the facts, advice, and warnings for the information of our own services.

RESUMÉ OF INSTRUCTIONS GIVEN AT A COURSE IN MATÉRIEL FOR ARTILLERY OFFICERS, FOURTH ARMY, NOVEMBER, 1916, BY COMMANDANT P. POUS, SOUS-INSPECTEUR DU MATERIÉL.

In addition to instructions in the regulations, the following points should be considered:

A. Carriages.

Former instructions indicated that certain care should be given daily, certain other care every 15 days. This last interval has proved too long for war conditions, even for limbers and caissons, which are too often neglected.

The daily care previously described should be attended to with the greatest care.

Bearing surfaces of instruments and levels should be scrupulously clean at all times.

Elevating and traversing gears should be operated to *their full extent* and oiled in the prescribed fashion.

All bronze and steel bearings, screws, racks, etc., should be carefully cleaned. All bearing surfaces should be cleaned and oiled. One should never find dirty black oil in elevating and traversing mechanisms. All loose screws and bolts should be tightened at once.

Verify the greasing of axles and of caterpillar plates; repair and replace everything not in good condition. Do not wait until parts are unserviceable. Carelessness results in excessive demands on the parts, delay in delivery, and harm to the interests of the service in time of war.

Send to the park promptly all parts replaced, in order that they may be utilized at the rear.

Keep cleaning matériel complete, renew the supply methodically, and prevent waste. Use nothing but regulation matériel, *especially for recoil mechanism.*

Recoil mechanisms should be verified as often as the nature of the service permits. All cylinders lose more or less oil, which

should be replaced at once. Many recoil mechanisms, especially in the older matériel, have been ruined because they have been used when half full.

75-mm. recoil brakes.—Certain batteries have either surcharged the reserve reservoir or else have left it empty. All surcharge changes the relative position of certain internal parts which may either interfere with normal action or even result in the ruin of the brake. There is no benefit in changing the prescribed reserve. It may be even a source of danger. On the contrary, there are many advantages in maintaining the normal reserve.

In case brakes work badly, report them as follows:

First. To the repair sections of the park:

(*a*) Brakes which give abrupt return to battery during normal firing. Pay no attention to merely *rapid* return to battery during rapid fire for effect.

(*b*) Brakes which lose oil excessively by the forward filling plug during firing.

(*c*) Brakes which lose oil by the gauge either at rest or when firing.

(*a*) and (*b*) can be repaired only in the rear; (*c*) can be repaired in the army park.

All brakes described above can be retained in service in spite of slight inconveniences. Small springs are issued to be screwed in the forward end of cylinders to take up excessive counter-recoil pending the receipt of new brakes.

Second. The following categories should be sent to the repair section with a written note:

(*d*) All brakes giving an excessive recoil.

(*e*) All brakes which do not properly return the piece to battery.

(*f*) All brakes in which the gauge does not properly function.

(*g*) All brakes in which, when the reserve reservoir is emptied, the oil spurts out violently, very thick, like mayonnaise.

NOTE.—Use only clean oil furnished from Bourges Arsenal and introduce it with the battery pump and not the screw pump.

Creusot brakes.—Bad care is often the cause of accidents which make it necessary to return pieces to the factory. These accidents are due to excess recoil caused by superpressure in the hydraulic brake (which is forced to work with orifices partially closed) to deteriorated parts of the brake, or to broken pistons.

Great attention should be given to the recoil. The following

table gives the proper amount of recoil for each type fired with the maximum charge:

Elevation.	105, M. 1913, meters.	155 Court, M. 1915, meters.	155 Long, M. 1877–1914, meters.	Mortar, 280 meters.
10°	1,25	.....	1,21	.....
20°	1,26	1,28	1,24	1,36
40°	1,27	1,30	1,27	1,395
60°	.....	.....	.....	1,410

If the recoil is too long, the brake is not full or else the recuperator has lost air or liquid. Verify filling, then measure the pressure in the recuperator.

In the course of intensive fire, certain failures in counter-recoil have been reported. This is caused by the dilation and the partial vaporization of the oil. The functionment will be corrected as soon as the piece is cooled.

In order to keep up the fire, it is necessary to put the gun at zero and to open the filling plug, let out the excess of liquid, and close the plug. When the matériel has cooled, refill.

The use of ordinary air in Schneider brakes corrodes to a certain extent the internal surfaces of the cylinders, especially for the cavalry cannon, model 1912. Azote (AZ) is furnished in reservoirs or in special containers. When azote is not available, use ordinary air, and recharge with azote as soon as it is furnished.

B. Verification of Adjustment of Sights.

Verification should be daily, or perhaps even after each firing, but only simple field adjustments are required.

(Note.—The methods were not translated for lack of time and because they were the same field expedients used in our Field Artillery Observer).

C. Repairs.

Spare parts will not be assembled in batteries when such assemblage involves filing of delicate or essential parts, forge work, or riveting.

Other replacements and repairs are made at repair sections. With the piece should be sent the "Book of the Piece" (obser-

ver's note—a small book kept by chief of section, giving complete information as to his piece), with a notation of repairs needed or a description of accidents, if any.

In addition, all guns and caissons should be sent periodically to the repair sections.

In the case of heavy calibers, important repairs are made as soon as possible, but complete new parts or new guns are sent by the heavy artillery service of the grand army park.

D. Care of Tubes.

Peace-time requirements as to care of tubes have proved absolutely insufficient for war conditions. A note from the grand quarter general, dated September 3, 1916, on the conservation of tubes meets all requirements. All batteries should have a copy. Recently the inspector general of matériel called attention to the importance of the note and stated that strict compliance would result in marked economies in guns.

War experience shows that the wear of tubes is not due alone to the number of rounds fired, but also to the way in which the fire is conducted and the way in which the tubes are cleaned, cooled, and cared for.

On account of very intensive fire—called for, no doubt, by necessity, but executed without care—certain 75-mm. guns have become unfit for use after from 3,000 to 6,000 rounds, whereas others after 20,000 rounds are found to be without excessive wear or copper fouling. For example, one battery has fired 3,800 rounds in 24 hours, nearly 1,000 rounds per gun, without wear, copper fouling, or change in the bore. (This is personally vouched for by Commandant Pous, who inspected the battery). The rounds were fired as follows: 1,200 rounds in 4 hours, 1,000 rounds in 2½ hours, 1,200 rounds in 3 hours, and 400 rounds in 1 hour. This was made possible by firing sections and platoons alternately and permitting the inactive pieces to be cooled, cleaned, and greased.

Copper fouling is one of the most frequent and important causes of trouble. Under the friction caused by the passage of the projectile through the bore light pieces of copper, either liquefied by high temperature or flaked off by friction, are detached from rotating bands and fired along the walls of the bore, where they sometimes remain as if they were welded. The small projections thus made increase the wear caused by

later rounds, and the copper, playing the part of a foreign body, becomes more and more deeply embedded in the metal of the tube, especially if the temperature is greatly raised by intensity of fire. The interior surface of the tube remains rough even after the copper has been removed chemically and is more liable to future copper fouling after a few additional rounds.

(*a*) For a given kind of copper the amount of fouling depends upon the following considerations:

(1) The condition of the bore, whether smooth and polished or rough, whether clean and lubricated or dirty and full of powder residue, whether dry and seldom or rarely cleaned, or whether subjected to excess heating or cared for by rest and cooling.

(2) The action of the lands and grooves on the projectile, which is a function of its velocity in the bore, its weight, and the inclination of the rifling. The last consideration explains the fact that in guns like the 75 mm., 100 mm., and 105 mm. with a constant rifling the fouling is chiefly at the beginning of the grooves, and nearer the muzzle in guns like the 155 mm. long with progressive rifling. It never occurs with low-velocity guns, except when they are badly cared for.

(*b*) The successive phenomena of copper fouling are interesting:

(1) The change in the surface of the lands and grooves, particularly the edges of the lands, such as is always noticed in guns badly fouled.

(2) The change in the rotating band of the projectile. This explains certain irregularity of fire hitherto inexplicable.

In some cases small flakes of the rotating band are nearly sheared off and a loss of pressure results, especially if the phenomenon takes place near the beginning of the rifling. This may explain certain inequalities in the fire of guns with a rifling at a constant pitch (75 mm. and 105 mm.) or even in the case of fire with the 155 mm. long of sufficient intensity to cause copper-fouling, especially if the gun has already been fouled.

In some cases bits of the copper are actually sheared off, either at the beginning of the rifling in guns of constant pitch or further forward in guns of progressive pitch like the 155 mm. long. In the first case the projectile leaves the gun with a speed of rotation practically zero, which causes the projectile fired at a range of 5,000 or 6,000 meters to fall at a distance

of 1,000 to 2,000 meters. In the second case the projectile leaves the gun with a certain speed of rotation and the firing will be normal if the range is not too great, but if the range is great—9,500 meters, for example—the projectile will "tumble" toward the end of the trajectory and often fall short by 500 meters.

From the foregoing it can be seen what difficulties, due to copper-fouling, will be caused by firing rapidly without proper precautions. But copper-fouling is not the only bad result. Improper usage causes erosion and premature wear on the lands near the origin. These, in their turn, render the tube more liable to copper-fouling. All these results of improper use and care result in destruction of matériel and waste of ammunition.

It is necessary to consider the gun as a machine tool which is used to cut the copper of the rifling band by turning a heavy inert mass under conditions which are at best difficult. This work must be done under varying conditions—when hot or cold, when dry, rough, and cracked, or when smooth, polished, and lubricated. Under unfavorable conditions "the superficial layers of metal are superheated, and this heating causes groups of cracks in the walls of the bore, which quickly deepen and form permanent important erosions." (Extract from an article by Tchernoff in the "Révue de Métallurgie" for October, 1915, quoted by Gen. St. Claire-Deville, inspector general of matériel).

The above truths are the basis of the note from the grand quarters general previously referred to, whose conclusions may be aphorized as follows:

"*For the best conservation of tubes they should be washed and greased before each shot.*"

In spite of the tactical and technical requirements of actual war, this ideal should be approached as closely as possible in order to safeguard our matériel and thus hasten the final victory.

In this connection it is interesting to note that a battery commander who attended one of the first lectures in this course has since realized this ideal with one of his guns. By the detail of two extra cannoneers he kept up a rate of fire of three rounds per minute for 30 minutes. The work required of the cannoneers was, of course, excessive, but at a recent inspection the men of whom the extra work was required appeared very proud of the results obtained.

As the power and initial velocity of a gun increases the need for special precautions is correspondingly increased. Strict compliance with the note from the grand quarters general re-

ferred to has produced most happy results with the Schneider matériel of 105 mm., 155 long, 155 short, and 280 mm. mortar, with the St. Chamond 155 mm., and with the 100 mm., 14 cm., and 145 mm.

"During firing with full charges tubes should be greased at least every four rounds." Assuredly, whenever the tactical situation demands it, the fire should be as intense as the matériel permits, but it is essential that commanders who order such fire from large calibers should have examined the situation in all its particulars and balanced the necessity of the moment with the probability of the partial or total destruction of some guns.

From the foregoing it follows that, with guns with varying charges, the full charges should never be used except when the range or the nature of the target demands it. The experience of Commandant Jere, consulting ordnance engineer at the Center of Artillery Studies, shows that *one round fired with full charge wears a gun as much as five rounds fired with half charges.*

Existing orders require the use of reduced charges whenever possible, but staff officers of the services of the interior who are charged with the distribution of munitions have unchangeable repugnance toward giving to parks and batteries a permanent number of charges in excess to the number of projectiles. This makes it rarely possible to comply with the orders covering the use of reduced charges. This state of affairs is to be regretted, but batteries should, in spite of it, use every effort to comply with the very necessary precautions.

E. Inspection of Guns.

The following indications will serve as a guide for officers charged with inspections and for battery officers.

The rôle of officers charged with inspections of guns in the field is defined by Chapter V of the Instructions for the Annual Inspection of Guns, dated January 10, 1906:

"Give the gun a general examination after each day's firing. See if any dangerous fault exists. Estimate the degree of seriousness of each depreciation and inform the proper authority thereof, either the commanding officer or the park commander.

"Decide provisionally if a gun should not be fired, report to the proper authority (army park or grand park of the army, as the case may be), enter verbally or in writing, so that the

facts may be known at the next visit of the sous-inspecteur of artillery, who will make recommendation as to final disposition." (Note 2209, Sept. 4, 1916. G. Q. G.).

Field decisions do not necessarily require the use of the star gauge on the Manceron apparatus (for measuring chambers). Make bold decisions, and in cases considered dangerous do not hesitate to retire the piece provisionally and report the circumstances.

At each visit have the bore cleaned carefully. Use hot water or kerosene oil, if necessary, to remove caked grease in guns badly cared for.

Light the interior by sunlight reflected by a white paper or by a candle or electric light. Look at both ends carefully.

COMMON MANIFESTATIONS OF DETERIORATION.

1. *Erosion.*—Large pitted areas close together in groups near the forcing cone and the beginning of the rifling. Unless they degenerate into fissures they are not dangerous.

Indentations in the chamber and barrel recess caused by the rupture of cartridge cases. They are usually without depth and not dangerous.

2. *Fissures* are the beginnings of cracks in the tube, which may be recognized as fine lines usually parallel to the axis of the piece. They are generally isolated and very deep. Their depth distinguishes them from the scars made by foreign bodies. They are rare, but very dangerous. It is important not to confuse fissures and scars made by tools or foreign bodies. Be on the watch for any deterioration of this nature, which increases with subsequent firing.

3. *Scars made by hard bodies* are frequent and may easily be mistaken for fissures. It should be noted that they are more continued than fissures, that they are usually long, and may or may not be parallel to the rifling. They are usually shallow and are not dangerous.

4. *Scratches, cuts, and dents* come ordinarily from the presence of a foreign body in the tube during firing or from a premature burst. They are of no importance unless they are of such a nature as to obstruct the passage of a projectile through the bore. In such a case retire the piece for *repair.* This decision is very important in view of the use of high explosive shells.

Dents are always situated in the rear part of the tube. They are very frequent in guns using fixed ammunition. In spite of their grave appearance when seen from one end of the piece, they are not serious, because they are not deep unless their edges form a projection in the bore.

5. *Swellings* are recognized by the appearance of the bore. Retire the gun until it can be passed upon definitely. Take careful note of the ammunition used, including all the marks of manufacture, and report to the commanding officer and to the park.

6. *Copper deposits* have the appearance of caked dirt and must be removed only under the instructions of a sous-inspecteur of matériel at repair sections, army parks, or the Grand Army Park. (See the note of July 22, 1915, reprinted May, 1916). In cases of slight copper fouling the copper can be removed in the battery by the use of the ammonia solution furnished by the repair section of the army park. Pay no attention to the tinge of copper without thickness, which is seen at the muzzle of guns even after a very few rounds.

7. *Wear on the lands near their origin.*—120 mm. and 155 mm. can be submitted to the sous-inspecteur for condemnation when the wear amounts to 1 mm. and when, *in addition*, the gun has become more inaccurate to the extent of giving dispersions on level ground equal to *eight times the probable error*. When adjusted and closely supervised fire with ammunition of the same lot should be insisted upon.

The same rule applies to 75 mm. guns when the wear exceeds 0.5 mm.

8. *Exterior dents caused by hostile fire.*—Verify the interior and if there is any interior swelling which would interfere with the passage of a projectile retire the gun.

9. *Displacement of locking hoops in 120 mm. and 155 mm. guns.*—If the movement is rapid or if it exceeds 4 or 5 mm., retire the gun until it can be inspected by a sous-inspecteur.

10. *De Bange breech systems.*—The primer seat becomes dirty rapidly, especially when firing "D" shells. Dirt commences at forward end and rapidly fills the primer seat if the forward part is not changed in time. It is necessary to watch carefully and change frequently to prolong life of the mushroom head. The mushroom head must be replaced when the primer seat becomes dirty and increases the pressure. Complete new mushroom heads and spare parts must be on hand at all times.

All gas-check pads of which the tin washers show signs of having been melted indicate insufficient obturation. The obturators of the 155 mm. short model of 1881 should not be separated from their gas-check rings. In urgent cases replace the entire obturator and send to the rear, even if certain parts are still serviceable.

11. *Retubed 105-mm. guns.*—The tubes lengthen and turn during firing. Report them when this amounts to 12 mm.

NOTE.—Batteries should record in their *Livret de Pièce* (individual gun records) all shots fired and all accidents and important incidents. This book pertains to the *piece* and not to the battery and should accompany the piece at all times when it is sent to the rear. It must be presented at all inspections by the sous-inspecteur, who will record in it all required information.

P. POUS,
Commandant Assistant Inspector for Artillery Matériel.

G. Q. G., *November 16, 1916.*

The following is a translation of the note of September 3, 1916, referred to on page 5:

NOTE OF SEPTEMBER 3, 1916, G. Q. G.

A. A receptacle full of water must be kept at each piece.

B. At each interruption of the firing, no matter if even for a few minutes only, wash and grease the bore without using enough die to cause smoke. During short interruptions the breech should not be dismounted, but at the end of the firing or the day it should be dismounted and cleaned.

During prolonged firings cause suitable intervals to be made and alternate the pieces.

C. If due to the exigencies of the service the fire has been intense enough to cause copper fouling, remove the copper as soon as possible in the manner hitherto prescribed.

D. Grease the rotating bands freely, leaving a certain amount of grease on forward edge of the band.

E. Whenever the rapidity of fire permits, before each shot is fired make sure that there is no foreign body in the bore, such as pieces of the cartridge cases or bits of unburned powder.

By order of the aid major general:

(Signed) POINDRON.

For the sake of completeness there is included the following translation of an earlier note on the same subject:

GRAND QUARTERS GENERAL,
Gen. Staff—1st Bureau,
No. 10363.
} At G. Q. G., *November 19, 1915.*

NOTE RELATIVE TO MEASURES TO BE TAKEN IN BATTERIES IN ORDER TO PREVENT EXCESSIVE HEATING OF 75 MM. TUBES.

During the intense fire of the recent attacks a certain number of 75 mm. guns fired for a long time without interruption and were thus heated excessively. This has resulted in a premature wearing of tubes and the necessary condemnation of several recoil mechanisms whose joints had been completely burned out.

75 mm. fire, like that of machine guns, should not be uninterrupted. The fire can take the form of rafales executed as rapidly as the service of the piece will permit, but it is necessary there should be intervals sufficient to avoid excessive heating.

Cooling can be hastened with water, either thrown on the outside of the gun or preferably used in washing the bore. The water should be kept near the piece in a pail or other suitable container.

By order of the aid major general:

M. JANIN.

NOTES ON ARTILLERY, BARRAGE, AND ACCOMPANYING FIRE.

(From data obtained in France in March, 1917

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CONTENTS.

NOTES ON ARTILLERY BARRAGE AND ACCOMPANYING FIRE.

The expression *tir de barrage* (curtain fire) is used so frequently in official communiqués and in journalism that it has become one of the catchwords of the present war; but, in spite of its importance, no previous report has been submitted on the subject because, although the word was constantly used, surprisingly little definite information about it was to be obtained. A recent satisfactory visit to a group of field artillery has made it possible, however, to submit the following notes, which are believed to be authentic. They include a translation of such written official information as is available and such further data and comment as was obtained on the visit referred to.

TIR DE BARRAGE.

Barrage fire has the following objects:

(*a*) To stop the attack of the enemy as soon as it is launched.

(*b*) To prevent the arrival of reserves and reinforcements.

Barrage fire is delivered by light artillery and by heavy howitzers.

OBSERVER'S NOTE.—In the French service the classification *Artillerie de campagne* has a more restricted meaning than the corresponding term *field artillery* in the United States service. It includes only what we designate as *light artillery* and will be so translated in official reports.

The barrage fire thus delivered is completed by fire from long-range heavy artillery directed on the rear of the hostile position. All arrangements should be made so that barrage fire may follow automatically the fire for counter preparation.

LIGHT ARTILLERY BARRAGE.

Front.—A distinct sector is assigned to each battery. If there are enough batteries available, the fire of several batteries may be superimposed on the same sector. But such duplication is used only when the barrage of one battery per sector is not sufficient or to replace the barrage of a battery which is forced to cease firing. There should be, in addition,

such an organization on any given front that, for each infantry unit, there is a corresponding artillery unit charged with the barrage fire for the sector concerned—a group (three batteries) of artillery for each infantry battalion, for example.

Objective.—The barrage must form a curtain as close to the friendly front line as the safety of friendly troops will permit. As soon as an effective barrage has been established close to the friendly front line the range is increased slightly so as to carry the fire to the enemy's front line, where the successive waves of the hostile assault are particularly vulnerable at the moment when they are massed or when they are just springing out of the trenches.

Finally, the barrage is completed by searching fire in depth directed against the communication trenches where the successive elements of the enemy are passing or resting.

In cases in which portions of the friendly trenches have been occupied by the enemy all or part of the barrage should be brought back to bear upon the captured portions of the friendly lines at the moment when the infantry makes such a demand.

Density of fire.—At the opening of barrage fire, the rapidity of fire should be as great as possible. The delivery of fire is afterwards modified to suit the circumstances and the requests of the infantry in the first-line trenches. In order that this may work smoothly, the group or battery commander must arrange for the most intimate relations between himself and the infantry commander of the front line.

Calculations should be based on a density of one round per minute on each 10 meters of front. Assuming that each gun fires five rounds per minute, it is necessary to assign at least one battery for each 200 meters of front.

Opening of barrage fire.—Barrage fire is opened at the request of the infantry either by telephone, optical signals, etc., or when battery commanders receive indications from observation stations (signal lights, display of small balloons, or of streamers from a balloon basket), or when the situation seems to demand this kind of fire, such as when a burst of infantry fire is heard at night or when the report of a gas attack has been confirmed in the daytime.

Barrage fire is stopped when the infantry asks for its cessation. When all telephone wires are cut it may be stopped on the responsibility of the artillery commander at the moment when he judges that the enemy attack has been broken up.

The barrage of heavy howitzers: Barrage from heavy howitzers is delivered automatically on the first line only. In other cases it is ordered specially by the artillery commander of the sector either on his own initiative or on the request of the infantry. It is stopped only at the request of the infantry.

Trench mortar barrage: Trench mortar barrage from the 75-mm. trench mortar is executed under the same conditions as that of the light artillery. Other trench mortars execute the barrage under the orders of the colonel commanding the infantry of the sector, or automatically when battery commanders have received information as to a hostile attack. It is stopped at the order of the colonel commanding the infantry.

Long-range heavy artillery delivers a barrage when so directed by the chief of artillery of the army corps.

Preparation for the barrage.—The barrage depends upon a prearranged scheme called the *barrage plan,* which includes all the details necessary for its execution. This plan should include the following:

1. Objectives.
2. Rate and method of fire.
3. Provisions for night barrages.
4. Observation stations and liaisons to be established.
5. The orders for each battery.
6. The artillery support to be requested from neighboring sectors.

In the group visited barrage fire was provided for and executed according to the foregoing provisions.

Except when an offensive action was being prepared or delivered, the barrage fire was considered the principal duty of the artillery, and all the dispositions and routine in the batteries were devoted to the perfection of the arrangement by which it could be delivered at the time and place required by the infantry. The only other fire normally delivered without special orders was that on localities where enemy activity was reported, and "reprisal fire" in response to enemy fire on friendly infantry. The group commander ordered barrage fire, fire on minor enemy activity, and reprisal fire. Counter-battery fire, fire for destruction, and all fire connected with an offensive action was planned and ordered especially by higher authority.

Barrage fire was divided into the "automatic barrage," which was the normal barrage required of any given battery, and

"reinforcing barrage," which was provided for in case the automatic barrage had proved insufficient.

The basis of the organization was the assignment of one group of light artillery to each infantry regiment. The group visited supported a regiment which had two battalions in the trenches and one in reserve. For the purpose of delivering barrage fire, one flank battery was assigned to each infantry battalion in the trenches and the third, or center, battery was so placed that its fire could reinforce the barrage fire of either of the other two. (See fig. 1).

In addition to this automatic and reinforcing barrage there were three batteries of 95-mm. guns available, and provisions were made to obtain additional barrage on each battalion sector from batteries in adjoining groups.

Each battalion sector was given a name, such as "Cousiers," "Puits sans Eau," "Vauban," etc.

The "barrage plan" of the group commander was carefully worked out, and consisted of a "barrage table" and a "barrage chart," both of which gave the same information but in different form.

Both the "barrage table" and the "barrage chart" included information covering the name of each sector, the limits of the sector shown by coordinates, the infantry battalion holding it, the battery assigned to it for the normal or automatic barrage, the reinforcing battery detailed specially for this purpose, the 95-mm. batteries whose fire could be obtained in emergency, and the available batteries from adjoining groups whose assistance was regularly provided for but reserved special situations.

The "barrage table" had the following general form. Its general provisions were prescribed by the colonel commanding the divisional artillery. Its details were planned by the group and battery commanders concerned.

Barrage chart—Organization of group sector.

Name.	Coordinates.	Infantry unit.	Automatic barrage.	Reinforcing barrage.	Emergency barrage.	Heavy artillery available.
Rosiers	348–267	[1] 1/56	[2] 1/48	3/48	5/48	[3] 2/101
Vauban	356–272	2/56	2/48	3/48	8/48	3/101

[1] 1/56 indicates first battalion, 56th Infantry.
[2] 1/48 indicates first battery, 48th Field Artillery.
[3] 2/101 indicates second battery, 101st Heavy Artillery.

Original tracing of above filed in R/S (F/W 1056–45).

The "barrage chart" was a section of a 1/10000 map with the limits of sectors and the positions of batteries carefully marked, and the corresponding barrages noted by shaded portions.

Communications.—The group commander's station was with that of one of his batteries and included an "advanced telephone central." (See separate report on artillery telephone communication). This connected the group commander with the infantry battalion commanders, not only in his own but the two adjoining sectors, the infantry regimental commanders of his own and adjoining sectors, all the observation stations of the divisional artillery, the batteries of his own group, the headquarters of neighboring groups, the heavy artillery, the aerial service, the divisional artillery commander, and the divisional infantry commander.

To furnish communication when the wires were cut there was connection by projectors or optical telegraph between the infantry regimental commander's station in the group sector and the lookout station of the group, which was an armored cupola immediately over the group commander's post.

For emergencies, the following rocket or light signals were provided:

Red	Barrage needed.
White	Cease firing.
Red and white	Lengthen range.
One green	Gas warning.
Two green	Gas attack.

This code was changed from time to time, but the variations are so limited that the Germans usually were in possession of it, and were able, by sending up rockets themselves, to cause some confusion. In order to avoid waste of ammunition and unnecessary alarms, orders provided that—

(*a*) A signal light sent up in the midst of small-arms or hostile artillery fire will be at once responded to, but

(*b*) A signal light sent up during quiet times will be confirmed by telephone before being responded to, but

(*c*) If telephone confirmation is impossible, the signal light will be responded to by immediate fire.

During the visit to the group on one occasion the lookout reported red rockets in a certain sector. As it was quiet at the time, the group commander called up the infantry battalion

commander on the telephone and was told that there was no need for barrage, and that it was the Germans who were sending up the rockets.

Personal liaison.—The lieutenants of the group were detailed by roster for three days' tour of duty with the infantry regiment. During this time they lived in the infantry trenches and messed with the infantry officers. They were in charge of the advanced observation stations and in close touch with everything in the sector. The relations between the artillery and infantry officers were uniformly cordial and intimate. The same batteries had supported the same battalions since August, 1914.

Limit of safety.—Due to dispersion and the possibility of a change in atmospheric conditions since the previous adjustment, 150 meters was taken as the limit of safety on delivering a defensive barrage. The advanced posts of the infantry sector were in some cases within 30 meters of the advanced German posts, and in cases in which it was necessary to fire closer to the infantry line than the limit of safety, the infantry were always notified so that they could take cover in their dugouts. The limit of safety here referred to applies to defensive barrages. For attacks, the accompanying fire, sometimes called the "mobile barrage," is planned separately in each case and often is closer to the infantry than 80 meters.

Time required to deliver barrage fire.—Calculations were based on the following times:

	Minutes after request.
To obtain automatic barrage	2
To obtain reinforcing barrage	5
To obtain help from adjoining group	10 to 15

During the visit to the group, only automatic barrages were called for, but in no case did it take longer than two minutes to open fire. The gun detachment slept within 5 yards of their gun, and were awakened by an electric bell in the lookout cupola. The gun was always laid with the automatic barrage data. The presence of an officer in the battery was considered necessary, but he appeared almost instantly.

Amount of fire.—The understanding with the infantry was that batteries should fire 40 rounds from each piece when a barrage was asked for, and that, at the conclusion, inquiry should be made as to whether or not that was sufficient. Ten minutes was required for this.

Rate of fire.—The automatic barrage was opened at the rate of six rounds per piece per minute, and this rate was tapered off to one round per piece per minute.

Counter preparation.—Arrangements were also made, both by table and by graphical chart, for counter-preparation fire. Each battery had its normal mission and its reinforcing mission. Each hostile position had its normal counter-preparation battery and its reinforcing batteries just as in the automatic and reinforcing barrage.

Fire against special localities.—In order to bring immediate fire on special localities where the enemy are in the habit of work or passing, there was a special code between the infantry regimental commander and the group commander. Each locality had a letter designation, and the kind of fire desired was designated by "R" (rafale) or "L" (lentement-slowly). For example, if the message "CL" was received, it signified that the infantry wanted slow fire on the point "C." When a rafale was asked for, usually only one round from each piece was fired as quickly as possible. This was ordinarily directed against working parties, who unquestionably would take cover at the first shots and so render any more fire wasted. Slow fire was delivered at a rate of one round every five minutes at irregular intervals and was designed to make passage down certain communication trenches, etc., dangerous.

Record of emplacements.—The following data was recorded in the group commander's records concerning each emplacement in the group sector, including the ones which were unoccupied but with the upkeep of which the group was charged:

(*a*) Designation of emplacement.

(*b*) Location by coordinates on map.

(*c*) Altitude.

(*d*) Minimum range at which the crest can be cleared at 300 A. S.

(*e*) Field of fire, both in casemates and outside of them.

(*f*) Daily registration point.

(*g*) Usual observation station.

(*h*) Normal barrage.

(*i*) Points from which infantry rockets are fired.

(*j*) Reinforcing barrage.

(*k*) Barrage after infantry gives up first line.

(*l*) Barrage after infantry leaves second line.

Referring to (*k*) and (*l*) above, this fire is never opened until the correctness of the information as to the giving up of

the infantry lines has been *confirmed* either by telephone or other means.

Additional information on file.—In addition to the foregoing information as to *tir de barrage*, etc., the group commander had the following:

(*a*) Information on gas attacks and the launching of gas.

(*b*) The telephonic organization of the sector.

(*c*) The infantry organization of the sector.

(*d*) German maps of the sector.

(*e*) Artillery and infantry panoramic sketches from observation stations.

(*f*) Charts showing "dead zones." The portions of the terrain invisible from observation stations and covered from the fire of the various batteries was marked off on pieces of tracing cloth for each station and battery. By superimposing these tracings on the map the exact capabilities and limitations of the various positions could be learned. This saved having a separate map for each station or battery.

"*Carnet de Tir*" (*data book*).—The carnet de tir, a small data book of about 100 pages intended for data for each position occupied by a battery. Data is entered as it is obtained, either in registration fire or fire for effect. The book is turned over to the relieving battery taking the same position, or, in case there is no relieving battery when the position is vacated, to the commanding officer of the artillery of the sector.

The following table of contents will show the subheads under which data is entered and the allotment of pages for each subject:

I. General information on the emplacement of the battery and its echelons, 1 page.
II. Position of the battery, 5 pages.
III. Missions, 2 pages.
IV. Standing orders (to open barrage, reprisal, fire, alarm, etc.), 4 pages.
V. Command post, 2 pages.
VI. Habitual observation station (with sketch), 4 pages.
VII. Advanced observation station (with sketch), 4 pages.
VIII. Data on observation, 1 page.
IX. Barrage (with sketch), including initial ranges for each piece and the mechanism of fire, 4 pages.

X. Registered fire on enemy batteries and other special points, 4 pages.

XI. Registration data from direct observation (each target has a printed form on which date and hour, direction and force of wind, etc., are entered, with the results), 18 pages.

XII. Registration data from aerial observation (each target has a table different from above, but in which the same sort of data is entered), 31 pages.

XIII. Notes on daily variations in ranges (tables showing date and hour, number of pieces, wind, atmospheric condition, angle of site and range), 7 pages.

XIV. Index of targets which have been registered on, giving page in the notebook on which the desired data can be found, 2 pages.

XV. Range tables of 75-mm. gun for different projectiles, 4 pages.

XVI. Short-range table for time-fuse shell, 75 mm., 2 pages.

XVII. Formulas, 3 pages.

Barrage maps.—The normal and reinforcing barrage zones of the group visited are shown graphically in figure 1. The location of the batteries of the adjoining groups is shown, and the way in which the barrage zones overlap and reinforce one another may readily be seen.

For the normal barrage the left battery of the group had an average range of 3,000 and fired over a front of about 1,000 meters with slightly oblique fire. The field of fire was 200 mils.

The right battery had an average range of 4,000 and fired over a front of 1,500 meters, with a field of fire of 380 mils.

The center, or reinforcing, battery had an average range of 2,700 and fired over a front equal to both the other zones, or 2,500 meters, with a field of fire of 700 mils.

Individual emplacement data.—In addition to the data book for the battery, in each emplacement there was posted up the data which affected that gun in particular. This was either painted on a board in large letters which could be read at night or else was in the form of sheets of paper tacked to a board. In each case there was given the data for fire on the registration point, the normal barrage, the reinforcing barrage,

the fire in a neighboring group sector, the method of fire, and the data for all special points on which the infantry ask for fire.

The guns were left each night laid on the point for the normal barrage.

The field of fire for the normal, automatic barrage was about 200 mils for the left battery and 380 mils for the right battery.

The entire field of fire for the pieces of the left battery was, on the average, 1,100 mils. In detail it was as follows: First piece,

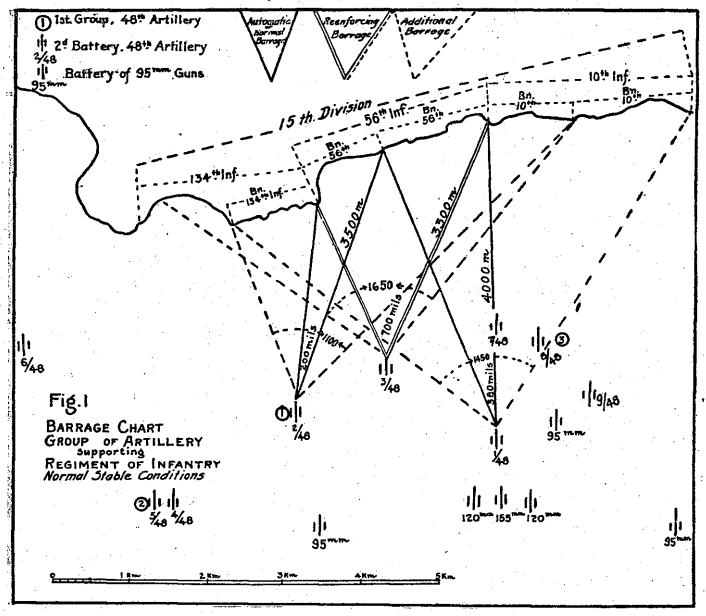


Fig. 1
BARRAGE CHART
GROUP OF ARTILLERY
Supporting
REGIMENT OF INFANTRY
Normal Stable Conditions

1,280; second piece, 925; third piece, 925; and fourth piece, 1,180 mils.

Volley fire, sweeping with three turns of the handwheel (equal to 5 mils) between shots, was the ordinary method of fire.

The *box barrage*, or *tir d'encagement*, as it is called in the French service, is sometimes referred to as a separate form of barrage, but since it is merely the delivery of three simultaneous barrages on both flanks and the rear of a position

in order to prevent escape and reenforcement, there is believed to be no need of multiplying technical terms to include this and every other possible form of barrage. The divisional and corps artillery commanders make their plans which are based on tactical requirements and the assistance required of the artillery. When these plans involve barrage fire delivered in a particular way, artillery officers prefer to receive simple orders for such fire without having all sorts of fantastic names attached to each particular kind. Such at least was the opinion of the artillery officers of the commands recently visited, who deplored the present tendency to multiply definitions.

Accompanying Fire.

Terminology.—In the opinion of the many French artillery officers of all ranks who have been consulted on the subject, the term *accompanying fire,* which was well recognized before the war, is a better term than *mobile barrage,* as it is often called in France, or *creeping barrage* as it is sometimes called in the British service. The officers consulted prefer to retain for the term "*barrage fire*" the curtain of fire habitually put up for the defense of a position such as has been described in the preceding pages. They deplore the present tendency to manufacture names for all sorts of intense fire and to call each one of them some special kind of a *barrage.* As some of them have expressed it, it may be called a trick of journalism and has no place in true military terminology, which should always be kept as simple as possible. As an example of this tendency, certain orders recently issued for an infantry maneuver used the terms "close barrage" and "distant barrage," the first being the accompanying fire which preceded the infantry in the attack, and the second the true barrage which was being delivered simultaneously by the long-range heavy artillery on the ultimate objective. Artillery officers disapproved of this nomenclature on the ground that it was unnecessary.

But although accompanying fire involves no new term and no new principle, its application has in recent months assumed a tremendous new importance, and the details which govern its successful application have been studied with the minutest care by French general staff, infantry, and artillery officers. No written instructions on the subject are known to exist. The present report is based on a study of orders which have been

issued and conversation with artillery officers who have planned and executed successful accompanying fire in recent attacks.

Object.—The object of all accompanying fire is to precede and assist the infantry advance. This is an old principle which involves the statement of an ideal which modern field artillerymen have long tried to realize. The first attempts made during the present war were often disastrous to the infantry, and examples of costly errors can be found as late as the British fighting on the Somme in July, 1916. The successful French attack in front of Douamont December 15, 1916, involved a tremendous amount of accompanying fire, which achieved its object almost perfectly. There is good reason to believe that the same methods will be used in the spring offensives.

Ideal results.—The ideal result is attained when the first infantryman follows into the objective the last shell of the accompanying fire. Unless this is done the defenders who have taken cover during the artillery fire will have time to man the trenches and bring machine guns into action at the last moment and may either successfully defend the position or make its capture very costly. If, however, there is no interval between the arrival of the last shell and the first infantryman, the defenders are necessarily caught in their shelters and will be killed or captured. This ideal result can never be entirely attained, and it is a hard but accurate reasoning which states that it is better to lose a few men by friendly artillery fire than to lose many and have an attack fail because the defenders have had an opportunity to man their trenches and machine guns in the interval between the last of the accompanying fire and the first wave of the assault.

Amount of artillery.—The number of guns shown in figure 1 for a division during the war of stabilization included only the normal divisional artillery of one regiment of three groups of three batteries each, one battery (12 guns) of 58 mm. trench mortars and 6 old-model heavy batteries in addition.

The artillery is always heavily reinforced for an attack by the addition of artillery from other divisions and corps and army artillery. During the recent visit to the artillery of a division it was reinforced by three groups (6 batteries) of modern 155 mm. howitzers and a battery of 58 mm. trench mortars for a very minor operation, the corps artillery received a total reinforcement of seventeen 155 mm. batteries for the three minor

operations involved. At a division maneuver held early in March, the divisional artillery included the following:

	Groups.	Batteries.	Guns.
75 mm	6	13	72
155 mm	4	8	32
220 mm	1	2	8
Total			112

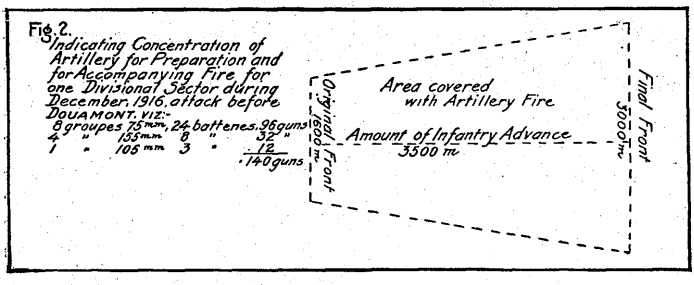
with the following trench artillery:

4 batteries ---------- 58 mm.
2 batteries ---------- 75 mm.
1 battery ---------- 240 mm.

The divisional artillery commander of a division which took part in the attack in front of Douamont in December, 1916, gave me the following figures for the artillery actually employed in the support of his division, viz:

	Groups.	Batteries.	Guns.
75 mm	8	24	96
155 mm	4	8	32
105 mm	1	3	12
Total			140

exclusive of trench artillery, for approximately 9,000 rifles. The front occupied by the division before and after the attack, the amount of advance, and the area covered by artillery fire is shown in figure 2.



Planning the attack.—The greatest cause of disaster in the execution of accompanying fire has been the failure to syn-

chronize the advance of the infantry line and the advance of the artillery fire. Attempts at continuous liaison which hoped to keep the artillery always informed on the position of the infantry have often been unsuccessful, not only on account of the difficulty of maintaining the liaison but also on account of the difficulty of controlling the artillery sufficiently to change continually the rate of progressive fire. After many such failures there grew up the later practice of attempting to predict the rate of the entire infantry advance by a careful study of the terrain and the map, and planning the rate of progression of the artillery fire accordingly. But this also proved difficult, because so many unforeseen circumstances altered the rate of the infantry advance and threw out the calculations. The methods which have brought success have involved a combination of the two previous methods. The basis of the present method remains the careful predicting of the rate of the infantry advance, the planning of the rate of progression for the accompanying fire and its execution by the watch; but the infantry advance is first predicted only from the initial point to an intermediate objective. When this intermediate objective is reached, the liaison between the infantry and artillery is depended upon to establish this fact, and an interval of time is allowed, so that there is opportunity for the infantry to reorganize under the protection of artillery fire and to send a second wave forward toward the second intermediate objective at a rate of advance previously predicted.

Failure in any detail involves general failure; but the opportunity for reorganization at the intermediate objectives and the possibility that, with good liaison and good command the time spent at each intermediate objective may be varied, gives sufficient flexibility to the general plan to make success a possibility. This method was successful before Douamont December 15, 1916.

Form of orders.—The artillery orders should include not only both a definite statement of the plan and the methods prescribed for its execution but also a chart showing the point of departure, each intermediate objective and the final objective, all with the appropriate hour and minute plainly marked. Both the plan and the chart are essentially *time-tables.* Such orders can never be properly drawn up unless there is complete professional and moral liaison between the infantry and the artillery and a most accurate and painstaking study of the map and of aerial photographs. In no other way can the probable rate of

infantry advance be predicted. The interpretation of aerial photographs has become a science and is done in each army corps by the officer in charge of the information service.

Both the written orders and the chart should show:

(*a*) The point of departure.

(*b*) The hour of departure or the hour "H."

(*c*) Each intermediate objective.

(*d*) The progression of the accompanying fire between each two points given for each two minutes.

(*e*) The length of time to be spent at each intermediate objective.

(*f*) The new hour of departure from each intermediate objective, or the hour "H plus n."

A general idea of a chart is shown in figure 3.

The hour of departure depends entirely upon the success of the artillery preparation. Formerly an attempt was made to determine exactly the length of time necessary for the artillery preparation and to order the launching of the infantry assault at the conclusion of that period. This practice involved tremendous British losses on the Somme even as late as November, 1916, because the necessary time to prepare an attack can never be definitely predicted. The present French method consists in issuing preliminary orders which state that on the *jour "J"* and at the *hour "H"* such and such an attack will be launched, and that previous to this day and hour the artillery preparation will be made. The commanding general keeps in touch with the progress of the preparation by means of aerial reconnaissances and especially by means of aerial photographs. Firing is stopped in some cases for 30 minutes, to allow smoke to clear away and photographs to be taken. As the preparation nears a successful conclusion, the *jour "J"* is announced in strictly confidential orders, but the *hour "H"* is never announced until every possible precaution has been taken to insure that all enemy positions and machine-gun emplacements have been destroyed. Aerial reconnaissance and photography are kept up until the last moment, which result in the commanding general having in his possession photographs taken 30 minutes before his decision is made. The *hour "H"* is then announced, and the attack is made according to the preliminary orders. In this way every possible provision for success is made.

Rate of advance.—Naturally the rate of the infantry advance is extremely variable. At maneuvers seen recently at Fourth Army Schools it was computed at both 75 and 50 meters per

minute. In planning the successful French advance from Douaumont on December 15, 1916, on account of the mud, which was in some places knee-deep, the rate was placed at 25 meters per minute.

Artillery formations.—In one of the divisions in the attack referred to the three batteries of each group were placed one in front of the other and a front of 300 meters was assigned to each group. In division maneuvers recently seen by members of the mission at Mailly the artillery was echeloned at distances varying from 500 meters to 3,000 meters behind the front line. The more distant units only fired during the first advance and were followed later by the others. As soon as the second units fired the distant ones changed position forward. This appears to have been the application of a principle generally understood in our service for a forward movement.

This formation apparently disregards all safety precautions which were considered necessary before the war; but it has

Fig. 3. *Progression of Accompanying Fire.*

been repeatedly observed at the front that neither artillery nor infantry hesitates to place itself in front of artillery in action, and that the idea of one battery "blanketing" the fire of another never seems to be considered.

Mid ranges are usually employed.

Frequency and amount of range changes.—Accompanying fire is necessarily progressive fire. The frequency and amount of range changes depends entirely upon the predicted rate of infantry advance already referred to. In the December attacks mentioned the range was changed 50 yards each 2 minutes. In other attacks which have been described by the artillery commanders concerned the range has been changed 25 yards each 30 seconds. It is believed that the range change of 25 meters is more common and is made as often as the predicted rate of progression permits. *Volley-fire* sweeping is usually employed, the range changes being strictly kept in the hands of officers who use synchronized watches. Watches are synchronized from data furnished by telephone from division headquarters about three hours before the hour "H," and again a few minutes before.

In calculating the range changes, the *slope of the ground must be considered.* Computations must be made on the actual horizontal advance of the infantry in a given time interval.

Ammunition used.—When there are enough batteries available it is considered advisable to have three batteries firing in advance of each infantry unit which occupies a front of from 200 to 300 meters. One battery should establish a fire from percussion shell with *instantaneous fuses 130 meters in front of the infantry;* another battery should fire *timed shrapnel with the point of burst 130 meters in front of the infantry,* and the height of burst carefully adjusted *between* 2 and 3 mils; and the third battery should *fire percussion shrapnel 80 meters in front of the infantry.* Percussion shrapnel is, of course, a comparatively inefficient projectile, but at the same time it is also the one which the infantry can approach the closest and which serves the purpose of having some sort of projectile go into the objective as soon as possible before the first infantryman, as was referred to in paragraph "Rate of advance," on page 45. This use of percussion shrapnel is at present anticipated in the fourth French Army, and is highly recommended by divisional artillery commanders who have used it.

Fire during halts.—When the infantry reaches any given objective it is necessary that the supporting artillery which has been delivering the accompanying fire should prevent defensive measures on the part of the enemy during the halt. To this end one battery in each group should establish *a barrage just ahead of the objective gained,* and the other two batteries should establish a *raking fire* (*tir de ratissage*) between the objective gained and the next objective. This is established with progressive fire from one battery and retrogressive fire from the other battery delivered on the zone between the two objectives. This procedure prevents the arrival of supports.

Rate of fire.—Contrary to a prevalent opinion, the rate of fire in accompanying fire is merely accelerated fire and can not be called rapid fire. It usually does not exceed four rounds per piece per minute. True rapid fire is used only in emergencies.

The reason for this comparative slowness is to be found in the fact that in some cases such fire must be kept up without stopping for four or five hours, and that there is a limit of physical endurance for gun detachments, and also in the fact that the experience of the war has shown that the life of guns can be greatly prolonged by moderation in rapidity of fire and

care of matériel. (See Report No. 63 on Inspection and Care of Matériel, Mar. 16, 1917). It has been stated on good authority that it is more economical for a government at war to send 5 batteries to the front to fire 4 rounds per minute than to send 1 battery and permit it to fire 20 rounds per minute. In the delivery of any prolonged fire it is necessary to adopt the general rule in each battery of using only 3 guns habitually and allowing each gun to be cooled and cleaned.

Conclusion.—In conclusion it may be stated that, so far as the technical execution of barrage fire and accompanying fire is concerned, it is believed that our present firing instructions and the methods generally used in the United States Artillery would permit our batteries to do everything which might be required of them in modern trench warfare or in war of movement as it is now discussed in France. The staff work connected with the planning of such fire is, on the contrary, something which can be created only by the most careful study of existing methods and past mistakes. From the point of view of matériel, it is not believed that our present 3-inch shell, with a base fuse, can be used successfully against personnel to the extent that the French shell is used, and that the use of timed shrapnel over friendly infantry, even with a calculated burst of 130 meters in front of them, would require a degree of training on the part of gun detachments in the setting of fuses and the centering of quadrant bubbles which is out of the question with newly-organized batteries. Furthermore, it is considered doubtful if matériel which depends upon a spring column for return to battery could satisfactorily stand the wear and tear of such prolonged firing.

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