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THE 240-MM. HOWITZER
(See *Current Field Artillery Notes*.)

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IMPRESSIONS OF A CORPS MUNITIONS OFFICER

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AWARDED HONORABLE MENTION, FIELD ARTILLERY JOURNAL PRIZE ESSAY COMPETITION, 1922

THE corps munitions officer is on the staff of the chief of artillery at the corps headquarters. He should be a major or a captain with one lieutenant assistant. Two noncommissioned officers are required for clerical duties. One officer who has been selected as a corps munitions officer for a new corps not yet in line should be attached to a corps staff in line for instruction. The corps munitions officer should be selected from among the officers who have served at the front with divisional artillery and who have had combat service with a unit as small as the battalion. By such selection the officer will have a correct conception as to the actual difficulties of ammunition service in the advanced zone under shell-fire. Coming from corps or army artillery units he is too apt to underestimate these difficulties. His duties are outlined in the following paragraphs.

Coöperate and keep in close touch with the operations section of the artillery staff. Study carefully the prospective operations and all other plans originating in the operations office. Note particularly if any proposed change in positions or movement of artillery units will require a change in the ammunition supply system to accommodate the units moving. Know the general location the artillery will occupy in case of an advance or retirement. Work out a plan for the re-supply of ammunition to meet such likely changes.

Coöperate with the G-1 of the corps. Keep the G-1 informed as to changes in the location of ammunition dumps and notify him when a change of station of the motor section, corps artillery park, will benefit the ammunition supply. Give him advance information when the movement of ammunition will be above normal, giving him this information as far in advance as possible. Talk over the circulation with him, requesting changes whenever necessary. A time schedule can often be arranged so that the bulk of the ammunition trucks either follow or precede the supply trains, thereby decreasing the road congestion.

Study the circulation map of the entire corps area. Know the

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routes from army dumps to corps dumps and from corps dumps to those of the division and corps artillery brigades. Cover as many of these roads as possible, especially those roads from corps dumps forward. Ammunition which can be taken out of a dump and sent forward can be more easily put in it from the rear, so that the important part to be borne in mind is, can the ammunition be taken out by the combat troops without undue labor or loss of time? If not, then put the corps dump where they can. The movement of ammunition forward from the corps dumps is more difficult and more dangerous than bringing it up from the rear, requires much night work on poor roads and is at all times subject to shell-fire. To help the combat troops is the first duty; they have the greatest difficulties to overcome, their tasks must be lightened as much as possible and a careful planning of the circulation is a big step in the right direction.

Personally reconnoitre the proposed location of corps ammunition dumps, making sure the ground location is as favorable as the map location indicates. Take the commanding officer of the depot section, corps artillery park, along on such reconnaissances. He is the one who must maintain and operate the dump and will have many valuable suggestions to offer as to the prospects and possibilities of locations. Failure to make such a reconnaissance may reveal too late that the enemy has direct observation on the dump and by shell-fire is able to delay materially the movement of trucks to and from the dump. The roads may be in poorer condition than indicated on the map, unloading and loading facilities may be poor or the ground may be too soft to support the piles of ammunition.

Know all the roads used by ammunition trains down to those roads used by the battalions of division and corps artillery. Become thoroughly acquainted with the terrain of the entire sector and particularly with that part which lies ahead. Do not tour the back areas as many do, but keep in the advanced area, always looking for better dump locations or for ways and means to assist in solving the problems of transportation. A small improvement at these headquarters will lighten the work for thousands of others. Be prepared to advise and explain to division and brigade munitions officers of relieving divisions all terrain problems affecting the ammunition supply. No mistakes or waste of transportation should be made by these officers through lack of opportunity to acquaint themselves with the sector problems. The corps munitions officer has better facilities at his command to study such problems and to make personal reconnaissances, he must be ready to assist these officers by giving them full information about the sector.

Visit the ammunition dumps frequently, noting the general conditions and the handling of ammunition by the depot personnel.

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Ammunition must be handled and cared for in accordance with regulations. If the roads are in need of repair call on the G-1 for the necessary road troops. Visit brigade dumps if there are any, but do not criticize their work unless a better workable method or system can be offered to replace that in use. Determine if the conditions of the roads permit of night hauling under all conditions, either by trucks or horse-drawn trains. Officers from the corps artillery park can make some of the road inspections, but the munitions officer must himself make as many inspections and reconnaissance as possible.

Be prepared to give the army all the information about the sector it asks for.

The assistant to the corps munitions officer has charge of the receiving and consolidating of the various reports and all other office work of a routine nature.

The re-supply of ammunition is based on the daily ammunition expenditures and proposed plan of operation. To properly insure this re-supply the unit commanders must know the daily ammunition situation. Reports must be rendered, and rendered on time. They are made as brief as possible, giving only such information as is necessary for the information of the next higher commander.

The battalion headquarters must know at all times of the day or night the amount and kind of ammunition at the guns, in the battalion dump, if there is one, in the battalion echelon or combat train and the plan of re-supply of ammunition as it is expended. The regiment must have like information of its battalions and the brigade of its regiments.

The corps must have the same information down to and to include brigades of divisional artillery and the battalions of corps artillery. The information on the report must show the amount brought forward from the last report, the amount received in the last twenty-four hours, the amount expended for the same period and the balance remaining on hand. These reports must not be complicated by calling for further data, as no other information is needed.

Reports are by telephone and written. The telephone reports are expenditure reports for the last twenty-four hours. The written report is but a confirmation of the telephone report and gives further information about the ammunition situation. The battalion report must reach regimental headquarters by 12:30 P.M. No written report is submitted. The regimental report reaches the brigade by 1:00 P.M. and the written report by 3:00 P.M. The telephone report from the brigade is made to corps headquarters by 2:00 P.M. and the written report by 6:00 P.M. The telephone report from corps to army is made by 4:00 P.M. and the written report by 9:00 P.M.

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The use of code in telephoning ammunition expenditures should be discontinued. The enemy intelligence service totals very well the ammunition falling in his sector, at least our own troops count very accurately the "incoming" shells and are more or less indifferent to the number of "outgoing" shells. It is somewhat unfair to our own artillery to presume that the enemy has not received all the ammunition intended for him. On several occasions messenger pigeons have brought the ammunition expenditures to corps headquarters, usually a few days late. Codifying the expenditure is not at all necessary.

Twelve noon is believed to be the best time to close reports. Much of the ammunition service, especially that part in the more advanced or regimental area, is night work. This work, however, is generally finished by daylight, at least by 9:00 A.M., and the organizations will have a definite knowledge of their ammunition situation by noon. Furthermore the artillery is not as active in the late morning and early afternoon as it is in the late afternoon at which time plans are being formulated and transmitted to organizations for the important night operations and officers are busy on these plans. All work which can be done satisfactorily before the late afternoon rush should be finished and out of the way. If reports can be sent from corps headquarters by 6:00 P.M., the remainder of the night can be devoted to the arrangement of the work for the next twenty-four hours. Furthermore, telephone lines are fairly free from 12:00 noon to 2:00 P.M., when reports are being made, while from 2:00 P.M. to 10:00 P.M. they are very busy.

Reports from the corps ammunition dumps close at 12:00 noon and should be in the hands of the corps munitions officer as soon thereafter as possible, but not later than 2:00 P.M. Knowing the status of this ammunition early in the afternoon, allotments of ammunition can be made to the brigades when they make their telephone reports, thereby decreasing the number of telephone calls. This report must be complete and must show the amount and types of ammunition, projectiles, powder and fuzes, both received and issued.

The re-supply of ammunition being automatic, based on the expenditures and the proposed artillery plan, it is only necessary in making requests for re-supply for munitions officers to call the attention of the munitions officer next higher up to the recent expenditures and immediate plans to receive new allotments of ammunition, no figures as to requests for coming operations need be given over the 'phone. This request is made when the daily expenditure report is given, combining two telephone calls in one. The earlier the overhead arrangements can be made, the earlier truck trains will receive their orders and a consequent increased efficiency in the performance of the night's work. At the time of 'phoning

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the probable time of arrival of the ammunition at the point of transfer can be given to the lower unit. Requests for special shells, gas and smoke should be made in writing at the bottom of the written report, the answer being given to the lower unit by telephone.

The amount of ammunition which can be maintained at the battery position depends upon the capacity of the transportation. No more ammunition should be requisitioned for nor issued to an organization than it can transport in the next twenty-four hours, munitions officers planning work ahead for trains for this period. It is useless to allot to any organization three to four days' fire which it cannot haul away in as many days; before the work is completed, the whole situation may change and the ammunition may not be required or is badly needed by another organization. No credit should be allowed to run more than forty-eight hours for brigades. Instances like the following were of frequent occurrence, showing that officers could not estimate the required amount of either transportation or ammunition. A major from the XX Division Headquarters breathlessly entered the corps munitions office and wanted 5,000,000 rounds of calibre .30 in five minutes. His wants were immediately filled on paper, 5,000,000 rounds of calibre .30 in five minutes, but four of the five million rounds were re-issued to other organizations in line and in reserve. At the end of four days only seven to eight hundred thousand rounds had been removed from the dump by this division. No more being required, the balance was dropped from the divisions return. With the transportation at his disposal the major could not have moved the ammunition he asked for in two weeks.

An officer should be detailed as a munitions officer only after having been fully instructed as to what is expected of him and the duties he is to perform. It appears that any officer was detailed to fill the position of corps munitions officer with no idea at all of what his duties were and at once made responsible for an ammunition supply of an organization the size of a corps. Munitions officers require some special training. He must be a good artilleryman prior to his detail to the staff. He should receive special instruction in kinds of ammunition, powder, projectiles, fuzes and the percentages issued for all calibres. Furthermore, he should receive instruction in the operations of artillery, maintenance of ammunition dumps and the care of ammunition in the field; better still, if the officer can be attached to a corps in line as assistant, his training will be materially bettered.

The officers and noncommissioned officers of the depot section, corps artillery park, must be thoroughly acquainted with the correct methods of handling ammunition in the field. They should receive instruction to cover the following points: The control and movements of truck trains in and about the dump; spacing and arranging of piles

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of ammunition, the kinds of fuzes, projectiles, powders and the percentages used; the operation and maintenance of ammunition dumps and their proper locations. The personnel at the corps dumps, in the Chateau-Thierry sector, was entirely changed three times in ten days during the month of August, all of which personnel was lacking in training in the handling of ammunition. As a result many errors were made in issuing powder; the wrong powder was issued with the wrong projectile or fuzes given out in improper proportion.

Ammunition problems, together with technical information essential in firing, were not complete in the training given artillery officers; at least, some artillery officers were surprisingly ignorant of the types of fuzes, charges and projectiles used in their own guns. For example, one battery commander of 75-mm. of the XX Field Artillery Brigade at Chateau-Thierry asked the officers of the depot section for information about ammunition in general and particularly when certain fuzes should be used, *i.e.*, with what projectile, on what kind of ground, degree of slope, etc. He had hiked four to five kilometres to the rear for this information and on leaving remarked that he had been firing for twenty-four hours and was not sure whether he should use long or short fuzes. The next day four officers from the same regiment reported to the ammunition dump for similar information. Another, a field officer, who had been a battalion commander of 155-mm. G.P.F., had taken the prescribed course of training for such artillery in a French school, had had one month's active service at the front with his battalion and was later connected with the ammunition service, asked at the end of this period if projectiles fired in the 155-mm. howitzer could be fired in the 155-mm. G.P.F. Such ignorance on the part of artillery officers is an injustice to the infantry it is supporting. Many other instances of such ignorance occurred. Greater emphasis must be placed in the schools on the use of different kinds of ammunition, not only for the calibre the officer belongs to, but all calibres, and on the ammunition service in general.

The supply of ammunition as previously stated depends primarily on the transportation. The first consideration then in establishing a corps dump is to select a location with such loading and unloading facilities as will insure a rapid movement of trucks in and out of the dump. Ammunition train personnel prefer going ten to fifteen kilometres further to a dump with good roads in and about it than to go to a dump much closer but with poor loading facilities.

Some officers advocate the use of wayside dumps, the reason given being that no suitable cross-road or place to turn around can be found, these wayside dumps to be established at any good spot on a straight road. Such a location may do very well for the smaller dumps of regiments and battalions when they cannot find better ones,

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but at a corps dump, where as many as one hundred and fifty trucks may arrive and as many more depart for the front daily, it is no easy matter to turn around so many trucks on a one-way road. To avoid such turning around a circuitous return route is often assigned the ammunition trains. Often an examination of this route itself by the munitions officer will reveal a better dump location on the circuit and solve the problem of the wayside dump. Return circuits for trains, both coming from the rear and going to the front at a wayside dump, are seldom found. Careful reconnaissance will usually solve such difficulties. Wayside dumps for the corps should be discouraged.

Cross-road locations should be avoided except when they are out of range of enemy shell-fire and off the main axial road. The dump should be located on a side road on a circuit of three to four kilometres, the main axial road forming a part of the circuit.

The number of dumps to be operated by the corps depends on the number of good axial roads. Assuming three divisions in line are assigned to the corps with one good axial road for each division, it is believed that for offensive action two dumps should be operated. If but one dump is operated considerable congestion occurs on roads leading to and adjacent to the dump. Where there is but one good axial road in the sector, but one dump can be operated. Congestion can be lessened, however, by making the dump longer, spreading it out, or it may be advisable to have two dumps on the same road at some distance apart. The operation of two dumps decreases the traffic to any one point and the congestion will not be serious at either. Each dump will be smaller, more easily concealed and the dangers from explosions decreased in proportion to its size. Operating two dumps the ammunition should be distributed about as follows: In one, the artillery ammunition for two brigades of divisional artillery and 2,000,000 rounds of calibre .30; in the other dump, ammunition for one brigade of divisional artillery, ammunition for the corps artillery, the balance of the small arms ammunition and pyrotechnics. If the sector is a quiet one, such as a training sector or trench sector, more dumps will have to be maintained in proportion to the front of the sector, or, no corps dump at all, ammunition being hauled direct to batteries from army dumps in transportation of the brigade.

Short roads within the dumps are most easily constructed after the corduroy type using planks, the planks being taken up and re-used in successive dumps. Too much faith should not be put in building such roads; reconnoitre more and locations may be found where it will not be necessary to build them.

Traverses for the corps, division and regimental dumps are not recommended. These dumps are too mobile to warrant the expenditure

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of the time and energy in constructing them in offensive operations; they belong to trench sectors. The corps dump in the Meuse-Argonne was moved four times in forty-seven days. Under such conditions it is doubtful if any benefits would be derived from their construction. In as much as little ammunition is stored in a corps dump at any one time, there can be little loss from shelling or from interior explosions. It requires many direct hits to destroy a dump; the corps dump at Culsy was shelled at irregular intervals for ten days, and while several casualties resulted, not more than five hundred 75-mm. and two hundred powder charges for the 155-mm. were destroyed during this period.

Third Army Corps dumps were located at different times as given in the following paragraphs. The dump on August 1, 1918, was at Mont-St. Pierre within a triangle of three roads. The apex of the triangle was to the north, the legs were about nine hundred metres long and ran in a general north and south direction. The base was parallel to the Marne River and was about two hundred metres long. This road was a part of the main axial road of the corps. A road went north from the apex of the triangle. This arrangement of roads made an ideal "turn around" for the truck trains. Artillery ammunition was piled along the west road, the better of the two, and small arms ammunition on the east road, somewhat higher on the side of a hill. Scattered groves of trees concealed the dump from aerial observation. Trucks could enter from the north, stop at any of the ammunition piles, turn around the dump and leave by either the south-north road or by the Marne River road running to the northwest. The whole was well arranged to give the best of service.

The dump was next established in the Bois Meuniere, southeast of Coulanges. The 75-mm. and 155-mm. were piled together near the north edge of the wood, while small arms ammunition, gas shells of all calibres and the corps artillery ammunition were one kilometre to the southeast in another part of the wood. Both dumps were served by one excellent road. Short roads or spurs running into the dump permitted the turning around of the trucks. The main road ran north from the dump, joining the main south-north road of the corps at the southern outskirts of Coulanges, three kilometres away. Trucks returning to the rear followed the road in a southerly direction, striking the main corps road ten kilometres to the south and west. The site on the whole was excellent.

When the combat units crossed the Vesle River, temporary dumps were established just south of the river, others to be established on the north bank as early as possible. The corps was relieved before the corps ammunition dumps were established on the north bank.

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Prior to the attack in the Meuse-Argonne on September 25–26, 1918, the dumps of the sector were located in and around Verdun. All were easy of access, the roads were in excellent condition and no particular difficulties were experienced in handling the ammunition to or from them. Three days prior to the attack ammunition for the corps was advanced to Germainville, thus bringing the ammunition twelve to twenty kilometres nearer to the battery positions. This dump was one hundred metres south of the village and on a circular road five hundred metres in circumference with good facilities for stacking and caring for ammunition. One good road entered the dump from the south which was used to bring up ammunition from the rear. One poor road went to the northeast and served the right division. A better road ran to the west and joined the main axial road of the corps one and one-half kilometres away and served the other two divisions and the corps artillery.

With the second advance, ammunition was to be sent across the old "No Man's Land," and as far as Malancourt, if not beyond. The corps ammunition trains followed the divisional artillery. Due to congestion on the main south-north road, which became a one-way road north of Esnes, trucks could not get through; the first trucks were therefore unloaded and turned around at Esnes. Trucks were later pushed through to Cuisy, the first convoy of twenty-five trucks making the trip in forty-eight hours. The dump at Cuisy was one-half kilometre northwest of the village on a small triangle of roads formed by the intersections of the Cuisy-Septarges-Montfaucon roads. The location was not particularly good, either for the storage of ammunition or for truck circulation, and was within range of the enemy's heavy artillery, but it was the only location possible. The difficulties of the ammunition service in crossing the old "No Man's Land" from this time on were very great and most trying. Twenty-four hours were required to make the round trip and then many trucks were ditched, steering arms and springs broken with the temporary loss of the truck. Much credit is due the officers and men of the First Corps Artillery Park (attached) who made the trips to this dump. Those members of the park who operated this dump at Cuisy were subjected to enemy shell-fire for ten days yet operated in a most satisfactory manner.

Congested traffic in and about Cuisy and Montfaucon made it advisable to reestablish the dump four hundred metres south of Nantillois. This location was in an old German railhead which prior to this date, October 26, 1918, had been under heavy enemy shell-fire. The unloading and loading facilities were good. This dump was operated but one week, then abandoned and moved to Romagne.

The dump at Romagne was in a large railroad yard just north of

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the village. Facilities for operating here were the best of any location in this sector. The roads within the dump accommodated one hundred trucks at a time while the excellent south-north road bordered on the dump itself.

One day before the Armistice the corps ammunition crossed the Meuse River at Dun-sur-Meuse and the dump established in the town of Milly. This dump was never used. It was located on a triangle of roads, perimeter about three kilometres. The apex of the triangle was at Dun-sur-Meuse, the west leg ran north to Stenay and Sedan and the east leg from Dun northeast to Milly. The base of the triangle ran from Milly straight west to the Dun-Stenay road and was about one kilometre long.

Not more than one dump was operated at any one time in the Meuse-Argonne sector, there being but one axial road for the entire corps. The operation of two dumps was contemplated after crossing the Meuse River.

Transportation was provided for by Packard three-ton and Nash Quad two-ton trucks, about one Packard to five Quads, one hundred and forty in all. This transportation was augmented from the army parks by a daily allowance in tonnage. The trucks from the army were all of five-ton capacity and operated by French personnel. During the last two weeks in October from ten to twenty five-ton trucks from the corps supply train hauled ammunition. The roads were in such poor condition that standing orders prohibited any truck from carrying more than a three-ton load. Trucks which violated these orders frequently stuck in shell-holes and blocked traffic. Many such trucks were unloaded where they were and continued around the circuit, the ammunition salvaged later by smaller trucks. All of this was a waste of transportation.

Under normal conditions for all seasons, trucks of more than three-ton capacity should not be used in corps or division areas. Trucks of greater capacity should be confined to army and S.O.S. areas. The larger trucks are too hard on the roads, stick in mud holes and stall on grades. Trucks of less than three-ton capacity are just so much waste in tonnage, a two-ton truck being practically as hard on roads as a three-ton truck and requires the same personnel to handle.

The number of trucks as given in existing tables of organization for the corps artillery park is sufficient if all are of the three-ton class, and the Army is ready to augment the transportation in large offensives. All, however, must be kept running, which means a better system of supplying spare parts must be maintained.

The narrow-gauge railway is primarily for hauling heavy ammunition and is admirable for the purpose, but is too often used to transport bulky materials such as rations, hay and grain and lumber,

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while trucks carry the much heavier loads of ammunition over the roads.

The corps artillery park must be under the immediate control of the chief of corps artillery at all times and not loaned or sent to divisions. Commanders of artillery brigades often request the delivery of ammunition direct to their batteries in corps transportation. This kind of assistance proved a mistake whenever tried; trucks were a long time in returning, often took the wrong roads, and were frequently misused by the officers to whom they reported. Control over trains disposed of in this manner is temporarily lost. The line of communications is too long to dispatch trucks from corps headquarters to batteries and hope for an equal and timely distribution of ammunition among the batteries. One round trip from army dump to battery position requires forty-eight hours and the loss of control for such a time is too long. Under this system a few trucks go to each battery position, necessitating the splitting of trains into small sections commanded by a noncommissioned officer. All of such chiefs of sections then must know the entire road circulation of a corps and be provided with all road maps covering the areas. Batteries are moved often so that trucks carrying ammunition to them experience great difficulty in locating the new positions. Such changes in battery positions are not known at corps headquarters in time to redirect the trucks to the new position, whereas such redirection can be given to the ammunition train of the artillery brigade from artillery brigade headquarters, these headquarters knowing the positions the batteries take immediately upon occupancy.

Divisions are best aided by keeping the corps dump well advanced. In this way the hauls of the division are shortened and theirs becomes a problem of distribution rather than one of long hauls. To aid one such organization by hauling direct to batteries means that the normal re-supply of ammunition to the corps dump is stopped while the reserve built up in the corps area is decreased by other organizations drawing upon it. Later, on account of this depletion of the corps reserve, trains from all divisions will be required to make forty-eight-hour trips to army dumps for their ammunition. Help the divisional artillery by keeping the dumps well forward. (N. B. In a quiet sector the corps dump is not desirable, ammunition being hauled direct to battery positions from army dumps in division transportation.)

The question has often been asked as to why a corps dump at all, why not haul directly to the battery positions? Some corps have operated without a dump. Where no corps dump is operated there is much confusion in trucks not finding the right battery position and being materially delayed in returning. In offensive operations the corps dump fills a long gap in the line from army dumps to

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battery positions. The haul between these two points is much too long to retain good control over the train movements on this route. The question then really is, shall the distributing point for divisions be well forward or far in the rear? If the distributing point is advanced to the divisional area, say to a division or artillery brigade dump, loss in ammunition and, even more important, the truck movement will be held up on account of enemy shell-fire. Furthermore, few sectors will be found in an offensive operation where three such divisional dumps can be located. Two such dumps will be combined or at least located closely together with resulting increased congestion on roads under shell-fire and no coördinating officer to control the distribution. If the distributing point is at the army dump, then it is too far to the rear to properly control the distribution of the ammunition and the dispatching of the ammunition trains. The solution is to operate the corps dump as the distributing point for divisions. It is kept well forward, yet normally is just out of range of enemy shell-fire; its operation is supervised by the corps munitions officer, an equal distribution to brigades can be made to carry out the program, and the division hauls are shortened. The corps will then have good control over the ammunition *en route* from army dump to corps dump and the brigade good control over their ammunition from corps dump to battery positions.

A small reserve is maintained at the corps dump. This reserve is never large enough to constitute a real reserve, but there is a sufficient amount of ammunition on hand to keep the divisional transportation moving for twenty-four hours in case delays occur in moving ammunition forward in corps or army areas.

There are several disadvantages to a corps dump. It requires the permanent detail or organization of two hundred and fifty to three hundred men to handle the ammunition. If the dump is operated at all this detail cannot be dispensed with. There is a considerable delay of trucks while loading and unloading. This time lost can be kept at the minimum by keeping the depot section at the corps dump at full strength, thereby loading rapidly, also by coördinating the movements of trains so that no two arrive at the dump at the same time and that those from the divisions arrive at the dump after the trucks from the rear have brought forward the day's supply. The roads in the vicinity of the dump must be maintained by special troops from engineer and pioneer regiments.

It is not believed best to advance the corps dump on the first day of an advance in order to keep up with the divisions. In an advance the divisional trains are required to relocate the new battery positions or battalions, not by any means an easy task. These trains then should not be required to find the new loading place as well. If the dump is not moved forward at this time, single trucks from division

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trains will know where to report for ammunition after unloading at battery positions and know where to report for new dispatch orders. Furthermore, the distance advanced the first day will not have a material effect on the time required for trucks to cover the additional distance advanced. Assuming that a considerable advance is made on the second day of attack, the total distance gained will require that the division's haul must be shortened, *i.e.*, corps ammunition must be moved forward. However, in the shifting and changing of artillery the number of moves it makes has a direct bearing on the ammunition expenditures. Artillery cannot move, dig in and fire large amounts of ammunition in one day, so the more the moves the smaller the ammunition expenditures and the problem for division trains becomes more and more one of good distribution. On the third day of attack the corps dump should be advanced, the distance depending on the ground gained and the general situation. A corps dump should never be advanced less than ten kilometres straight forward, unless to move a shorter distance will be an improvement in loading and truck circulation conditions at the dump. A distance less than this is of little help to a division.

Moving on "D" day lends to the general road congestion. The artillery should not be held back by corps ammunition trucks on the roads while the general road movement of troops will greatly delay the truck trains. Corps trucks can be used to a better advantage the first two days in hauling ammunition to the old dump and insuring a reserve supply well forward. Too much artillery on the one-way road in the Meuse-Argonne held up the ammunition for the divisional artillery and cut the ammunition supply system for two days. The supply to divisional artillery comes first and must have the right of way over ammunition for the corps and army artillery. On the third day of attack the roads are comparatively free from horse-drawn vehicles and the dump can then be established further forward. The ammunition brought up meanwhile to the old dump forms a good reserve in case of a counter-attack along the corps front.

The motor section, corps artillery park, must not be moved oftener than absolutely necessary, much valuable time being lost with every move. It should be located somewhere on the circuit the trucks follow from army dumps to corps dumps. It should be located near the filling points. Assuming that it requires twenty-four hours for one round trip, then in case of emergency ammunition can be taken from army dumps to corps dumps in twelve hours, or half the time required for a round trip, whereas, if located near the corps dump or unloading point, it will require twenty-four hours to bring up ammunition.

The amount of ammunition designated to be at the battery positions in the Meuse-Argonne sector was far in excess of the needs

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of the operations. In the early phases plans called for three days of fire to be *at* the battery positions and practically a full three days of fire was at the emplacements of the divisional artillery brigades on the day set for the attack. About ninety per cent. of this ammunition was unboxed and piled in and around the battery positions. Expenditure reports for the first twenty-four hours show that the maximum *one* day's fire for the different calibres was not exceeded by any calibre guns but the 75-mm. and these fired only twenty-nine rounds over one day's allowance. This then left two day's fire unboxed and scattered in the area when the artillery moved forward, all of which ammunition had to be salvaged before more ammunition came from the general army reserves. This work of salvaging presented many difficulties. Trucks, and in many places horse-drawn vehicles, could not go into the battery positions so that the ammunition had to be carried out by hand. Special details were left behind to do this work. It would have been much better if only a part of the three days' fire had been at the positions and the remainder near at hand in small piles, boxed, along the road ready to be picked up by truck trains or to be carried to the guns for firing. This error of having too much ammunition unboxed and at the emplacements was corrected later in the operation. The amount was cut to two-thirds of the original amount, or about two days' fire, and of this amount only that required for immediate use with a small reserve to be unboxed, the remainder to remain boxed and piled in places convenient to loading into trucks.

The expenditure allowance as published was the maximum allowance per day. An examination of the table of expenditures for the Third Army Corps in the Meuse-Argonne shows the average per gun for forty-seven days to be as follows:

- 75-mm. fired 94 rounds per gun per day. Maximum expenditure was 329 rounds per gun per day for one day only. On but three other days fired more than two-thirds of one day's fire per day.
- 155-mm. CS/17 fired 39 rounds per gun per day. Maximum expenditure was 196 rounds per gun per day for one day only. On but one other day fired more than two-thirds of one day's fire per day.
- 155-mm. LS/17 (Corps Artillery) fired 20 rounds per gun per day. Maximum expenditure was 88 rounds per gun per day for one day only. On but two other days fired more than one-half of one day's fire per day.
- 105-mm. (Corps Artillery) fired 24 rounds per gun per day. Maximum expenditure was 110 rounds per gun per day for one day only. On but five days fired more than one-half of one day's fire per day.

IMPRESSIONS OF A CORPS MUNITIONS OFFICER

It should be noted here that the ammunition expenditure would have been one-fifth more than the amounts given above had the road facilities permitted of a more rapid supply of ammunition. From time to time orders were issued to artillery commanders calling their attention to the difficulties of the transportation service and to economize in ammunition whenever possible. Many staff officers, particularly those from other branches of the service, speak of a day's fire as an every-day occurrence. It then becomes an often-discussed question among the staff, the artillery usually getting the worst of it. A day's fire should be defined as the amount of ammunition which can be replaced every twenty-four hours under normal conditions by the combat trains and the ammunition train artillery brigade.

During an operation the fewer the types of ammunition to be handled the more satisfactory is the supply. Special types in rapidly changing operations are needed at once or not at all. It requires all the available transportation to re-supply the daily expenditures of the normal types and any trucks used for special shells means the corresponding decrease in tonnage of normal types. To fill then an urgent need of special ammunition, corps or army trucks are sent to battery positions and usually take up an oversupply. Much of the ammunition is not used and the transportation which brought it up is wasted. Special shells should be fired by corps or army artillery, both better able to estimate the ammunition requirements.

The supply of small arms ammunition should be controlled by the artillery munitions officer both at the corps and at the army. This insures coördination in the movements of the infantry and artillery ammunition, removes any possibility of establishing two dumps in the same place and saves transportation. It must be remembered, however, that the supply is not all artillery, but that the infantry supply comes first and the officers in charge at these headquarters must always take care of the infantry's needs first. In the supply, then, the infantry ammunition comes first, then for the divisional artillery, 75-mm. and 155-mm., the corps artillery, and lastly, the army artillery. The smaller calibre has priority toward the front when there is not sufficient transportation to carry all. The transportation of small arms as compared with transportation of artillery ammunition is negligible, however, as not one truck in ten carries ammunition for the infantry. If for no other reason than for the control of transportation the two services should be combined under the artillery munitions officers at these headquarters, should remain on the artillery staff and should not be under G-1 or G-4 in the corps.

In the divisions the handling of the infantry ammunition should be with the G-1 of the division and not with the artillery brigade.

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Then, if the artillery and infantry become separated through relief of one and not the other as has happened, each arm will have its own munitions officer. Besides, it requires two officers to properly handle the supply of ammunition for both arms within the division and there is no reason why the two offices should be combined. One lieutenant from the infantry should be detailed as infantry munitions officer for the division. His duties are of a distributing nature, requiring careful distribution and arrangement of many overhead details, but does not require the use of many vehicles. The transportation should come from the division supply train and only in great emergency from the ammunition train of the artillery brigade, the latter being under the control of the artillery brigade commander.

The corps munitions officer requires the use of one touring car, Dodge type, for his personal use, and it should not be available for other officers of the artillery staff except by special permission from him.

The following equipment is required for the office in the field: One typewriter, three small folding tables (2' × 3'), one field desk (small size), two lock boxes for stationery and office supplies (made from fuze boxes picked up in the field), twenty-four file holders, the use of a mimeograph from time to time (usually the one in the intelligence section is available). One desk telephone properly connected at all times is necessary and in constant use.

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LECTURE TO SWISS OFFICERS BY LIEUTENANT-COLONEL OF ARTILLERY H. CORDA

CHIEF INSTRUCTOR IN TACTICS AND MILITARY HISTORY AT THE SCHOOL OF ARTILLERY, FONTAINEBLEAU

Translated from the *Revue Militaire Suisse*, May, 1921

PART II†

THE EFFORT TO OBTAIN SURPRISE

SURPRISE is of a "strategic order" when applied to the general direction of operations, that is to say when the offensive is launched in a region where the enemy cannot either carry out a counter-manœuvre, or bring up his reserves in time to be effective.

It is on the contrary of a "tactical order" when the enemy is taken by surprise by the exact choice of the moment and the front of attack, and when he is overwhelmed by the rapidity of its execution.

It should be noted that even if the former is not effected, the latter often is, by the fact alone of the suddenness of the assault at zero hour, which always occasions a certain degree of surprise even to an enemy who has been warned of the attack.

Example: At Malmaison, in Artois, as in Champagne, 1915.

Further example: The opening of the battles of Verdun and the Somme.

As a general rule surprise is effected:

(1) *By seizing the initiative*, which creates situations instead of accepting them, strikes at the moral of the enemy and paralyzes his actions.

(2) *By observing secrecy in operations*, that is to say secrecy with regard to their preparation, this secrecy should be respected by the commanders throughout the chain of command and impressed upon their subordinates.

(3) *Finally, by the rapidity of execution*. But there is more; surprise can be prepared by a number of minor methods of the utmost importance, which our instructions of 30th October, 1917, laid stress upon, and of which the principles are as follows:

1. *The preparation of surprise. Impose and demand secrecy throughout the chain of command, and the avoidance of anything which may attract the attention of hostile espionage.*

At Cambrai, as at Riga, this essential preliminary was materialized almost entirely, thanks to the following measures:

The clever spreading of false information.

* Reprint from *The Journal of the Royal Artillery*, April, 1922.

† Continued from May-June, 1922, FIELD ARTILLERY JOURNAL.

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Holding attacks carried out on fronts other than the front of attack, either by artillery action, or by movements of troops and dummy works.

Removal of all distinguishing marks enabling units to be identified.

Preliminary orders copied by officers, and distributed solely to officers.

Attacking troops and those in the line only warned at the last moment.

Employment of very discreet officers on reconnaissance work.

Prohibition of routine telephonic communication for ten days before the attack (Cambrai) or at less than one kilometre from the lines (Riga). Exclusive use of cipher.

Testing of telegraph and telephone lines by A.H.Q. technical experts.

Strict censoring of correspondence (under open cover), or even suppression of same.

Supervision of relations between troops and inhabitants.

Stoppage of leave.

2. *The preparation of the battle zone should be undertaken well in advance or not at all according to the organisation of the offensive.*

At Cambrai the English were able to do away with their preliminary works almost entirely. Thanks to the development of their light railway system and its intensive exploitation, they were enabled to bring up their material without attracting the attention of the enemy.

At Riga, General von Hutier chose the point for the crossing of the Dvina, that is to say, the point for the break-through of the hostile front, in the neighbourhood of Uxhull (a few kilometres southeast of Riga) for the precise reason that a wooded zone extended to the south of the river, which permitted all the preparatory works to be concealed.

3. *Conceal preparatory work from the enemy by: Strict control of traffic: Carrying out movements of troops only at night: Judicious employment of camouflage.*

The German Command, like the British Command, insisted upon the strict adherence to all these orders.

Closing of all routes in view of the enemy.

Movements to be carried out only at night when less than 40 km. from the lines.

Great improvements attained in camouflage, thanks to the repeated advice of officers visiting army corps.

Camouflage arranged a long time beforehand for batteries and munition dumps.

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Great care to conceal the parks and bivouacs from direct observation by the enemy or his air force.

Lighting of large fires to be prohibited.

Prohibition of any digging for the artillery.

Concealment of guns in woods and ruins.

Digging in of telephone cable to be forbidden.

4. *To avoid as far as possible revealing the extent of air resources.*

Precautions enforced by the British and Germans, for instance, in the relief of balloons, was the successive ascent of another.

5. *The assembly for attack of infantry divisions of the first line should not be carried out till the last minute.*

The Germans attach great importance to the maintaining of higher formations as long as possible far from the scene of their offensive, and to pushing them forward at the last moment by the most rapid means.

It was thus that at Riga they had concentrated their massed attack (eight infantry divisions, two and a half cavalry divisions), at 120 km. to the rear, in a zone whose conformation presented a great analogy with that where the operation was to be carried out, and where they had trained the infantry divisions for ten days in open warfare and in every detail of manœuvre.

The attacking infantry division did not mass upon the front till the very night preceding the attack.

6. *To reduce artillery preparation as far as possible.* We will speak of this again later on.

7. *Finally, one last primary point, in the effort to obtain surprise, is the rapidity in which two consecutive attacks follow on each other.*

It is essential, the Germans say in their new Artillery Instructions, to insist that big attacks are carried out in a single day.

The Year 1918

Surprise added to the power of material was thus the principal characteristic of the great offensives of 1918. The two adversaries sought it and obtained it under different forms.

German Side.—You have all of you still alive in your memory the overwhelming successes of the Germans in the spring of 1918, which they attained by applying, with even more formidable resources, the methods which had stood them in such good stead at Riga. On the 21st March, from the north of Arras as far as the forest of St. Gobain, their attack upon this front of 80 km. was launched after a preparation of barely a few hours, by forty infantry divisions in the first line, against fourteen British divisions. The first two days they advanced 15 km., 10 km. in the two following, 40 km. from the 26th to the 31st March, the day upon which they

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attained Montdidier. *The 27th May*, under similar conditions, a mass of forty infantry divisions, of which sixteen were in the first line, was suddenly launched upon a front of 35 km., held by five Franco-British infantry divisions. On the 30th it was at Chateau-Thierry. In these attacks one always finds the same general characteristics.

The effort to obtain surprise by the means already quoted.

Violence and briefness of preparation.

Formidable power of the attacking force, and of a force detailed for the intensive exploitation of the initial success.

On the French Side.—"But the events of the morrow should prove that the French command itself already knew," as General von Ardenne wrote, "how to use astonishing stratagems for the concealment of its preparations."

Our strategy has sought to obtain the result, less by the weight of the blow struck, than by the *disorganisation produced in the general dispositions* of the enemy.

It is above all by the considered choice of its points of attack, by the variety and by the suddenness with which its offensives were launched, that the Allied Supreme Command obtained immense results with relatively restricted means.

We have obtained surprise by doing away with artillery preparation almost completely, thanks to the *neutralising effect by gas and smoke shells*, and above all by the *employment of massed tanks*, which at the same time enable us to solve the delicate problem of the *close artillery support of infantry*. At the same time, to provide against the new conditions towards which the forms of battle are bound to evolve, our Supreme Command gave instructions to break away from the methods of static warfare and endeavoured to train all the new factors in methods of open warfare. That is to say in simple, bold and rapid methods of attack. This was the subject of an Instruction at the beginning of July, 1918, of which the following is a summary of the principles.

(1) *Attacks prepared with the utmost degree of secrecy* and launched with the maximum surprise designed for a break-through by *tanks* with as little artillery preparation as possible should tend above all to the seizing of ground occupied by the mass of hostile artillery, and beyond this a development in depth with a view to the immediate capture of distant objectives. In other words, the exploitation of success shall henceforward be immediate and deep, in such a way "as to ensure the continuity of effort and prevent the enemy from reorganising."

(2) *Infantry* capable nowadays of reducing local resistance by its own weapon will advance bodily, "*not hesitating to quit definitely the zone of action of friendly artillery.*" It will be disposed *flexibly*

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in depth in such a manner as to admit of the *surrounding and outflanking of nests of resistance*.

(3) *Artillery* will carry out preparation as brief and violent as possible, above all keeping in view the following points:

Neutralising by gas and smoke shells the hostile artillery and the principal defensive organisations.

Instead of consisting of uniform and parallel barrages, its supporting fire will be planned upon the movements of the infantry, making *particularly dense and deep concentrations* upon points where the infantry will have to make its effort.

It will give support as constant as is possible to the latter, *carrying out changes of position during the attack*.

Batteries or sections of accompanying artillery are placed, if necessary, at the immediate disposition of battalions or regiments.

(4) Finally, it will be possible to give to these units frontages of attack far greater than that for the attack of fortified positions.

Such was the conception of battle during the last months of the war.

The excellence of the tactics of the master hand of the Supreme Command was, as we know, quickly vindicated, and it attained with the first effort the most important strategic results.

Certainly what will redound to the honour of our supreme command is to have grasped the decisive and opportune moment, to apply to the classic tactics of the battle of open warfare, all those destructive forces and that formidable material, the products of the war itself, which for four years appeared to have completely changed all the old principles of the art of war.

Effort to Obtain Surprise by the Artillery

It was thus only at the end of three years, that the offensive doctrine, developing an imposingly large scope, succeeded at last in 1918 in welding at one and the same time surprise and force, these two conditions essential to success, apparently mutually contradictory.

Of all the causes which have retarded this development, the bringing into action of artillery was no doubt one of the principal.

The size of the masses to be moved from one front to another, the mountains of projectiles necessary for its consumption, the complicated arrangement called for by the preparation of its shoots, even the duration of its destructive bombardments, the difficulties of moving it over torn-up ground, were mostly the causes which, for a long time, aggravated or gave rise to the delays in the preparation of these attacks.

And whatever precautions were taken to organise a considerable primary advance, proportional to the scope of the operation, by preliminary organisation of the area of attack, on favourable portions

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of the front, into "zones," it was very evident that they would remain illusory, so long as one did not strive to reduce to a minimum the time employed for the deployment of means of attack and their immediate getting into action.

Now for a long time, we must admit, we were far more concerned to augment the power of artillery by a continual increase of the number of guns employed, than by making for rapidity in bringing it into action.

And it was only in 1917, that the attention of the command was strongly directed to the improvement of the conditions of this intervention, and that real progress was effected with regard to this point.

Let us briefly examine the principal points bearing on it:

1. Bringing artillery into position.
2. Duration of preparation.
3. Changes of position of artillery after the first attack.

I. Bringing Large Forces of Artillery into Position

The effort to obtain rapidity in deployment, entails above all for artillery, the fulfilment of the following conditions:

(1) The avoiding for as long as possible the concentrations of resources behind the front of attack.

(2) The moving only at the last possible moment of these resources to their fighting position, and the putting into line *en bloc* all the supplementary artillery, that is to say in a few nights.

(3) The working out of all these movements, in such a manner that preparatory fire follows as quickly as possible after the deployment of artillery.

But on the other hand, artillery must be ready to fire, that is to say:

1. The emplacements must be completed.
2. Ammunition must be on the spot.

There are thus contradictory conditions; and in fact the rapidity of deployment of artillery for reinforcements consists of:

- A. Works to be constructed.
- B. The daily consumption of artillery on the front.
- C. The establishment of an ammunition supply system.

A. *Works to be Constructed.*—From the moment surprise effect was aimed at, it was obviously necessary to renounce bringing batteries up to position beforehand, in order that they could construct their emplacements themselves.

The initial enemy reaction being in general rather weak, the necessity for bomb-proof dug-outs was no longer felt, and it was then admitted that it was sufficient for the batteries to have at most

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forty-eight hours before the opening of fire to carry out the most simple works, on condition:

(1) That there had beforehand been established in the proximity of the battery zone, some carefully camouflaged dumps of useful material.

(2) That the troops in sector had carried out beforehand all the work which concerns the general organization of fire: the choice of reference points, the principal observation posts, maps, advanced telephone exchanges, etc.

B. *The Capacity for Artillery in the Area.*—This degree of daily receptivity of the front has been very variable; it naturally depends, upon the state of the ground, the capacity of the road system of the advanced area, and the organisation of traffic.

In the spring of 1915, in Artois, about three weeks were required to put into line the 350 guns of the reserve heavy artillery of the Xth Army.

In the IInd Army in August, 1917, at Verdun, the deployment of the 160 reserve brigades was rather slow; it lasted forty-two days (on an average a half brigade daily into a sector of an infantry division). The attack took place twelve days later.

In the VIth Army in October, 1917 (*La Malmaison*), it was quicker and attained at least one group and a half per day and per infantry divisional sector. It was completed seventeen days before the attack.

It appears, after the experience of certain reinforcing moves, that one could attain better results and put into line by night at least three brigades per sector of an attacking division. At Cambrai, with one single road per army corps, the British reached fifteen batteries per army corps sector.

C. *Establishment of the Ammunition Supply.*—It is very obvious that the time necessary for the establishment of this supply must have its influence on that of the minimum duration of the deployment of a mass of artillery, since for the transport of munitions from army depôts to the batteries, one is obliged to take into account the personnel and transport resources of this supplementary artillery.

For a long time, it was admitted, from the lessons of attack of the nature of Verdun (20th August), or *La Malmaison*, that to allow for the establishment of munition supplies, it was necessary at a minimum, to echelon the deployment over *about seven nights from J—15 to J—8*¹, which gave four days' respite to the late arrived batteries, and left a margin of four days for artillery preparation properly so-called.

But little by little, the increase of our motor transport capacities

¹ *J* being the day of attack.

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(daily capacity 15,000 to 18,000 tons) has allowed improvement in practice on these theoretical statistics, the abolition of the large battery dumps, and to assure to the massed attacking artillery the daily supply on the spot of necessary munitions.

On the other hand, the progressive decrease of the duration of the preparation has as an immediate result a similar decrease in the total weight of munitions to be consumed.

To sum up, thanks to the progress realised in these three factors, we have been able finally in our last offensive actions, to reduce to three or four days at the most the duration of artillery deployment, which is, all the same, an extensive affair, and thus we have contributed to a great degree to obtaining surprise effect. *It was, for example, that in April, 1917*, the attack of the 4th Army before Moronvillers, the 187 reserve batteries of heavy artillery, that is to say 500 guns, did not begin to arrive in the army zone until the 25th March. Nevertheless they were ready to fire on the 1st April.

For the attack on the 18th July, 1918, before the forest of Villers-Cotterets, all the artillery was brought up in three nights, and the attack commenced the following day. One sees progress effected in this direction. It is due partly to the employment of motor transport, as well as to the improvements brought about in the orders for traffic control, which admits of the more and more rapid carrying out of the movements of masses of artillery from one sector to another.

The year 1918 gave a special demonstration with regard to this, by reason of the fluctuations to which it was subjected upon different fronts, not only on the 21st March, on the 27th May and the 18th July, but again in all the repeated offensive operations which followed. *But it is thanks to the excellent handling of artillery in mass*, that we were able, in fact, to attack upon immense fronts, with forces sometimes inferior to those of the Germans, almost always effecting surprise, and building up in strength, for each of these powerful attacks, a mass of artillery capable of breaking the obstacle at the desired point.

II. *The Duration of Preparation*

At the attack of the 10th Army, in Artois, the 9th May, 1915, the artillery preparation lasted nearly seven days.

The 18th July, 1918, the same army debouched from the forest of Villers-Cotterets, without artillery preparation, and penetrated at the first effort 6 km. into the enemy lines. These two figures show in an eloquent manner all the advance made in three years from the point of view of our ideas upon this question.

The Density of Artillery.—Theoretically, as much for the increase of surprise effect as for the decrease in expenditure of munitions,

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as well as the nerve strain and fatigue to troops and commanders, it is advisable to reduce as much as possible the duration of preparation. To this end, the first idea which presents itself is to augment the density of artillery. And in fact, as is shown in the table below, the density at the battle of Malmaison was double that at the battle of the Somme.

Operations.	1 Field Gun per M.	1 Heavy Gun per M.	Total less trench artillery, 1 Gun per M.
Somme (July, 1916)	36	30	17
Verdun (Germans, Feb., 1916)			20
Verdun (Germans, May, 1916)			15
Aisne (April, 1917)	35	26	14
Moronvillers (April, 1917)	35	26	15
Verdun (October, 1916)	28	17	10
Verdun (October, 1917)	19	17	9
Malmaison (August, 1917)	16	15	7
Cambrai (end of 1917)	(with	tanks)	12
Riga (end of 1917)	13	19	8
Germans, in March, 1918.....			8

We have done better still; in June, 1917, the British, at the attack upon Messines, arrived at one gun per about six metres, and towards the same period upon, it is true, a very narrow front, in Flanders, the first army (General Anthoine) attained a density of one gun for 3 m. 50 (not counting trench artillery).

This celebrated dictum is emphasized: "*Guns, ammunition, and more guns.*" It would appear, however, that the maximum limit had been reached at Verdun, 1917, as at Malmaison, for despite ever-increasing demands of infantry in this respect, it must not be lost sight of, as Instructions of the higher command at this period have forcibly reminded us:

(1) *That all exaggeration of the density of artillery has, as an inevitable reaction, the decrease in the width of the fronts upon which an attack can be carried out with the means at one's disposition at a given moment.*

(2) *That, on the other hand, the effect given is not always proportional to the number of batteries engaged, as in practice it is limited:*

By the necessity of observation.

By the room available.

By the difficulties of ammunition supply.

One has therefore been led to strike a balance between the two factors *resources and duration*, which effect the preparation. And it is thus that in the great attacks of 1916 and 1917, an effective mean of five days was arrived at. But admitting that towards the end of 1917, by resolutely fixing the mean at one day's consumption for all calibres, and by exceeding it even slightly for the short 155-mm.,

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it was possible to carry out similar preparations in four days and even sometimes to reduce it to three, in cases where observation was easy. To finish with this question of artillery density, let us say at once that with a view to cutting short the ever-increasing demands made by the army or army corps commanders, the Supreme Command in May, 1918, issued a Memorandum annexed to the Instructions of the 30th October, establishing the allotments for three types of operation.²

The *maximum* issue, corresponding with the situation of an enemy "on his guard," that is to say, reinforced and strongly dug in upon well-organised positions.

Medium issue, corresponding to the situation of an enemy more or less "surprised," and consequently not reinforced and moderately well-entrenched.

Minimum issue, corresponding to the situation where the enemy retiring either on being threatened, or before preliminary attacks, it would be necessary to change the attack formations into march formation.

These issues, which vary:

From ten to eighteen batteries per kilometre for field artillery, from five to ten batteries per kilometre for heavy artillery, permit of rapidly estimating the artillery necessary for an offensive.

In reality from the 18th July, 1918, when a general Allied offensive was launched upon the Western Front, everyone attacked with what he had, that is to say, often with resources in artillery inferior to those provided for by the minimum issue. But as we have said before, the attacks which succeeded very well at *Cambrai* and *Riga* by cutting adrift boldly from the beaten tracks, proved at the end of 1917 that one could go much further with this system of cutting down the duration of preparation, thanks to the employment of *tanks and gas shells*.

Neutralisation by Gas Shells.—As long as explosive shells were the only means for neutralisation, one was naturally forced to precede every offensive action by a large number of counter-battery shoots, which, by reason of ranging and of fire for effect, naturally necessitated a certain duration of preparation. Later on when we possessed powerful gas shells, it was naturally advantageous to substitute this preliminary counter-battery work for intensive neutralisation actions, as prescribed by the Instructions when seeking surprise effect. Counter-battery work was thus given up during the preparation and carrying out of attacks, since it took too much time, and *neutralisation by the massed employment of gas shells*, became the normal method of counter-battery work, which led to an appreciable shortening of the duration of preparation.

² Based upon the experience of big attacks.

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Employment of Tanks.—In the summer, their use had been contemplated in the Instructions: "to attack by surprise upon normally quiet fronts and to destroy obstacles."

Whilst on the one hand, the position of these weapons is not needed to permit infantry to occupy defences completely disorganised by artillery, on the contrary, they acquire much extra value the moment they attack positions upon which, to increase surprise, only an abbreviated preparation has been carried out. Again, if there is a complete absence of preparation, this is even more the case. Thus, their employment is all the more necessary, and at the same time all the more easy, because the ground has not been torn up. But whereas the Germans, although constructing a certain number of tanks, had above all concentrated on the employment of gas shells, we adopted the tank without further ado, and obtained the double advantage of having on the one hand, a means of increasing surprise effect by the cutting out of preparation, and, on the other hand, the solution of the problem of close support of infantry by artillery.

Further, the principal cause of the success of our tanks is that our light Renault tanks were launched into the battle as they should be, at the psychological moment. We waited until we possessed great quantities before bringing them out, and well-commanded units were formed; other branches of the service had been trained to work with them. To sum up, the organization bore fruit, and it will be to the honor of our supreme command to have been able, despite the impatience of many, to await the decisive moment. For new material has value only if it is employed *en masse*, and if it enables the enemy to be struck under such conditions that a counter-blow is difficult for him. Now this was the case.

Progress Effected in Ranging and Execution of Fire

Here again the progress realised permitted of the notable cutting down of the duration of the preparation. We can now cut almost completely the period of registration and ranging, thanks to the impatience of many, to await the decisive moment. For new material

Obtaining lines of fire and preliminary data by the map.

Meteorological corrections.

Grouping of charges by weight, etc.

Calibration of guns.

All these operations can be carried out beforehand; thus the batteries have no longer any need to arrive until the last moment, and to fire a few cautious rounds for corrections.

Further, the rapidity of fire of modern natures has permitted the considerable augmentation of the rapidity of fire for effect and their effect at a given moment.

To sum up, thanks to these various improvements, the duration

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of preparation could be shortened, and, in 1918, the long artillery preparation of the preceding years definitely disappeared; a few examples will prove this:

German attack of the 21st March, 1918: Preparation of five hours (gas shells).

German attack of the 27th May, 1918: Preparation of two hours forty minutes (gas shells).

French attack of the 18th July: Preparation nil (tanks).

British attack of the 8th August: Preparation nil (tanks).

French attack of the 8th August: Preparation of forty-five minutes (tanks).

III. *Artillery Movements Following on the First Attack*

The forward bounds of the artillery, and especially of the heavy artillery, are certainly the most delicate phase of all break-through operations, the stumbling-block of all attacks.

The delays encountered in the putting into action of a new disposition of artillery are due to the following causes:

(1) There is the difficulty, in a degree hitherto unknown, of the movement of pieces and of the transport of munitions across torn-up ground, where sometimes not even the trace of a track or road exists. However, other things being equal, the shorter the preparation, the less this difficulty will be felt. This should be borne in mind.

From 1916 upon the Somme, one knows what difficulties were encountered over this vast expanse of shell-holes, and the carrying out of the simplest movements of artillery involved such delays, that an exploitation of success became impossible.

The experience of 1917 only confirmed this truth, and even in 1918, despite the general character of open warfare at the end of the campaign, artillery encountered the utmost difficulties in following up.

(2) The sudden drop in the fighting efficiency of the artillery organisation, after its change of position, is derived from the fact of its being brought face to face with unknown ground, and with an improvised observation system, difficulties to which must be added also the imperfections of new communications put up in a hurry. To a certain extent, it was possible to alleviate a few of these inconveniences by determining beforehand, at least approximately:

The new observation posts and battle H.Q.'s.

The new organisations of the command and groupings.

The laying out of new signal lines.

The allotment of new zones of action.

And even by fixing *a priori* the greater part of the new battle positions and establishing beforehand the corresponding fighting maps.

EVOLUTION IN OFFENSIVE METHODS

However, the problem of moving artillery on the field of battle has not met with a satisfactory solution.

If tractors, together with the employment of railways, have enabled us to solve the problem of moving artillery from one sector to another upon a vast front, that is to say the problem of the strategic mobility of artillery, the problem of its changes of position upon a field of battle, in other words tactical mobility, has not been solved during the war. It will only be done by the adoption of a system of artillery caterpillars, the system of the future.

CONCLUSION

What will be the definite doctrine? Of what will the future battle consist? It would be hard to endeavour to prophesy the future.

Certainly, we shall always see again open warfare as in 1914, and as we have seen it at the end of 1918, since defeat alone, that is to say a *forced retreat* of one of the adversaries, will lead to the solution of the conflict. But certainly also one will seek to limit this retreat, and we shall again have recourse to field fortifications.

Thus we cannot consider these operations otherwise than as a series of attacks or of defence of positions more or less fortified, preceded by periods of movement more or less long, over torn-up ground or in open country. There will then perhaps be no more reason to make such a profound distinction between static warfare and the war of movement in open country, since the operations to be contemplated proceed the one from the other, since even in open country one comes up against organised villages, or ridges and woods placed in a state of defence, and since we shall certainly fight, sometimes on positions, sometimes between positions, and perhaps even beyond the zone of these positions, over a ground which may be free of all defensive organisations.

We must not, therefore, think that the general and definitive form of the battle will be a struggle against stabilised fronts as we have known them during more than three years, with its slow and restricted methods of procedure.

This, in the highest sense of the word, will require more elasticity, more rapidity in conception and decision, and as Marshal Foch says:

"The improvements in industry will modify the characteristics of war, will continue the evolution of the art, but without changing in any way the fundamental principles of the conduct of war."

"Mobility and manœuvre alone will always produce success."

Another important conclusion to be drawn from this evolution of the procedure of fighting in the course of the war, is that if

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armies at the beginning of the war be compared with that at the final stages, radical changes will be perceived.

Artillery and engineers have been more than doubled, whilst the cavalry and infantry have been reduced; in the latter, the personal weapon (the rifle) has had to give place to many specialities such as grenades, machine-guns, machine rifles (lt.m-guns), guns of small calibre and trench mortars.

Further, the motor transport, transportation services, aviation, tanks, have developed to an enormous extent. Anyway, material and mechanism in all forms have invaded all the branches of the service and all modern armies, and dominate today the conditions of war to such a point, that without them the most heroic valor would only end in a bloody disaster. But this mechanism and this material will still continue to develop and improve during peace; the armies of tomorrow will have then, for fear of finding themselves in the next war with obsolete weapons, to follow unceasingly the improvements, adapting their form and their organisation to the new materials which will arise, to teach the employment of these to their soldiers and to enlarge the industrial output for the day of war.

It is enough to say, how much more delicate and difficult the technical instruction of the troops will become in all branches of the service, and how with the time of training more and more reduced by the financial necessities imposed from henceforth upon nations, the task of the officer personnel will become more heavy, and will demand more work on their part, more intellectual work and a more scientific brain.

And yet, although to a certain extent material bolstered up moral, we must not let ourselves run away with the idea that material, however perfect, is all that counts.

The moral of the combatant will always remain the supreme argument in war, and it is with material handled by men that war will always be made, and to conclude, the truth of which you must remain convinced is that the solid moral education of the soldier will always remain the fundamental element of success and of victory.

FIRE CONTROL OF LONG-RANGE MOBILE ARTILLERY

BY FIRST LIEUTENANT THOMAS NORTH.
FIELD ARTILLERY, U. S. ARMY

PROGRESS made by the Ordnance Corps on design and production of matériel to meet the demands of the so-called Calibre Board indicates that the Field Artillery will be employing, in the near future, mobile pieces capable of shooting to 20,000 and even 25,000 yards. In fact, the computed extreme range of the new 155 gun is 26,000 yards; of the 4.7" gun, 20,500. Faced by such indications as these, it is timely that we should consider the means whereby we shall be able to employ such weapons.

In analyzing the problems involved, the following assumptions can reasonably be made:

1. That the Field Artillery will be equipped with mobile field pieces capable of firing at ranges up to 26,000 yards.

2. That at certain times it will be necessary for these pieces to fire at such ranges.

3. That these pieces will be needed in the rôle of field pieces (corps and army artillery); and that fire at the ranges mentioned will be required at short notice—hours, not days.

4. That, at first, accurate fire-control maps will not be available when these pieces are called upon to fire.

5. That the point of impact may be so far behind the enemy's lines, or so defiladed by intervening terrain as to render it impossible to adjust fire from a terrestrial O.P.

6. That visibility under battle conditions may be low.

7. That the means adopted to control the fire must be practical, accurate, rapid, and as simple as possible while fulfilling the other requirements.

Targets Will Be Zones.—It is evident from the conditions cited that the targets for such guns must, of necessity, be zones rather than points. Given the very best of airplane observation, unimpeded, it might be possible to adjust on a point for demolition, although the dispersion at the long ranges would probably be so great as to render the ammunition consumption prohibitive. But we cannot count upon this airplane observation for each battery. (Moreover, if we place the limit of the power of the eye for adjustment of fire at 7000 yards—an empiric average—it seems logical to suggest that demolitions beyond such distances should be executed by the Air Service bombing units.)

So far as fire-control by the Artillery and its own agencies is

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concerned, direct visual observation of such long-range fire from terrestrial observation posts will be very exceptional. As a rule, of course, the O.P.-target line will be shorter than the gun-target line, but not so much so as to remove the difficulty, and terrestrial observation will always be so uncertain that no system of fire should be based upon it.

Therefore:

- (1) Because all the shots will, in general, not be observed by airplane, balloon or terrestrial observer,
- (2) Because of the dispersion in range and deflection,
- (3) Because of unavoidable inaccuracies in the preparation of firing data (which become magnified at long ranges),

it is evident that the appropriate targets for such guns as we are considering will be zones, or objectives of considerable area.

Primarily an Artillery Problem.—Whatever be the weapon placed in the hands of the field artilleryman, it is proper to insist that he should use every effort to employ it with the means at his disposal, without recourse to other arms. To accept the situation passively and say that if we have no maps we cannot shoot without fire-control from an airplane, is a too-hasty confession of inadequate methods. The guns are there—they must be used. Accordingly, it is incumbent upon the Field Artillery to develop methods and instruments which will render us independent of the Air Service, except for those bare necessities which are clearly outside of our scope.

Relative Positions of Gun and Target.—Heretofore the artilleryman has dealt in terms of known quantities, so to speak. He has known, or could derive from the use of his instruments and maps, the location of battery and target relative to a control, and therefore to each other. But in the problem under consideration there will be, in the general case, an unknown—the location of the target—and it is the purpose of this paper to show that this location may be established with the minimum of assistance from the Air Service. Herein lies the heart of the problem. We must know range, direction and (perhaps) site; or distance, azimuth and difference in elevation, in the language of the topographer. Furthermore, this relative position must be known with greater accuracy than heretofore, for an angular displacement increases the actual distance between the point of impact and the target as the range increases. True enough, the effect of this displacement might be reduced were it possible to employ projectiles having a greater area of effectiveness than those at present in use. How can we identify a target, and how can we utilize such information?

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1. By map location, where maps exist. The map must be known to be accurate, else it must be supplemented by one of the other agencies mentioned.
2. By direct visual observation, where visible from an O.P. Visual observation at long ranges may give nothing but direction—the distance being too great to permit an observer to adjust fire. It may be possible to utilize a range-finder in determining distances.
3. By intersection from known points of the control, where the target can be seen, and where some sort of control exists. Range and direction can be derived from such intersection, and methods of map-firing may be followed, or aerial observation employed. Instruments and control must be accurate.
4. By flash or sound-ranging. Range and direction can be derived from plotted intersections, and methods of map firing may be followed, or aerial observation employed. Apparatus must function efficiently and instruments and control must be accurate.
5. By aerial observer (airplane or balloon). If an airplane observer locates a target it should be possible for him at the same time to locate it with reference to something else—by including it in a photograph, or series of photographs, with some previously located points, by aerial mapping. In some cases he might indicate a target by dropping a signal when vertically over it, etc.
6. By information from prisoners or agents (usually indefinite). This information cannot ordinarily be utilized without being supplemented.

Of these methods, 1 may be considered the exceptional case in this, or in any other, country, except parts of Europe, because the mapping of the United States is far from complete, and the scale (1/62,500 or 1/125,000) and the methods employed preclude the use of such maps for map-firing. (Other countries, except in the region mentioned, are mapped less completely.) If each sheet could be covered with a network of triangulation, or traverse, with recorded permanent stations, say, every mile, it would be feasible to execute map-firing in those areas mapped. This method cannot be considered in the present problem, except insofar as its principles can be applied to the solution in the general case under discussion. Methods 2 and 3 do not apply, although they may be employed very often when conditions are so favorable. Method 4, so far as it applies to flash-ranging, need not be considered here as it likewise depends upon direct terrestrial observation of the target. Sound-ranging will not locate silent targets, but in the general case under

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consideration it might be put to use in ranging our own bursts.¹ Method 6 needs no comment. It seems, therefore, that we must seek a solution in method 5. That is to say, failing direct observation or intersections on a target which is not a firing battery, we must have recourse to the Air Service for the initial step in locating it. This is a physical necessity; but the artillery should not fail to do its part in coöperating, in order to simplify the task allotted to another agency (the Air Service personnel) and also to take immediate advantage of the data furnished.

Battlefield Topography.—Relative position can be determined only by some sort of topographic methods—photographic, sound-ranging, triangulation, traverse, etc., all implying some sort of topographic relationship or "control." To furnish a general system of control is the function, in peace-time, of civil agencies (U. S. Geological Survey and the U. S. Coast and Geodetic Survey, etc.) and the Corps of Engineers. In war-time this duty devolves entirely upon the Engineers. Must we also coördinate the work of this second organization with our own arm? Reduced to essentials, this question may be put in the form, "Can the Engineers be depended upon to furnish the Field Artillery with the necessary control when and where needed?" and "Should this be an Engineer function?" The answers become plainer the more the problem is examined.

There are, in general, two methods of securing control for topographical purposes: traverse and triangulation. Traverse is obviously impossible behind the enemy's lines, although it may be employed in conjunction with triangulation within our own.

The speed with which the topographic units of the Engineers can work, under war conditions, is dependent upon several factors:

1. Size of topographic force, their facilities, instruments and experience.
2. Demands made upon them by other arms.
3. Nature of terrain.
4. Weather.
5. Accuracy required.
6. Speed with which the army moves.
7. Proper functioning of supply.
8. Enemy activity.

Let us turn, for the moment, from the problem of the Engineers to another aspect of our own.

Accuracy Required.—It may be stated as a general principle that any method adopted for locating the target and for laying the gun should be such as would function under average circumstances (weather, time, training of personnel, etc.) with an error not greater

¹ Experience in France seemed to show that the best results in ranging bursts were obtained when the target itself had been located by sound-ranging methods, thus counter-balancing the disturbing effects of atmospheric variables.

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than the inherent inaccuracy of the gun. If we accept such a principle we see that any method based upon uncertain terrestrial observation will not meet our needs in the general case.

Basing an estimate on the range tables of the 155-mm. G.P.F., it seems reasonable to expect that these guns which we are considering should be subject to a deflection probable error of not more than 1 mil. The range probable error, similarly to be expected, may be as much as 5 to 8 mils. It is plain that extreme accuracy is not as essential in range as in direction.

The probable error is a function of the tube, the round, the atmosphere, the sight, and a number of other causes; the inherent inaccuracy of the gun is a function of the tube, the round and the atmosphere. It is less than the probable error. Applying the principle adopted above, it may be assumed that the gun should be pointed in direction with an error of not more than 1 mil.

As has already been stated, the appropriate targets for these guns will be zones, with appreciable extent in length and depth. This principle should not be forgotten, for while it may be possible to set forth a method whereby theoretically the gun may be pointed in direction and elevation within the inherent errors of the gun, the practical difficulties under battle conditions may introduce other errors. These errors decrease in importance inversely with the area of the target. In formulating a method subject to human inaccuracies, however, a logical standard must be set, upon which the method will be based and for which, in practice, we must strive.

In any method involving topographic operations, the possible sources of error may be analyzed as herein discussed:

Surveying Instruments.

- (1) *Inherent inaccuracy* may be reduced by fineness of graduation, applied corrections, repetition, etc., to within allowable limits. Time element must be considered. Field adjustments should be as few as possible.
- (2) *Operator's Error*.—Reduce by selection of personnel, care, maintenance of morale, and *practice*.

Computing.

- (1) *Operator's Error*.—Eliminate by practice, and checking where time permits. Slide-rules and rule-of-thumb methods help where practicable.

Plotting.

- (1) *Inherent Inaccuracy of Instruments*.—Select materials which are proof against distortion due to varying weather conditions. If deflections are to be read from the plotting board, it is advisable that the protractor be accurate to one minute of arc. Board should stand transportation under field conditions.

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- (2) *Operator's Error*.—Under ideal conditions, a draftsman's error in plotting locations might easily amount to .3 mm., while under field conditions it might amount to 1 mm. On a plotting board, scale 1/20,000, this would be equivalent to a displacement of 20 yards or 10 yards, scale 1/10,000. It might be cumulative, for instance, in the case of the gun with respect to the target. This would be far less harmful than in the case of the aiming point with respect to the gun, particularly if the aiming point were comparatively close, because here the displacement would result in a relatively large angular error in deflection. It might be better to compute the position of points before plotting them. This will be discussed later.

Laying.

- (1) *Inherent Inaccuracy of the Sight*.—The panoramic sight is theoretically accurate to 1 mil. It is doubtful if the error is not greater than this in practice, due to:
 - (a) Backlash in azimuth mechanism,
 - (b) Uneven bearings, worms, etc.,
 - (c) Maladjustment of azimuth micrometer.
- (2) *Improper Adjustment of Line of Sight*.—Usually small.
- (3) *Lost motion* in bracket or other device for mounting the sight on the gun.
- (4) *Gunner's error* (in sighting; also error resulting from lost motion in traversing and elevating mechanism) can be reduced and made constant by practice.
- (5) *Displacement of piece due to recoil* may result in a large deflection error if the aiming-point is to a flank and not far distant.² Accordingly the aiming point should be so selected as to minimize such errors, and the gun position checked with reference to a marker at appropriate times.
- (6) *Inclination of trunnions* becomes important at long ranges.

Ballistics.

Sources of error may be subdivided into three groups:

- (1) *Lack of uniformity in the rounds and drift* may be corrected with precision by data furnished in the range tables.
- (2) *Group or Incalculable Disturbing Factors, Resulting in "Dispersion."*—In the problem under consideration these will assist rather than hinder solution.

² By using the aiming rule and infinite aiming point this error may be eliminated. However, the infinite aiming-point method involves certain topographic operations which may introduce other errors.

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- (3) *Meteorological Variations.*—With accurately prepared firing data this is probably the source of largest error. Based upon observations made of a balloon ascending at an assumed rate, readings reduced to assumed strata of atmosphere, an assumed proportion of the various results gives the ballistic wind. At best, this is but an intelligent guess. Ballistic temperature and pressure are similarly derived by estimated proportion from a series of observations. These computations were published every two hours in the last war. But it is reasonable to expect that during these two-hour periods there may occur in the atmospheric conditions changes of sufficient magnitude to impair materially the accuracy of firing based upon the published meteorological data; in fact, Ordnance Department experiments seem to confirm this.

If the method involves airplane mapping or photography, the resulting source of error, so far as it concerns us, is distortion of projection, due to whatever cause, whereby the photographed target is displaced with respect to the control. The technic of airplane photography is here involved, and the Field Artillery, if we decide to utilize such methods, can do little more than demand a certain standard of accuracy from those who make these photographs.

Here is, indeed, a formidable list to face with the hope of evolving a solution with a possible error of not more than 1 mil, but, by the selection of processes and instruments, and proper training of personnel, such a solution should not be impossible.

Range and Site.—Because of the relatively large area covered by the range zone of dispersion as compared with the deflection zone of dispersion, the same high degree of precision in preparing data is not so essential in regard to range, although it is important enough. In the first place, with the deflection correct, the problem of an aerial observer, harassed by the enemy, would be much easier. The doctrine that you must see where you shoot always applies, even though the observation consists in perfunctory airplane observation or photography of the shell-craters when the occasion offers. It is safe to say that any topographic method which will give deflections correct with the degree of accuracy specified, will also give distances correct within the allowable error.

At the mean long-ranges being considered the angle of fall will be quite large. Assuming an angle of fall of 50 degrees, the displacement of the point of fall due to a difference of elevation of gun and target of 50 feet will be $50 \cot 50^\circ = 42$ feet. It can be seen that while it would be desirable to know the site of the target with respect to the battery, the displacement of the point of fall for small difference of elevation will not be serious where the target is a zone.

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It is to be hoped that the range tables will include allowance for the curvature of the earth, which, at 20,000 yards is equivalent to a difference of elevation of over 90 feet; or about 150 feet at 25,000 yards.

SOME SUGGESTIONS

General Scheme.—It will be inferred from the preceding discussion that the problem is regarded as one to be solved by the application and extension of topographic methods. To summarize: First, establish a control; second, locate the target, by map, aerial photograph, aerial map, flash or sound-ranging, or a combination of these; third, shoot by direct observation on a visible reference point, aerial observation, map-firing methods, high-burst ranging, sound-ranging, or a combination of these methods.

Engineer Methods.—The framework of the whole scheme is the control. How should this control be furnished? In the event of operations in a region not covered by fire-control maps it would be the duty of the Engineers to prepare such maps based upon and including the necessary control. However, the needs of other arms as well as the Field Artillery must be consulted and met. In order to locate control points it would be necessary for the Engineers either to start from an existing control, probably a precise or primary triangulation figure of the U. S. Geological Survey, or U. S. Coast and Geodetic Survey, or else establish a precise control of their own, and carry the triangulation forward. The Engineers' topographic unit would follow the army as it advanced, carrying the triangulations, and filling in the topography. Triangulating and filling-in are two distinct operations, entrusted to different parties.

The accuracy of the triangulation required to give locations for the Artillery is of a high order. In terrain unfavorable for triangulation (flat or heavily wooded country) it would be necessary to run traverse with the accuracy of the standardized secondary traverse. This requires the use of standardized steel tapes, with spring balances, thermometers, corrections for sag, etc., all involving a great deal of time. Moreover, inasmuch as the error allowable in such a triangulation or traverse is 5" in closure or 1/5000 in distance, it is clear that in an extensive terrain it would be necessary to carry forward a triangulation of a higher degree of accuracy for checking the secondary, or else accurately measure new base lines as the triangulation went forward.

These operations are slow, dependent upon the factors mentioned in an earlier paragraph. True enough, in Problem B, of the 29th Engineers in France, wherein a mobile reproduction plant and topographic unit operated under reproduced war conditions in the Argonne region, it was found that the triangulation could be carried

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forward with the speed of the movement of the army in the first phase of that battle. On the other hand, so many factors affect the speed of the topographic units that it would be inadvisable for the Artillery to rely upon any other arm for the carrying forward of the control on a schedule to meet its needs.

Solution Demands Accuracy.—The degree of accuracy with which the topographic operations must be performed in this Artillery problem falls not far short of that demanded by the so-called "precise survey," and must be attained by personnel trained under war-time conditions and with a very limited amount of time in the field. Accordingly, it may be necessary to consider with some caution a method or process which would be simple and practicable in a peace-time undertaking of a similar nature. Take the matter of measuring a base-line, for instance. To the surveyor, the steel tape appeals. But with the necessity for immediate results in war-time, we cannot be sure that a smooth stretch of ground will be available; a broken tape is a dangerous hindrance; field conditions may render it impossible to take proper care of the tape; illumination of the tape at night is both difficult and dangerous.

Instruments.—Before committing ourselves to any scheme involving the use of more precise instruments than those in present use it would be well to consider the degree of mechanical accuracy with which the gun could actually be pointed, apart from errors introduced by firing. Unless methods be radically changed, the result of any method of preparing data will be used as a sight setting. Since greater precision is essential in laying for deflection than for elevation, let us consider the matter of deflection setting on the sight. As stated previously, the panoramic sight is theoretically accurate to 1 mil, but practically its possible error is greater than this due to the causes outlined. However, the Ordnance Department have already produced a sight graduated to $\frac{1}{2}$ mil. In this sight there are two tangent screws, each of which may give rise to an error of 1 minute, or a possible cumulated error of $2' = .6$ mil, approximately. This seems to represent the ultimate degree of accuracy possible unless the sight be designed with bearings tapered as in the engineer's transit; it is not necessary to enlarge upon the new difficulties which such a redesign would involve. Accuracy to .6 mil in the sight setting would more than meet our needs. Inasmuch as the least reading of this sight is .5 mil, the apparent possible error is slightly less than the actual.

This sight will be attached to the 4.7 gun, and presumably also to the 155-mm. gun, by a spring clamp holding the sight in a circular seat. Lost motion in the bracket will be eliminated and the sight will be in effect a very short extension of the trunnion. Lost motion in the traverse can be taken up by a properly trained gunner.

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There seems to be no mechanical reason, therefore, why the gun cannot be laid with an error not greater than 1 mil.³

Such being the case, it is evident that our present fire control instruments, which read to the nearest mil, and in the employment of which it is usual to make certain approximations (offsets, obliquity, etc.) are not sufficiently accurate, for the reason that to take advantage of the accuracy of a sight, the topographic operations incident to laying the gun must have a possible error which shall not be greater than that of the sight. The ball-and-socket head, the coarse cross-wires, the low-power telescope, the general instability of both the goniometer and the aiming circle make them unreliable for work of the kind needed, while the battery commander scissors instrument suffers the same drawbacks, except perhaps that of instability. A telescopic instrument of the nature of an engineer's transit with vertical and horizontal wires, stadia wires, and mil scale in the field; with illuminated reticule for night work; with vertical and horizontal limbs, the latter reading to 30" which would give angles with a probable error of not more than 1' with readings in two positions, direct and reverse, might serve. Of course, with the high-power and limited field of the telescope required, such instrument could not be used to observe fire.

To permit of the plotting of the data derived from the use of such instruments, some form of portable plotting board should be used. On a scale of 1/20,000 a board about four feet long would be required. Because its use would be for corps and army artillery rather than divisional, it should not be impossible to carry in the field a board eight feet long, giving a scale of 1/10,000.

Since the use of such instruments involves also the use of an accurately measured base line somewhere in rear of the battle line, carried forward and expanded by triangulation instruments, some base-line measuring instruments will be needed.

To observe the fire, an instrument with a larger field than the transit will be necessary; if the reticule could be so devised as to enable the observer to use the instrument for high-burst ranging, so much the better.

Control.—In general the method suggested for establishing the control is: Equip the artillery brigade with the necessary instruments and personnel (reinforced temporarily, if necessary, from the component units) for establishing an independent triangulation of its own. This triangulation to be built up from a base line, measured in the most rapid way consistent with the required accuracy, and expanded to points in close proximity to the forward observation stations, which latter can be "cut in" where visible, or else tied in by traverse as soon as the occasion presents itself. Time

³ Circumstances may sometimes permit of the use of the aiming-rule (infinite aiming-point) method of laying.

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will often be the limiting factor, but effort should be made to secure the location of the observation stations with a lateral displacement of not more than 7 or 8 metres. Several operations could be carried on simultaneously. For example, the reconnaissance having been made: (a) Measure base line; (b) read angles at more than one station simultaneously; (c) prepare plotting board and plot data as sent in; (d) prepare and utilize communication system for transmitting triangulation data; (e) run wire to observation posts; (f) intersect from O.P.'s on recognizable points behind the enemy's line, etc. The number and extent of the simultaneous operations will be dependent upon the resources of the particular problem, its limitations, and the ability of the Orientation Officer.

It is plain that the Orientation Officer should be thoroughly trained in surveying methods in order that he may be able to select the best scheme of triangulation figures, and the best methods to employ. No rule-of-thumb methods can be laid down. He must be able to visualize the needs of the situation from his reconnaissance and lay his plans accordingly. For the same reason it would be unwise to specify, for instance, limiting angles for the expansion figures. His experience should be the criterion. He should aim to locate his forward observation stations along a front of not less than one-quarter, and, if possible, equal to one-half of the observation distance. Under stabilized conditions, experience may show the need of checking data at battery positions and observation posts by an astronomic determination of azimuth. Such process sounds more formidable than it really is, and the operations can be made more or less mechanical, so far as the individual observer is concerned, leaving it to the Orientation Officer and his immediate assistants to make the necessary computations.

Instruments should be so oriented as to give directions on intersections behind the enemy lines with an error not greater than two minutes, and preferably less. The Orienting Officer should not lose sight of the fact that the determination of direction is of greater importance than the calculation of the exact coördinates of the target. Where possible, more than three observations on each point beyond the enemy lines should be made. Every effort should be made to make sufficient repetitions in the reading of angles in the triangulation behind our own lines to give an average error of not more than 10". Any supplementary traverse should be so run as to give positions within a probable error of 1/5000.

Base-line Measurement.—The measurement of the base line is a matter for considerable thought. It is evident that the accuracy of the gunfire is dependent essentially upon the accuracy with which this base line is measured, and it is probably not an exaggeration to say that its length should be accurately determined with an accuracy of 1/10,000. Such accuracy can be obtained in civil practice

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by the use of a steel tape, applying corrections for the temperature of the tape to the nearest 5 degrees Fahrenheit, and the tension within one pound; with correction for grade. In the light of the objections to this method previously mentioned, there is a field for the investigation of more mechanical methods of base-line measurement. It is possible that the filar micrometer method might offer a solution. Zeiss makes use of an accurately ground tangent screw, with micrometer action on the limb to measure the angle subtended by a short horizontal, portable base, thence expanding through one or two figures to a base of 1000 metres, or more. As an experiment, the following is suggested: Stretch a 50-metre invar tape between two tripods, with targets to mark the ends of the tape; use a constant tension. This tape to be stretched at right angles across the centre of the desired base line. With a 30" transit (three readings, direct and reverse), measure the angle subtended at each end of the base by this tape; thence calculate the length of the base.

Computing vs. Plotting.—The required observations having been made, the best method of utilizing them in the preparation of the firing data must be decided upon. There are, in general, two methods. The first is to compute the location of each station by traverse tables, calculating the coördinates with respect to an assumed origin, of all points involved. Then plot these stations on the board. This, without doubt, is the most accurate method, but it takes time and it is imperative that the calculations be checked. The other method is to plot the location of each station from the readings transmitted to the plotting board, and superimpose a grid with assumed origin. The objections to this method are that the plotting board must be substantial and protected from the weather, the plotter must work with great accuracy—the responsibility of this work demands the services of an officer—the board should be equipped with one, or possibly two heavy arm protractors, reading to 1', and the material of the board should be proof against variations due to the weather conditions. It would be desirable that the scale of the plotting be 1/10,000, making the board eight feet long for the extreme ranges. The latter method is probably the quickest, but it is liable to greater inaccuracy than the former. Both methods are suggested as subjects for experiment.

Batteries and Battalions.—All necessary data should be turned over to each battalion for plotting on a similar board (the occasion for its use might demand that it be handed to each battery) in the form of coördinates of points derived by computation or by reading from the plotting board, according to the method decided upon.

Aiming Points.—Whichever method is adopted, it is essential that the position of aiming-points and of place-marks for the batteries be determined with the utmost precision. Undoubtedly each battalion, at least, would send its reconnaissance officer with the

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brigade party, and it should be his duty to select the aiming points (or establish them) in time to enable them to be "cut in" by intersection in the original triangulation. Each place-mark should be similarly "cut in" where possible. Displacement in the plotting of these points may result in a serious deflection error, although deflections may be checked, in a measure, by registering on a known point of the triangulation behind the enemy's line.

Some such methods as outlined above should furnish the control which is necessary. There is every practical reason why this duty could not be assigned to the Engineers; it must therefore be regarded as an extension of the functions of the brigade Orientation Officer. The degree of responsibility placed upon this officer would warrant the appropriate rank and technical experience of a field grade. With the advance of the Engineers, the triangulation of the Artillery could be tied into their control to the benefit of all.

Target Location.—Where a map is available it might be of great value, or useless according to its accuracy, for the purpose of locating the target with respect to the control. As has already been mentioned, for neutralization fire on enemy batteries at short range, or on an area marked by an enemy battery at longer range, present methods of flash or sound-ranging could find a use. In fact, with any target visible from one or more O.P.'s at distances which are not prohibitive, existing methods of fire control could be applied. Where the target is invisible, and not susceptible to sound-ranging (supposing that opportunity permitted the installation of a sound-ranging system), the Air Service should be called upon to coöperate. This is the general case being considered. The methods suggested are:

- (1) The airplane photographs the target, together with at least two points which can be intersected from our O.P.'s. The photograph then enables us to locate the target with respect to the control.
- (2) The airplane flies towards the target, and when vertically over it drops a powerful flare, to be intersected by our O.P.'s. This would give direction and distance to the target.
- (3) Two points behind our line are selected about 6 or 7 miles apart (or as far apart as possible) and tied in during the original brigade triangulation. At a given signal panels are laid at these points, to be photographed by an airplane which proceeds forward to photograph a strip penetrating into enemy territory. These two points form a base by which the photographic force orient their prints; a recognizable point of the triangulation scheme behind the enemy's line

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will be of the greatest value in this orientation. From the resulting map, the location of invisible targets can be derived, and the time required for the whole operation required of the Air Service can be less than twenty-four hours. Methods of determining differences in elevation of points in an aerial map are still under experiment by the Air Service. Every effort should be made by the Field Artillery to cooperate with the development work now going on in the map-making branch of the Air Service.

It may be raised as an objection that such methods are dependent upon the weather conditions. True enough, but the enemy will be in no happier circumstances, and moreover, even the lightest field pieces will be dependent upon clear weather for the proper execution of their mission in unmapped terrain.

Execution of Fire.—Fire may be executed as a map problem, or, where the target is close to a visible point, by bilateral observation adjusted with respect to this reference point, provided that the bursts can be seen. Whatever the means employed, every effort should be used to observe the fire in some manner—and no hesitancy should be felt in calling upon the Air Service to observe the bursts (if practicable) or to photograph the results, for such observation of fire, so essential to accurate shooting, cannot possibly be made by the Artillery agencies. Where the occasion presents itself, sound-ranging our bursts may prove of assistance.

The production of an efficient time-fuze would aid materially in the elimination of error due to unrecorded variation in meteorological conditions, by the use of a high-burst ranging system. Thus the actual trajectory could be adjusted on the target by observation of the bursts in air, without recourse to corrections for conditions of the moment, and a high-burst group fired, say, every half hour would serve as a check on the accuracy of the fire. Of the various methods of high-burst ranging, experiment alone can evolve that which most satisfactorily meets our needs. Experiment, also, must decide as to the best design for all instruments required.

The methods suggested are admittedly complex. It is not pretended that they alone offer a solution, and experience may show the desirability of substituting others in some cases. They require a high degree of training (on the part of the orientation officer—less so for the observers) and of coordination. Nevertheless, they are based upon practices which have proven successful in other fields. Let it not be forgotten that these weapons with their power and accuracy force us to enter the realms of geodesy with a host of handicaps foreign to the geodesist. The field guns of tomorrow are a reality. Let us be prepared to use them.

SOME REMARKS ON MOUNTAIN ARTILLERY*†

BY CAPTAIN OF ARTILLERY, A. MORTUREUX, FRENCH ARMY

CHAPTER III¹

PRINCIPAL PROBLEMS OF FIRE IN THE MOUNTAINS

THE desiderata that we have deduced, in the preceding chapter, from the limitations imposed by the mountains bring up in the first place, as we have seen, the problems of precision, of power, and of fire at high angles. We are going to examine these complex problems in succession, calling the reader's attention to the number of requirements for the construction of the guns that they involve that are mutually contradictory and generally in opposition to the two conditions fixed: Lightness and reduced dimensions.

(a) Precision

Precision is all the more to be striven for in the mountains in that the number of kinds of ammunition has to be reduced, and all the more so as the calibre becomes greater. On the other hand, in the majority of cases, the configuration of the terrain greatly increases the probable error (in proportion to the inclination of the reverse slope, that is, e^2 times $\frac{\sin \omega}{\sin(\omega + \eta)}$). Hence it is necessary to utilize the projectiles to the best advantage without useless waste.

Precision is dependent upon a multitude of factors, the study of which would take us a long way into the realm of exterior and interior ballistics. Hence we shall limit ourselves to a few remarks of a general nature concerning the gun, the projectile, and certain methods of firing.

In order for precision to be secured with a gun, it is necessary for the aiming parts and devices not to blemish by any error the laying in direction and the elevation that it is desired to give the piece.

At present some progress is yet to be made along this line. To consider only our mountain gun, the possible errors inherent in its construction are considerable. For example, the tolerance allowed in manufacturing is quite high, in consequence of the superposition of the levels for laying; in fact, the algebraic sum of the tolerance

* Translation of an article in *Revue d'Artillerie*, May, 1922. By courtesy of Military Intelligence Division, General Staff, U. S. Army.

† Continued from May-June, 1922, FIELD ARTILLERY JOURNAL.

¹ See *Revue d'Artillerie*, Vol. 89, April, 1922, p. 349.

² e = probable error.

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allowed at the time of the testing of the device may amount to ten sexagesimal minutes in the most unfavorable cases. As the test of the laying devices is made with the gun placed horizontally, there may be added to the number mentioned above the play of the gun on its chassis and of the chassis on the carriage. The slightest bump to the laying apparatus being used on a piece may likewise involve considerable errors.

Apart from the inherent qualities of the gun, the best precision, which is shown by the probable error, is obtained only when a certain optimum relation is secured between the gun (characterized by its design), the load (density of the charge) and the projectile. This harmonious agreement should therefore remain constant.

In the state of present possibilities (ammunition and gun), this agreement may be such that the probable error will not exceed 1/100 of the range.

Assuming that the conditions stated above have been fulfilled and that the V_0 ³ remains constant, we take it that only the variations of the coefficient and of the ballistic mass of the projectile affect the precision.

We know that if we consider the projectile by itself, precision is increased by raising its coefficient and its ballistic mass, a result that is obtained on the one hand by augmentation of the calibre and the weight, and on the other, by diminution of the index of form, that is, by making the ogive longer and more slender.

As the length of the cartridge should be such that it can be placed in a chest to be loaded on the back of a mule,⁴ the lengthening of the projectile can be done only by reducing the space for the explosive charge or the possibility of transporting the shell.

The diminution in the interior capacity of the projectile can only be compensated for by an explosive that is more powerful in proportion to its volume; we have yet to find this. The diameter of the projectile is fixed by the calibre; now the limit for the latter in mountain guns is soon reached. The same is true of the weight of the projectile, for it is important to transport the largest possible number of shells on the back of a single mule.

Therefore the projectile will be a compromise between the optimum conditions and the limitations indicated above. The shell having been determined thus, it will be of importance in securing precision to augment as much as possible the length of the gun and the muzzle velocity imparted to the projectile.

³ V_0 = initial or muzzle velocity.

⁴ With some guns, each mule carries two similar chests, attached horizontally. Another method of transportation used for the Skoda and Krupp guns does not include a large chest: The projectiles are either placed singly in osier baskets or by threes in long flat boxes. For the 75, six baskets or two boxes are placed vertically on each pack-saddle. Thus longer cartridges can be transported.

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Besides, external causes, such as the density of the atmosphere and other injurious meteorological phenomena, may have a bad effect on the projectile after it has been started on its trajectory and may decrease precision. These factors, taken altogether, correspond to a change in the ballistic coefficient of the projectile.

In the mountains, low-pressure areas suddenly change the condition of the atmosphere and create wind waves in changing directions; now the projectiles pass through rarefied and dry air, now through a very dense medium having a very high degree of hygrometric saturation (opaque clouds filled with snow).

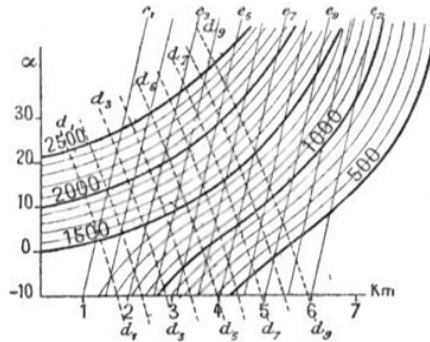


FIG. 1. $e_1, e_3, e_5, e_7, e_9, e_{11}$ are curves of equal fuse setting.
 d_1, d_3, d_5, d_7, d_9 are curves of equal deflection.

Large angles of site are likewise factors that change the shape of the trajectories, shortening or lengthening them according to whether they are positive or negative.

Hence fire for effect should, as a rule, be preceded by ranging by direct sight on an auxiliary target or verification of the fire by airplane, if ammunition is not to be wasted.

It must be assumed, however, that mountain artillery should be in condition to make sudden attacks, not preceded by ranging, and that it will frequently fire without observation in the course of missions of neutralization, offensive or defensive counter-preparation, interdiction fire on crossings that must be used, etc. Hence it is necessary for those handling this artillery to be in possession of methods for correcting the disturbing influences mentioned above and to constantly keep in touch with meteorologic stations not far away.

These corrections can be put down in the form of simple charts much like those already drawn up for firing on balloons by the Filloux 155 high-power guns, the 155 long gun, 1917 model, etc.; these charts enable us to eliminate long calculations.

There is much similarity, in fact, between firing in the mountains and firing at balloons (large angles of site and high altitudes reached by the projectiles).

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It seems that the three principal charts should be the following:

First chart, enabling us to obtain by simple reading the following data as functions of the distance and the altitude of the target:

- (a) The quadrant angle of departure α (corrected by the complementary site correction);
- (b) The drift;
- (c) Fuse setting.

For this purpose, the chart, consisting of curves of equal altitude, equal drift and equal fuse setting, would be about as shown in Fig. 1 (p. 323).

Second chart, giving the corrections for:

- (a) A variation $\Delta\omega$ in the weight of a litre of air;
- (b) A longitudinal wind of 10 m.

Third chart, giving the corrections for the fuse setting Δe .⁵

- (a) That for a variation $\Delta\omega$ in the weight of a litre of air;
- (b) That for a longitudinal wind of 10 m.

Likewise it would greatly increase the rapidity of the calculations to show the usual corrections for dV_0 , dp and dt ⁶ by charts.

Whatever the value of such charts and of the corrections made in the calculations for the preparation of fire may be, there will be cases in which we shall be prevented from securing the precision counted on because of rapid changes that occur in the atmosphere and the hygrometric condition of the charges.

Consequently it seems that the processes of registering and adjustment by air bursts might be means that could be usefully applied many a time in the mountains. Being independent of the influences mentioned above, these processes enable us to disregard them; they record the results of adjustment for future use and supply the means for reproducing it identically. To be sure, they involve the necessity of having two observation posts the coördinates of which are carefully determined and which are at a distance from each other, but their location on the terrain is facilitated by the fact that it is not necessary for these posts to overlook the zone of the objectives.

Whenever circumstances permit, it would be very advantageous to establish two observation posts provided with tangent reticules; being 2 or 3 km. distant from each other, they should have means

⁵ Δe here refers to a small change or variation in fuze setting. The lettering used in the article is faulty in this instance, due to the fact that e has previously been used for another purpose.

⁶ dV_0 = variation in muzzle velocity.

dp = variation in weight of projectile.

dt probably is used to represent a variation in density of air, commonly designated as $d\omega$. We have never seen the term dt used in connection with differential corrections, but presume from its relation with the other corrections that it is used as stated above.—EDITOR.

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of visual signalling,⁷ for sending the very simple results of their observations to a central post situated half-way between them, as a rule. This arrangement cannot always be easily made, but the effort expended in securing this kind of bilateral adjustment will be largely compensated for by the efficiency secured.

The *Revue d'Artillerie* has already pointed out (vol. 87, June, 1921, p. 548) the service rendered by the firing courses at Lake Garda that were established by the French Tenth Army upon its arrival on the Italian front, for the application to mountainous countries of modern processes of preparation of fire. We will add that the Germans, being obliged during the war to create mountain units for the Tyrol, Carpathian, and Serbian fronts, strove also to create or improve methods for firing in the mountains.

The author of the article entitled "Die Gebirgsartillerie" wrote as follows in regard to this in the review *Artilleristische Monatshefte* (January 15, 1922):

"A school of fire had to be organized for the study of artillery fire in mountainous country, intended not only for mountain artillery, but also for heavy artillery and field artillery.

"In the spring of 1917 the Artillery Direction succeeded, with the aid of the Bavarian Ministry of War, in establishing a special course for fire in mountainous country at Sonthofen, and the Sonthofen school of mountain artillery fire became a permanent establishment in September, 1917. This school was organized on a large scale and equipped with all improvements; balloonists, ranging service, aviation detachment, meteorologic service; the results of the instruction given there became tangible at the time of the break through in the Julian Alps (Tolmein and Flitsch) and the offensive in Upper Italy.

"The artillerists were not the only ones to benefit by the clear and judicious rules taught at Sonthofen and by the practical means that were recommended there for the conduct of the fire in mountainous country; the ranging service, the aerial observation service, even the signal corps, got from it some lessons that were extremely profitable for war in mountainous countries. But this school was specially profitable to the mountain artillery, putting it in position to meet the severest demands."

(b) *Power (Effectiveness)*

While it is admitted without controversy that the precision should be as great as possible, the question of range is under discussion.

Opinions are divided into two sides:

⁷ Some means of visual signalling is indispensable in the mountains, where the installation of telephone lines is often very slow and very difficult. The 24-cm. and 40-cm. searchlights are very cumbersome; it seems that apparatus having the same luminous range and of a smaller type could be built.

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First Class of Arguments.—In the mountains, range is not of much importance; it is much more important to have a gun with a low V_0 (about 300 to 350 m.), enabling us to use trajectories of slight extent, which present the advantage of large angles of impact and allow us to stick a battery behind any unevenness of the terrain, without being bothered by the question of minimum elevations.

Thus it will be much easier to accumulate guns in one position, in case of necessity, for it will be possible to place the batteries at short distances one behind the other.

The defilade and the profile of the terrain being the same, such a gun will have a much smaller dead angle zone.

Lastly, with a low V_0 , the gun can be lighter, the wear of the tube and of the whole gun will certainly be less, hence greater longevity for the whole thing, simplification of repairs and replacement of parts.

Second Class of Arguments.—Ability to fire at long ranges is particularly advantageous for a mountain gun. This ability allows the control of dominating positions to be utilized to the best advantage; it makes it possible to extend the fire to the enemy's lines of communication, which in the mountains are almost always a limited number of passages that he is compelled to take; in the offensive, it extends the action of fire and lessens the number of changes of position.

As to the problem of the dead angle, long range may be an aid in solving it, either by echeloning the artillery in depth or by lateral flanking.

What conclusion can we draw from these two hypotheses, in which technics and tactics aid or oppose each other in turn?

It appears simply that the best thing to do would be to build a gun that would fire at long range or at short range with large angles of impact, as desired. As we shall see in connection with questions of stability, or ammunition supply, and of conservation of ammunition, not all of these qualities can be secured in a single gun that fires only one kind of ammunition.

Let us consider briefly the two best-known and most elementary means of increasing the range of a given gun; increasing the V_0 and changing the shape and weight of the projectile.

1. Increasing the V_0 is limited by:
 - (a) The resistance of the tube and of other parts of the gun;
 - (b) The stability of the whole.

The present tubes will stand pressures of 2000 kgs.; making guns in one piece (auto-frettage) and the constant progress of metallurgy allow us to hope for the use of much greater pressures for a given thickness of metal, that is, for a given weight, a result that is especially important for a mountain gun.

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The resistance of the other parts is connected with the weight of the metal of which they are composed.

As we know, stability is summed up by the two general formulas:⁸

$$RH < P_l l_t \quad \text{and} \quad LR = \frac{1}{2g} \frac{(P_r v)^2}{P_r}$$

This stability is favored by the large quadrant angles of elevation, the weight of the recoiling mass, the length of the trail, the length and the slight height of the trunnions above the ground.

For the mountain gun, the weight of the recoiling mass and the length of the recoil must necessarily be low. The only favorable factors will be the slight height of the trunnions above the ground that is inherent in the gun and the great length of the trail, secured, if necessary, by making it extensible.

If a mountain gun fires with large positive angles, inversely it ought to be able to fire from below upward with large negative angles of site. The problem of stability is singularly complicated by this necessity and by that of respecting the condition $RH < P_l l_t$.

2. The change of form of the projectile may affect either the ogive or the base.

Making the ogive longer and more slender is done, as we have already remarked, at the expense of the interior space for the explosive and of ease in transportation.

A chamfer of the base of a projectile that is well calculated for the gun gives us an appreciable gain in range. For mountain guns of a calibre close to 75 mm., however, this could not exceed 1000 m., unless the projectile were made heavier and its centre of gravity changed.

But there is one serious drawback to the chamfered base, which is connected with putting the ammunition up in cartridges.

Amidst the chaotic conditions of transportation, the projectiles are almost certain to work loose from the cases, and then dampness may penetrate into the powder of the charge.

We will not dwell on increasing the weight of the projectile, which makes it harder to transport and lowers its capacity.

(c) *Fire at High Angles*

(Angle of impact and fire in the dead angle)

Curved fire, with its large angles of fall, is of prime importance in the mountains.

⁸ In these formulas, R is the total resistance on recoil (brake), H is the height of the trunnions above the ground, P , the total weight of the gun, l , the horizontal distance from the centre of gravity of the whole to the trail spade driven into the ground, L the length of the trail, P_r the weight of the recoiling mass, v the velocity of recoil of the recoiling mass.

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In fact, it allows us to reach targets that, thanks to their defilade, would remain invulnerable against the flat trajectories of long guns.

This kind of fire, moreover, favors the destruction of the target, insuring the penetration of the projectile if the latter has sufficient solidity, remaining velocity and weight; then it can be provided with a delay action fuse.

Lastly, when the effect of this curved fire can be utilized at short range, the artillery can effectively sweep the terrain that escapes the fire of the machine guns; on the defensive, it can thus give valuable support to the infantry.

In Macedonia certain battery positions or zones of the terrain were rightly reputed "taboo," for they escaped the enemy projectiles; not all of the enemy sectors had, in fact, howitzers and mortars suited to the country. The same was even more marked on our side, in spite of the utilization of our 120 C., model 1890, howitzers (Baquet) and some 120 C Serbian guns (Schneider system).

In Morocco the rebels acquired great skill in taking advantage of the protection of a defilade; in the mountainous regions they crossed the line of guns of the fixed posts, as close to them as possible and under the shelter of protecting cover. Thus it was that in the region of Ouergbia (100 km. north of Fez), they moved with impunity into the lowlands of the Oueds, along the very steep cliffs by which the valleys are connected with the surrounding level regions. Let us also recall the combat of Bouk-Nadel (January, 1920), described at the beginning of this study; we might add to it the affairs of Ain Mediona (April 5, 1919), Had-Recifa (April 26, 1919), and many others.

General Peltier, in an article published in the *Revue des troupes coloniales* (September–October, 1921), points out the importance of the problem of fire in the dead angle and brings out the necessity that exists for complementing the armament in guns (direct support) and automatic arms of columns operating in the colonies by a weapon of the light mortar type. He writes on this subject:

"What is needed in the colonies as a weapon for accompaniment is a gun meeting the general conditions fixed: Lightness, mobility, simplicity, ease of maintenance, powerful, quickly put in use and firing rapidly, effective against masked or sheltered men against whom hand fire-arms with flat trajectory are powerless; it should be of small calibre, so as not to paralyze the columns by its ammunition supply, which should be inexpensive.

"This weapon is in existence in the form of a plan presented by Colonel Jouhandeau under the name of the improved Jouhandeau mortar."⁹

⁹ A 75-mm. mortar firing a 3-kg. projectile containing 900 gr. of explosive. Range 1500 m.; probable error equal to 1/100 of the range. Rate of fire six rounds per minute. Loaded on a single mule.

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Such a gun seems to be essential for colonial operations, because these are conducted by isolated columns, liable to be attacked by surprise and handicapped by the transportation of ammunition, but for continuous fronts and theatres of operations in which powerful forces are opposed to each other, conditions are different.

The artillery will not have to think so much about the time for going into battery and dependence on ammunition supply; on the other hand, the means of action to be employed should be as powerful as possible.

The infantry, on its side, will have its own weapons (Stokes, VB, etc.) or will be supported in certain cases by tanks.

Consequently what is needed is a mountain howitzer built for curved or even high-angle fire, firing a resistant and powerful shell, using different charges, some of them very much reduced, and firing with precision. Such a gun, an auxiliary and complement to the rapid-fire gun, will enable us to efficaciously sweep distant or nearby terrain, whatever be its profile.

In France, until recently, we had considered only the adoption of a single type of mountain gun, on the one hand, in order to simplify the ammunition supply and the organization of the units, on the other hand, because the mortar did not inspire confidence in regard to its precision of fire and the effectiveness of the shrapnel balls.

The discussion of the question of determining whether preference should be given the long gun or the howitzer as a mountain gun is very old.

The reports of the Commissions of Grenoble and of Toulouse, appointed in 1821 to organize the first symptoms of mountain artillery,¹⁰ are quite suggestive in regard to this. Viscount de Vaux, at that time Minister of War, wrote, in summarizing the conclusions of these commissions:

"Since 1820 different kinds of mountain artillery guns have been subjected to comparative tests in the Districts of Grenoble, Toulouse, Bayonne and Perpignan, for the purpose of organizing into batteries the one that seemed to be best adapted to the conditions of this service; this task was entrusted to the mixed commission on gun-carriages and vehicles, that on tubes and that on armament for fortresses.

"The opinions of these different commissions, the reports of the different tests, the reports of the officers who followed them or

¹⁰ In the year XI, of the French Republic, in the new organization of the artillery matériel, there was created a mountain artillery (3-lb. and 4-lb. guns, 24-lb. howitzer). This system, created in haste, did not meet the expectations of its founders. Under the Empire, units of mountain artillery were provided at the time when needed by the transformation of mounted batteries. Four-lb. and 12-lb. pieces were thus used in Spain and in the Alps.

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directed them, in fact, all the documents likely to throw light on this question, were then sent to the Consulting Committee on Artillery, which was ordered to examine them and report on them.

"Taking up the question of the tubes that should enter into the organization of a mountain artillery unit, the Commission decided, both on the basis of the discussion of various opinions and from the examination of the facts observed in the tests or experience in war, that the four-pound mountain gun has two advantages over the twelve-pound howitzer:

"1. Greater range and greater precision;

"2. The possibility that it affords of transporting a large amount of ammunition with a given number of pack mules.

"But, on the other hand, it was also decided:

"1. That under the most common circumstances of mountain warfare the long gun can produce hardly any effect, because of the configuration of the country in which it is operating, while howitzer fire is much more effective and has a much stronger effect on the morale of the troops against which it is used;

"2. That in cases in which the long gun can act, if the points to be bombarded are not out of good range of the howitzer, the latter gun produces much more decisive effects than the long gun, acting by the shock and by the explosion of its projectiles;

"3. If the long gun has the advantage of greater accuracy, the howitzer which can throw a shell to the same distance, still has the effectiveness due to its splinters and even its detonation.

"For these reasons the Committee proposed to me the adoption of the twelve howitzer as the sole piece for mountain artillery."

At the time of the adoption of the mountain 65-mm., guns allowing curved fire were examined by the commission then in existence (1903). Together with the present 65-mm., built in the Bourges Artillery Workshops, Captain Bloch presented two guns, a 75-mm. long gun and a 120-mm. howitzer; Baquet, Deport and Franiatte guns were also examined.

The considerations of the Artillery Committee, recommending the adoption of the Bourges mountain 65-mm., may be summed up as follows:

"Short guns are to be eliminated, as they do not appear advantageous. The remaining velocity of the shell is too slight for the shrapnel balls to be effective. The present high-explosive shell has too limited a zone of action to be effective, and as the fire of the piece is not sufficiently accurate, the consumption of projectiles would be too great.

"Therefore a gun of small calibre must be taken in order to be able to secure great enough muzzle velocity to insure the efficacy of the shrapnel and the precision of the fire."

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It seems today that the power and the moral effect of the high-explosive shell and the importance of its use in comparison to that of shrapnel shell have been plainly proved by the war. Thus the problem is stated in a new form, but the difficulties of solution remain great.

The advances made in ballistics, and those that certainly will be applied to the manufacture of powders, appear capable of lending more precision to howitzer fire, by the use of a standardized powder that will give a pressure curve well suited to short guns (ballistite, for example), combined with a projectile of sufficient weight and suitable design for maintaining equilibrium along its trajectory. With a view to securing a better loading density with reduced charges, it seems possible to make arrangements that will allow the volume of the explosive chamber to be reduced in proportion to the charge.¹¹

As the projectile should be rather heavy, the rate of fire will be slowed down and ammunition supply will become more complicated, but the weapon will be more effective because of its large explosive charge and its high angles of impact; the result will be a much greater effect on morale.

A much more serious drawback of the howitzer would be the use of a separate charge, itself divisible, a condition that would involve the necessity of having an intermediate dump for charges. It would also be difficult to keep the charges from dampness.

With a view to settling the problem of curved fire, certain partisans of one single mountain gun have proposed to keep a gun of medium calibre, the trajectories of which would be made curved by firing shells having collars.

This process, which greatly decreases the range, may evidently render some service; it is used in the Italian mountain batteries that are equipped with the Italian 65-mm. gun. However, experience has shown that the dispersion is increased in a very large proportion and that the use of such fire is to be avoided when it would have to be employed in the vicinity of infantry.

Other artillerists would willingly recommend the adoption of reduced charges put up in cartridges, forming a certain proportion (15 to 20 per cent.) of the total ammunition supply of a battery.

This method would require a supplementary type of ammunition and we would run the risk of transporting the lot of cartridges with reduced charges for a long time without finding any use for them, while they would take up room that might have been used for ammunition with full charges.

Lastly, the single type of gun with ammunition in two parts and with divisible charges has its partisans. But whatever the talent of

¹¹ One firm that builds guns has just taken out a patent on a device of this kind.

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the constructor may be, such a gun will never be anything but an unsatisfactory approximation to all the necessary qualities: Lightness, power, etc. On the other hand, this solution lowers the rapidity of fire and makes the conservation of the charges quite uncertain. There is also bound to be a certain amount of complication about its use, which may cause errors in fire and may require more complex apparatus for laying, etc.

However, it seems possible to secure air-tight sealing of the charges in their cartridge cases, the rapid removal of the obturating plug being insured at the time that the charge is to be transformed for firing.

These drawbacks did not stop the construction of the Skoda 75-mm. gun, which, like its big brother the 105 howitzer, was given a cartridge case arranged to contain a divisible charge. It remains to be seen whether the closing by a plug did not cause disappointments, as seems probable.

The United States seems likewise to have adopted the divisible charge for its 75-mm. mountain gun, 1920 model. It is intended for each projectile to be placed, together with its cartridge case containing the charges, in a tin container having a special cover, the fastening of which insures the constant position of the projectile in its cartridge case.

As a complement to the preceding remarks, the two tables following show the possibilities of fire of the most modern mountain howitzer (Table I) and allow us to compare with the 75-mm. field gun, 1897 model, three mountain guns: The 65-mm., 1906 model; the Schneider 75-mm., 1919 model; and the Skoda 75-mm., 1915 model (Table II).

This comparison applies to the possibilities of defilade (α = angle of quadrant elevation), range, angle of impact c and remaining velocity V_r of the projectile.

The mountain 65-mm., not very powerful with its 3.81-kg. projectile, has approximately the same possibilities (α , c , V_r , range) as the 75-mm., 1897 model, using the reduced charge. The Schneider 75-mm. appears effective in the domain of range, with limited possibilities for α and c at moderate ranges.

The Skoda 75-mm. gun, which fires up to 7 km., is particularly important because of the capabilities that it offers for α and c ; the remaining velocities of the projectile are approximately equal to those of the mountain 65-mm.

(To be continued.)

SOME REMARKS ON MOUNTAIN ARTILLERY

I. EXTRACT FROM RANGE TABLE OF THE 105-MM. HIGH-POWERED MOUNTAIN HOWITZER MODEL 1919 SCHNEIDER

Weight of projectile: 12 kilograms

Range in Metres	Charge 0 $V_0=350m$			Charge 1 $V_0=277m$			Charge 2 $V_0=237m$			Charge 3 $V_0=210m$			Charge 4 $V_0=184m$		
	<i>d</i>	<i>c</i>	V_r	<i>d</i>	<i>c</i>	V_r	<i>d</i>	<i>c</i>	V_r	<i>d</i>	<i>c</i>	V_r	<i>d</i>	<i>c</i>	V_r
500.....	0 50	1 16	330	1 31	1 55	268	2 11	2 38	229	2 52	3 18	204	3 50	4 20	184
1,000.....	2 04	2 40	314	3 26	3 56	261	7 48	5 25	223	6 19	6 57	198	8 25	9 12	173
2,000.....	4 57	6 03	289	7 42	8 37	248	10 32	11 40	210	14 01	15 26	187	19 07	21 09	164
3,000.....	8 18	10 09	272	12 30	14 12	231	17 17	19 25	200	23 05	27 13	179	41	44	160
4,000.....	12 06	14 58	260	18 15	21 03	226	27 46	31	192	"	44 28	176			
5,000.....	16 32	20 18	255	25 36	30	216	45	190							
6,000.....	21 30	26 17	244	40	46 38	214									
7,000.....	27 36	33 45	242												
8,000.....	37 36	45 50	243												

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II. COMPARATIVE TABLE OF DIFFERENT MODELS IN THAT WHICH CONCERNS THE ANGLE OF FIRE ∞ , THE ANGLE OF FALL C, AND THE REMAINING VELOCITY V_r .

	75-mm. Mod. 1897						66-mm. Mountain Mod. 1906	75-mm. Mountain Schneider Mod. 1919			75-mm. Mountain Skoda Mod. 1915							
	Normal Charge			Reduced charge				∞	c	V _r	∞	c	V _r	∞	c	V _r		
	∞	c	V _r	∞	c	V _r											330 3.8	425 6.5
V_0 m	550	290	290	330	330	330	330	425	425	350 (1)	350 (1)	350 (1)	350 (1)	350 (1)	350 (1)	350 (1)		
Mean weight of projectile..... kg	5.4	5.4	5.4	3.8	3.8	3.8	3.8	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5		
(Short fuse)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus explosif ordin.)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)	(Obus expl. forme D)		
Range	∞	c	V _r	∞	c	V _r	∞	c	V _r	∞	c	V _r	∞	c	V _r	∞	c	V _r
Metres	o	o	m	o	o	m	o	o	m	o	o	m	o	o	m	o	o	m
1.000.....	1. 8	1 23	410	3 40	4	270	2 34	3 7	289	1 40	2 2	362	2 30	3 04	299			
2.000.....	2. 51	4 2	323	7 55	9	234	6 1	7 23	259	3 52	4 46	319	5 40	7	268			
3.000.....	5. 15	7 58	282	13 8	15 56	210	10 15	13 3	236	6 25	8 09	293	9 32	11 44	248			
4.000.....	8. 20	13 4	255	19 45	25 20	195	15 33	20 26	220	9 19	12 07	276	14 02	17 42	233			
5.000.....	12. 8	19 26	236	29 55	38 50	188	22 39	30 5	211	12 37	16 40	264	19 28	30 56	221			
6.000.....	17. 1	27 17	223	"	"	"	"	"	"	16 43	21 57	255	26 40	34 52	216			
7.000.....	23. 8	37 3	218	"	"	"	"	"	"	21 46	28 15	249	45	55 12	221			
8.000.....	33. 5	50 25	227	"	"	"	"	"	"	29	36 38	246	"	"	"			
8.500.....	"	"	"	"	"	"	"	"	"	35 08	42 40	247	"	"	"			
8.700.....	"	"	"	"	"	"	"	"	"	40	45 44	248	"	"	"			

(1) The numbers given for ∞ , c, V_r relate, for the Skoda matériel, to the heaviest charge. This matériel, which employs three different charges permits of obtaining at shorter distances than 6000 metres of greater angles of fall than those indicated in the table.

THE NEW EDITION OF "FIELD ARTILLERY FIRING"

BY LIEUTENANT-COLONEL J. W. KILBRETH, FIELD ARTILLERY, U. S.
ARMY

THE Editor of the JOURNAL has asked the Field Artillery Training Regulations Board to write a statement in regard to T. R., 430–85, Field Artillery Firing, now in press and soon to be issued to the service. It was believed that some explanation of the general ideas in the minds of the board—of the purpose of the pamphlet and of the various conditions to which the matter of the pamphlet had to be adapted—might make clear a number of points for one studying the pamphlet for the first time.

The purpose of the pamphlet is to provide a guide for the battery commander and his subordinates in the preparation and conduct of fire. It deals with the preparation and execution of the various forms of fire and with the employment of materiel and ammunition in carrying out the missions assigned by higher artillery commanders or indicated by the tactical situation. It does not deal with the tactical manœuvring of field artillery or the tactical application of fire in battle. These latter are discussed in T. R., 430–105, Tactical Employment of Field Artillery.

In regard to the methods to be employed, the board believes that practically all experienced field artillerymen (aside from a few extremists) agree. The policy of the field artillery, as announced by the Chief and as practiced in the Field Artillery School, is that every officer should be prepared to apply every refinement in the accurate preparation of fire in the most stabilized position and, at the same time, be able to deliver instant and accurate fire in a meeting engagement with no instruments but his hands and field glasses. The board believes that a battery should normally be prepared to open fire on targets of immediate importance as soon as the guns are placed in position, and that the topographic and other operations necessary for the most accurate fire should be begun at once and continued throughout the time the battery remains in position. The most rapid preparation of fire with limited means and the most deliberate and accurate preparation are not regarded as distinct methods but merely as steps in the same process.

In the discussion of these steps, it may appear that too great emphasis has been laid on the more deliberate and accurate methods. This is explained in part by the following introduction to the pamphlet written by General Snow:

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"More space is devoted in this pamphlet to the deliberate preparation of fire by topographic means, and generally to methods which can be used only in situations more or less stabilized, than is devoted to the more difficult problems of rapid preparation and conduct of fire without maps.

This is due to the fact that the former can be described in great detail in a written text, whereas the latter cannot be so described, but must necessarily be covered only by the enunciation of general principles. The application of these principles varies with each specific problem. It is only by the continued practice in actual or simulated firing, under the supervision of experienced officers, that skill in the application of these principles can be obtained.

The reader must, therefore, not be misled by the space devoted herein to different methods of fire, as to their relative importance. But on the contrary, all field artillerymen must bear in mind that the vital part of a battery officer's education cannot be learned from books, but comes from practical instruction under skilled instructors in solving numerous concrete problems in a war of movement."

In addition, this pamphlet was written for the heavy field artillery as well as for the light, and the former will employ only the more accurate methods. The more deliberate and accurate methods are usually described first for two reasons—they are more definite and easier to explain and serve as a basis for the other methods, and, by leading up to these latter as the culmination of the work, stress is laid on their importance.

In many cases the board has attempted more detailed explanations than has been customary in drill regulations. This is due to the changed purpose of training regulations. In the past, drill regulations have given rather brief rules to serve as guides to experienced officers in the instruction of their subordinates—in writing *this* pamphlet, the board was ordered by the Chief of Field Artillery to keep constantly in view the case of the noncommissioned officer of some isolated unit of the National Guard or Reserves studying the pamphlet without immediate access to an instructor.

In writing the pamphlet, the board was influenced by the urgent need for prompt publication. For this reason, the board made no attempt to determine (by tests which would necessarily have been inadequate) which was the best of several accepted and tried methods. It was thought better to accept some method which was known to be satisfactory, rather than to delay publication by seeking for the best.

For the same reason, some suggested changes in accepted methods (possibly advantageous) were rejected. It seemed better to leave them for test by the Field Artillery School or other agencies rather than to adopt them untried.

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Effort was made to limit the number of methods prescribed for doing the same thing. To describe a number of alternative methods of equal value would have resulted only in confusing the student. Many "short cuts" and rules-of-thumb which are convenient in practice for the experienced are dangerous if prescribed in regulations.

The board attempted also to limit the number of terms used. The complicated terminology which grew up during the war is very confusing, especially to one not then in the service. All terms which seemed useless were dropped.

In general, the board followed the methods now used by the Department of Gunnery at the Field Artillery School, Fort Sill, but kept constantly in mind the danger of being unduly influenced by local conditions. Pressure of school work prevented the Department of Gunnery from making a detailed study of the pamphlet, but all methods which deviated from School procedure were submitted to that Department and approved by it. A member of the Department with several years' experience as an instructor was assigned to the board to insure coördination.

The difficulties of preparing this pamphlet to meet the various conditions imposed are of interest to no one, but some of the more obvious should be kept in mind in studying it. If some method of procedure seems over-elaborate to an officer with a 75-mm. battery, he should try to look at it from the point of view of one with a 240-mm. battery before suggesting changes. If some explanations seem too detailed, he should put himself in the place of a corporal of a newly organized national guard battery, who must study without any background of experience or the aid of an instructor.

THE SHRAPNEL QUESTION AGAIN

LIEUTENANT-GENERAL H. ROHNE, IN ARTILLERISTISCHE MONATSHEFTE,
MARCH-APRIL, 1922

(ABRIDGED TRANSLATION BY COL. OLIVER L. SPAULDING, JR., F. A.)

LUDENDORFF, in his Memoirs, condemns the shrapnel. His views may be correct for position warfare, but not, in my opinion, for the open. I have expressed my opinions in several magazine articles, and should hardly return to the subject had it not been for an article in the *Norsk Artilleri-Tidskrift*, No. 6, 1921, in which a German officer, with long war experience as a battery commander, gave a very low estimate of the shrapnel and called for its complete abolition. He sums up his view in the following words: "Shrapnel may be effective against thick skirmish lines in the open, if the battery commander is skillful, observation good, the fuzes burning well and the guns new. But shell with instantaneous fuzes have equal material and greater moral effect; so, considering both the ammunition supply and firing methods, there seems no good reason for the retention of the shrapnel."

Many criticisms at once suggest themselves. I dispute the statement that in the open the material effect of the shell is equal to that of the shrapnel; it is so only when the projectile falls in or very close to the target. The Firing Regulations say that with time shell and low bursts the field gun will give splinter effect 45 m. on each side of the point of burst and that percussion shell with instantaneous fuze gives about the same result. But the regulations say also that the effect in depth of the percussion shell is slight, amounting to about 20 m. for light guns; and that its effect upon horizontal targets is almost negligible, especially if instantaneous fuzes are not used.

This gives an idea of the number of projectiles necessary to give effect. Only those shells need be considered which fall within 20 m. in front of the target. Taking the range table dispersion at 3000 m., we get 50 per cent. effective shots under the most favorable conditions, that is, when the centre of impact is 10 m. in front of the target. Under service conditions, the dispersion will be much greater; if it is double, we get 26.4 per cent., if triple, 18 per cent. We can never expect perfect adjustment; if the range is only 25 m. out, the percentages of effective shots fall to 29.4, 16.8 and 15.3. If the error in range is 50 m., they become 0, 6.7 and 9.5 per cent. If the error is 100 m., no effect can be expected. These errors are normal. It is a common mistake to assume the maximum effect, and neglect to consider how rapidly this falls off. I called attention to this twenty-four years ago; but my suggestions were rejected on

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the ground that too close ballistic study might weaken the confidence of the other arms in the artillery! I have now the melancholy satisfaction, that at least one of my suggestions, verification of the bracket, has been adopted as a result of war experience.

The depth effect of the time shrapnel greatly reduces the effect of errors, provided only one does not overshoot. Again, the regulations provide for searching the bracket; evidently, since the depth effect of the shrapnel is six times that of the shell, it will take only one-sixth as many shots. This means a saving not only of ammunition, but what is sometimes of more importance, a saving of time. At extreme ranges, where the dispersion in depth of the shrapnel bullets is small, the shell approximates to the shrapnel in effect, and may be preferable.

In position warfare, where the target area was studied for weeks and months, with the aid of accurate large scale maps, and where allowance could be made for the state of the atmosphere and the peculiarities of each gun, the defects of the shell were less apparent and those of the shrapnel more so. It is not surprising, then, that under these conditions the shrapnel was abandoned, as Ludendorff says.

But the shrapnel is superior to the shell, not only against "thick skirmish lines," but against all targets in the open. The conditions specified by the writer above mentioned, for success in shrapnel fire, are equally important for time shell; in fact, that projectile requires even better observation. With the shrapnel, it is sufficient to sweep the ground within the bracket. With shell, this takes too much ammunition; the only alternative is to narrow the bracket and fire series. The bursts are then very close to the target, and false observations are not uncommon; and even if this is not the case, shots will often fall "over," when the centre of impact is "short." As for wear of the guns, this reduces the muzzle velocity, and hence the range; it reduces also the burst range, but not to the same extent. This point was discussed in an article in the last number of this magazine.

It is unquestionably a disadvantage of the shrapnel that the fuzes do not always burn uniformly, and the height of burst must be adjusted. But this is not a "delicate operation"; less accuracy is needed than with the shell, on account of the greater depth of dispersion. It would, however, simplify matters if we adjusted height of burst by a change in the fuze setting, not in the elevation.

I realize that these views may be set down as theoretical, and not borne out by experience; the writer in the *Artilleri-Tidskrift* bases his article entirely upon war experience. I can only say, that when theory and practice disagree, it is not always theory which is wrong. Theory is based upon experience—peace experience,

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it is true, but gained by carefully planned and executed tests, where all the conditions are accurately known, and the effect of variations calculated beforehand. If war experience indicates another result, we should consider carefully whether we have to do with a *real* experience or a falsely interpreted observation. We should be very careful not to generalize too hastily from even a reliably observed fact. I might point out a few specific cases where the writer has drawn what I consider an unreliable, because too hasty, conclusion.

He mentions a case, early in the war, where twenty batteries came into action out of a ravine, under hostile observation and fire, without serious loss. He finds the reason in high bursts, the bullets not having the necessary striking energy. This idea is found over and over in the article, so that it will pay to look into it. The writer thinks the range was correct; otherwise the illustration would be without force to indicate the inferiority of shrapnel.

From peace-time experiments we assume that to put a man out of action the shrapnel bullet must have a striking energy of 8 metre-kilograms; that is, with a 10-gram bullet, a striking velocity of 125 metres per second. The French make much greater demands; they call for 19 metre-kilograms, requiring a 12-gram bullet and 180 metres per second. Their regulations as to height of burst are based upon these requirements.

Let us now inquire whether, with correct range, the energy of the bullet is adequate. Unfortunately, this will require a little calculation,¹ but nothing more than anyone can do who has passed the ensign's examination.

Let us assume that in the case in question the range was 6000 metres. The normal height of burst, according to the French regulations, is 18 metres. The angle of fall is $21^{\circ} 30'$, half the angle of the cone is $12^{\circ} 10'$. The farthest bullet will fall at a range from the burst of $18 \cdot \cot(21^{\circ} 30' - 12^{\circ} 10')$, or 108 metres; the shortest $18 \cdot \cot(21^{\circ} 30' + 12^{\circ} 10')$, or 27 metres.

How far, now, may the point of burst be drawn back, without reducing the striking energy of the farthest bullet below the permissible limit?

At the point of burst, according to the range tables, the shrapnel has a remaining velocity of 230 metres per second; the French count upon an increase in velocity of the bullets of 80 metres at the burst. Assuming only half this increase, we get 270 metres per second. Calculating according to Siacci's method, we find that a reduction

¹ The writer remarks facetiously, "No one does any calculation, at such times, on the angle of the cone of dispersion, the striking energy of the fragments, etc., to see what projectile will have the best effect." This is true; but a famous sculptor once remarked, "The sculptor should not study anatomy when he is at work; he must have studied it." The artillerist should not do any figuring in action; he should have done it before.

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in velocity of a 12-gram bullet, from 270 metres to 180, corresponds to a range of 158 metres. The height of burst corresponding to this is $158 \cdot \sin 9^\circ 20'$, or 25 metres. If the height of burst is greater than this, the longest bullets will lack the necessary striking energy. If the height is over $158 \cdot \sin 21^\circ 30'$, of 57 metres (9.5 mils), the whole upper half of the cone lacks the energy. If it is over $158 \cdot \sin 33^\circ 40'$, or 87 metres, none of the bullets will be effective. Are we to expect a battery commander, trying for a 3-mil burst, to get 9? And even so, half his bullets would be effective.

And note that this calculation is based upon a striking energy of 19 metre-kilograms, which is enough to penetrate the large bones of a horse. If we use the German figure, 8 metre-kilograms, a 12-gram bullet would hold the necessary velocity for 275 metres, or 1.7 times as far as in the former case. Increasing the permissible heights of burst accordingly, we get a height of 97 metres for effect by half the bullets; not until we reach 147 metres are all ineffective.

Assuming any other range than 6000, one gets about the same result.

How is it to be explained, then, that so large a target suffered so slight loss from shrapnel fire? Two explanations suggest themselves, with little to choose between them. Perhaps the enemy was shooting short; or perhaps he was not firing at the artillery at all, but at some other target nearby, so that only stray shots got into the ravine. If the range was wrong, the effect would have been zero with any projectile. The high bursts may perhaps be accounted for, if we remember that in time of peace we are generally in the habit of looking at bursts from a long distance, so that they look low. An 18-m. burst measures 3 mils at 6000, 6 mils at 3000, and at 600 has the astounding height of 30 mils. It is impossible to judge the absolute height, unless one has full information as to conditions and keeps all this in mind.

During this march, one of the battery commanders is said to have been struck by four shrapnel bullets, which left no trace except four bruises. I must admit that I doubt it; I am very skeptical about stories that are in contradiction of all experience. That the battery commander believed he was struck, I do not dispute for a moment. But I would point out that it is very improbable that one person should be struck four times, when the total losses were negligible. If the bullets came from a single projectile, that would indicate a great density, therefore short range to the burst, therefore great striking energy. I think there must be some other explanation for the four bruises.²

² It is hard to understand why the writer takes so much pains to dispute the statement. Even from his point of view, that only an occasional shot reached the column, this seems not improbable. As for the lack of damage to the battery commander, ineffective bullets among effective ones are not unheard of, where the cause is not determinable. Perhaps this man simply happened in the way of a stray, but had luck. "He who is born to be hanged can not be drowned."—*Translator*.

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It seems to me that the unfavorable effect of the high bursts is exaggerated, by reason of the preconceived idea that this necessarily reduces the striking energy too much. That this is not so, has just been demonstrated. The proper placing of the centre of impact makes much more difference than the height of burst. If the mean trajectory is 100 metres over, there will be no effect whatever with low or normal bursts, but high ones may give a little. If it is too short, then again high bursts give more effect than low ones. It is only when the range is correct that bursts below normal can possibly have more effect than high ones; the density of the pattern is then greater, and one gets more hits. At the same time, one must accept the disadvantages, that the lateral spread is small, and that there are more grazes.

The article in question goes on to relate two occurrences, intended to show that percussion shell is more effective against skirmish lines lying down than time shrapnel. In one case, French infantry is said to have advanced, each man carrying a sheaf of wheat. The advance was stopped at the first volleys of shrapnel; but these sheaves, and the standing grain remaining in the fields, gave enough protection so that the next two volleys did not drive them back, although the height of burst was good. Percussion shell at once got the effect desired.

It seems to me that this may equally well be taken to prove the exact opposite. Without considering whether or not a sheaf of wheat may give protection against shrapnel bullets, it seems possible that the French were not thinking about that at all, but were simply trying to confuse the Germans by their Birnam Wood and Dunsinane trick. To stop the advance was a success in itself. If the enemy did not fall back under the shrapnel fire, perhaps it was because he realized that this would mean annihilation. The slight and local effect of the shell may have encouraged him to try to get away. I do not assert that this *was* the case; but it can not be denied that it *might* have been. It is certainly equally legitimate to argue in this way as in the other—the more so, as instantaneous fuzes were not yet in use at the time.

Preconceived ideas are readily taken up and disseminated; one more example of this. The writer says that German officers who observed the Balkan wars reported, on their return, that one could readily hear the approach of a shell, and take cover; but that advantage was not taken of this discovery. This seems to me fortunate, for it was not a real discovery, but a hasty generalization, entirely unreliable.

For 6000 metres, the time of flight of a French 75-mm. shrapnel is 19.9". Assuming that the sound of its flight is audible at 1000 metres, the sound takes 3½" to pass from the 5000-metre point to

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the 6000 metre. The time of flight for 5000 is 15.3". So, then, it is 18.6" from the instant of firing until the first faint sound is heard at the 6000-metre point; the projectile strikes $1\frac{1}{3}$ " later. Whether or not this is time enough to decide to lie down, and actually do it, is doubtful. The "reaction time," even with trained observers who are devoting their entire attention to it, is 0.3". If the range is less, the available time is less; at 4000 metres, where the time of flight is 11.4", it is only 0.2", and at 3000 metres it is zero. It is worse yet with a high-velocity heavy gun. With the Krupp 10.5-cm. rifle (740-m. muzzle velocity), the sound does not get ahead of the shell below 6400 metres, and at 8000 the difference is only 0.6". With high-angle fire, it is of course different. With the Krupp 10.5-cm. howitzer and smallest charge (160-m. muzzle velocity), and a range of 2300 metres, there is an interval of 8" between the perception of the sound and the arrival of the shell, which is more than enough. With very heavy pieces, where longer ranges are used and where the sound of the projectile might be audible farther, things are still more favorable; it is not unlikely that the observations in question had reference to such pieces, and were erroneously generalized.

It is hardly necessary to describe the progress of an attack, where the men were trained to lie down every time they heard a shell.

The shell has one undeniable advantage in its moral effect, by reason of its more powerful bursting charge. But this effect, which is very great with a burst close at hand, falls off rapidly, for the intensity of the sound is of course in inverse proportion to the square of the distance. How few shells fall close to the target has been noted above. The writer himself tells of his battery having been under shell-fire on September 1, 1914; and, although the bursts were often between the guns, the losses were but slight. He does not mention any moral effect, so presumably there was none, although, as appears from other sources, some of the shells were of heavy calibre. This leads to the conclusion that the moral effect is only upon those who are not accustomed to artillery, and that suitable instruction of the men is the proper antidote. Percin says that the French were much more afraid of machine guns than of heavy artillery, after they had become accustomed to the sound.

One consideration should not be overlooked, in comparing time and percussion fire. One is apt to conclude, naturally but erroneously, from the varying heights of burst, that the dispersion is greater than with percussion fire. But the very fact that errors show up so clearly is in itself an advantage; we are only deceiving ourselves if we think that these errors do not occur in percussion fire, because we do not notice them. It is in percussion fire that they are most serious. An error in laying changes the point of fall, and it

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changes the height of burst, but not the burst range. Hence it makes little difference in shrapnel effect, unless it causes a graze. During adjustment it is different; especially at long ranges the dispersion in height reduces the number of observable shots. It would be well to leave it to the battery commander, whether he will adjust with time or percussion, but require absolutely that in adjusting height of burst he shall keep to the range he has found, and change only his fuze setting. This causes no difficulty whatever, only it may take a little longer to adjust the height after ranging with percussion. With high bursts, one can estimate, at least roughly, the correction; with grazes only, one must make bold changes, and get air bursts at once.

It is also worth noting, that disregarding irregularities of the fuze itself the dispersion of air bursts is less than that of impacts; when dispersion increases, by reason of atmospheric conditions or cannoners' errors, the increase is less for air bursts.

In position warfare the shrapnel is less useful than in the open; but this writer discards it entirely. Even for flanking trenches, for sweeping approaches perpendicular to the front, for interdiction and barrage, he considers it useless. But everything that he says in support of this view, especially concerning the difficulty of adjustment, applies equally to percussion shell, especially if we remember how close to the target the latter projectile must burst. Maps, weather reports, and all the rest, help out the shrapnel as well as the shell; the only difference is in height of burst. And this I do not consider difficult; it is only imagination that makes it seem so. In percussion fire, the observer sees every shot on the ground; he does not realize that there is a very considerable dispersion in range, or at least does not appreciate its magnitude. In time fire the dispersion in range is exactly the same, as far as the trajectory is concerned, but even with accurate fuzes it causes a variation in height, which is annoying to the observer. This can not be eliminated, but it is not necessary to eliminate it. With it goes a dispersion in burst ranges, which, with good fuzes, is not greater than that of impacts, and is often less. A false bracket is more likely with percussion, and it is also more serious, by reason of the greater length of the shrapnel dispersion cone.

The procedure is simply this: Adjustment in range with grazes or very low bursts, great accuracy not being necessary so long as one is sure he is not overshooting; then adjustment of height of burst by changes in fuze-setting alone.

The writer says very properly that the German artillery had not paid enough attention to the effect of the weather upon the burning of fuzes. I will go further, and say that it had paid no attention to the effect of the weather upon the trajectory. This

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confirms my own statements, made in this magazine in 1919, that the technical training of our artillery officers was inadequate, which statements were so violently disputed. I wrote on this subject, anonymously, in the *Archiv für die Offiziere der Artillerie und Ingenieur-Korps*, as long ago as 1894. The accepted view in the artillery at that time was that variations in burst were due entirely to imperfections in the fuzes. I pointed out that with the best of fuzes we should get high bursts with high-muzzle velocity and light air, as in summer, and grazes with low-muzzle velocity and heavy air, as in winter. I showed further that whenever the range was changed by a certain amount, by reason of these conditions, the burst range was altered only half as much.

After the publication of Siacci's "Ballistique exterieure" I calculated in 1902 the variations in centre of impact caused by variations in muzzle velocity, elevation, atmospheric condition and wind, for the 98 rifle and for the two field guns. I pointed out that these calculations would be of little value for manœuvre warfare, where neither the exact range nor the atmospheric conditions were known, but that they would be important in siege work. Unfortunately I could not make the calculations for siege guns, the range tables being held secret.

In the next year, Captain Krause calculated for the board on rifle tests the effect of the weather upon the trajectory of the rifle, and found a very close agreement between theory and practice; but this work remained neglected by the artillery. Captain Becker, whose article on the subject in *Technik und Wehrmacht*, No. 9/10, 1921, contains a historical summary, seems not to have known of it.

In 1915, during the war, the Austrian Lieutenant-Colonel Schmidt, published in the *Mitteilungen über Gegenstände des Artillerie und Geniewesens*, Nos. 6 to 9, a very remarkable article on the variations of points of burst. Using his formulæ with my own modifications (see this magazine, January, 1922, page 4), I calculated variations in trajectory and burst range for four different types of Krupp guns, the light and heavy gun and howitzer. I did not at the time publish this work; in the first place, I knew that the Artillery Experiment Board was working on the effect of the weather, and assumed, wrongly, that burst ranges were to be considered; in the second place, I knew, from experience, that a narrow-minded censor would prohibit publication. And the War Department was much too busy to take the matter up; in the same year a paper on this subject, submitted by Doctor Cranz, the recognized authority, received no consideration.

These papers dealt only with the variations in point of burst due to variations in the trajectory. Of much more importance are the variations due to deterioration of the fuzes in storage. A

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variation of 1 per cent. in the moisture of the fuze train causes a variation of 10 per cent. in the burning time, which is serious enough with the long ranges of modern guns; a greater deterioration makes the fuze useless.

The writer in the *Artilleri-Tidskrift* very rightly mentions this, and describes the difficulties of ammunition storage in position warfare. I can not say how far these difficulties may be overcome, but will only remark that they must have been much greater in the siege operations of former times, when the loose black powder and wooden fuzes had to be kept in open storage. I am not in a position to say how they were protected against dampness.

It is self-evident that mechanical fuzes should have less dispersion (see this magazine, January, 1922, page 1); but also, what is more important, they suffer less in storage. The parts are of metal, and finely finished, and are but little affected by moisture. Recently the Krupp works have succeeded in making an entirely rustless steel, both in heavy armor plate and in thin, flexible sheets. About ten years ago a number of clockwork mechanisms were placed in store, wrapped only in paper, in a room so damp that water ran down the walls; after six years they were moved, without unpacking, to a dry room; and after four years more were still serviceable.

Mechanical fuzes are of course more expensive, but here, as so often, the best is the cheapest. If the fuze is unserviceable, the whole projectile is worthless. Remembering that a shrapnel is six or seven times as effective as a shell, there can be no doubt which is the cheaper for use against targets in the open.

An old Prussian proverb says that difficulties are not simply to be recognized, but overcome. So we should not try to avoid the difficulties in handling shrapnel by abolishing the projectile, but by improved construction of the shrapnel itself and perfected regulations. I should look upon its abolition, especially for the field gun, as a most unfortunate mistake.

I am not blind to the weaknesses of the shrapnel, or rather of time fire. In ranging upon concealed targets with air observation, which is normal in position warfare, it is difficult or impossible to use time fire. On the other hand, with certain targets, such as high observation stations or chimneys, ranging is possible only with time fire, since even from the air the graze bursts can not be judged. So then, more freedom as to ranging methods, and thorough study of time fire; the difficulties will disappear of themselves.

This article had been finished when the January number of the *Revue d'Artillerie* came to hand, with an article on time fire. Here also is found a certain opposition to this method of fire, chiefly on account of the awkwardness of preparation to open fire. But it

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is to be noted that this is chiefly due to the fact that the French fire both shrapnel and shell with various charges, so that fuze and sight settings do not agree. The writer makes several propositions for simplification of the firing methods, which can not be discussed here for lack of knowledge of the details of the fuze setters and range tables referred to. It is to be noted, however, that the writer makes the same demand which has been made here, for uniformity in graduation between sight and fuze; this has already been accomplished in Switzerland.

I have expressed my opinion above, perfectly frankly, but also, I think, entirely impersonally. My only interest in the matter is for the cause of truth and the Fatherland. I have absolutely no prejudice against the high-explosive shell; in fact, I think I was the first Prussian officer to advocate its adoption, in the *Archiv* in the year 1887. But it has not fulfilled my expectations. Others may have the same feeling in regard to shrapnel. Hence I look upon it as not only useful, but necessary, to have a full and free discussion, and would invite all who disagree with me to advocate their views in the *Monatshefte*, where only friends of the shrapnel have heretofore appeared. Such a discussion need not degenerate into a quarrel.

EXPERIMENTAL FIRING 75-MM. SHRAPNEL AT THE INFANTRY SCHOOL, FORT BENNING, GA.

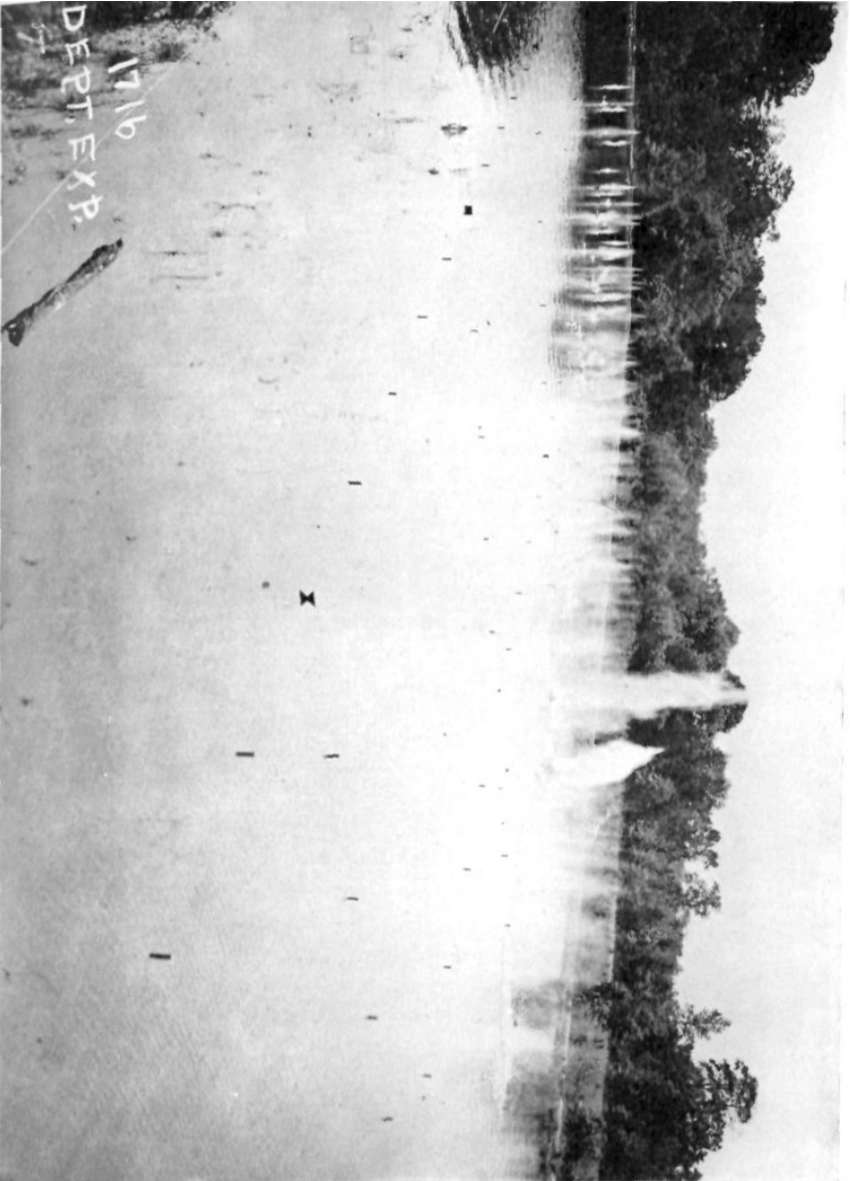
BY MAJOR EMER YEAGER, FIELD ARTILLERY, U. S. ARMY

THE lake on the experimental range at Fort Benning is approximately 400 yards long and 150 yards in width. The range extends in a generally northwesterly-southeasterly direction. The lake is at the southeastern end. On the northeastern side and about 150 yards from each end are two towers, 100 yards apart. The upper platforms in both the towers are roughly thirty feet above the surface of the water. The tower nearer the firing point is called tower No. 1, the farther one, No. 2.

The lake is staked off, both longitudinally and laterally, with lines of stakes which are twenty-five yards apart. The individual stakes are set at five-yard intervals. The firing was done with a single 75-mm. gun from Battery C, 83d Field Artillery, Captain J. G. Watkins, commanding. The piece was laid topographically. Captain Watkins adjusted it for direction and range from the near end of the lake. He adjusted the height of burst from No. 1 Tower, by selecting a scale on the line of trees, which can be seen in the background of the accompanying photographs.

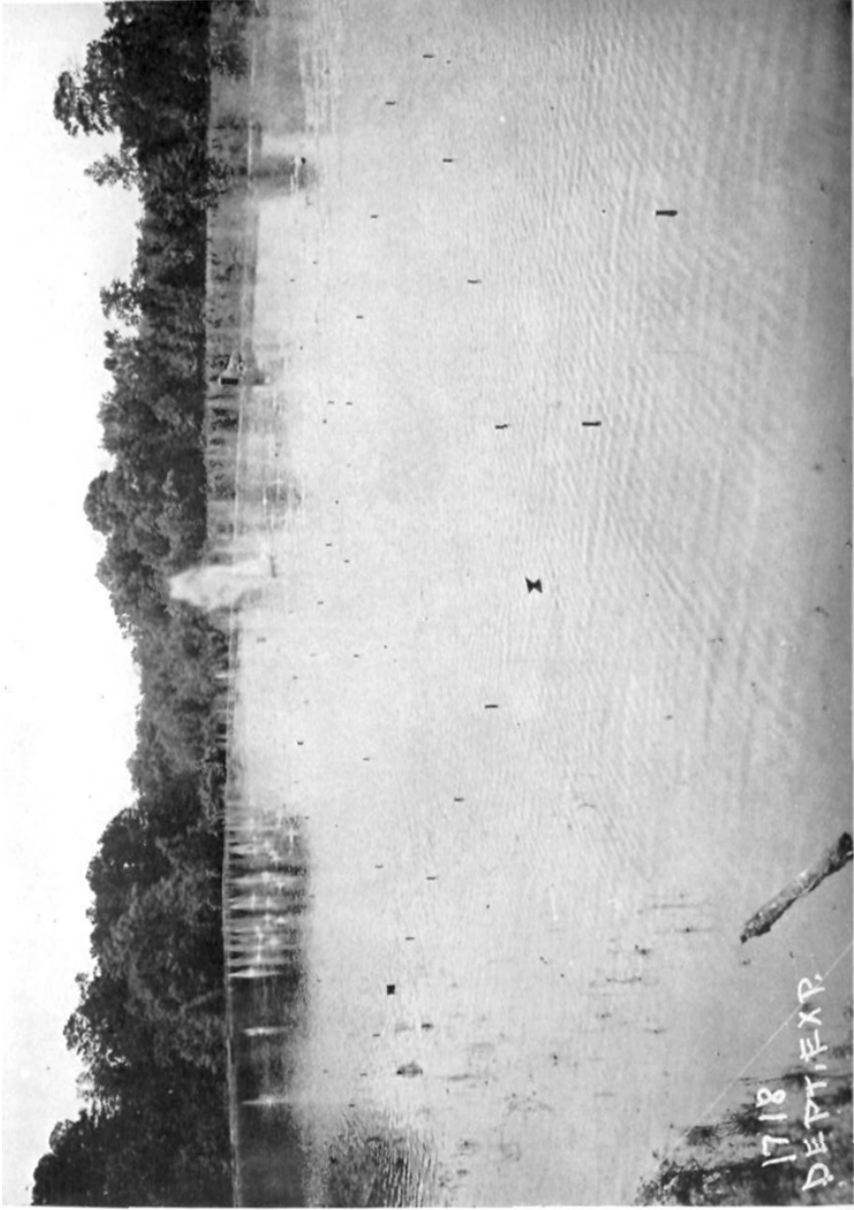
This firing was done for the purpose of determining if it was safe to fire 75-mm. projectiles into the lake without endangering navigation on the Chattahoochee River, which runs parallel to the range, and the lives of the inhabitants in Alabama, across the river. As it was found that there was no danger when using air bursts, further experiments and study will undoubtedly be carried on in the future.

The legends attached to the accompanying photographs are self-explanatory.



NO. 1—SHRAPNEL PATTERN 75 MM GUN

Range 3600 metres - Height of burst 3 miles - Length of pattern 105 yards - Width 35 yards. Notice splashes of fuse and shrapnel case. The farther one is the fuse. Taken from Tower No. 2.



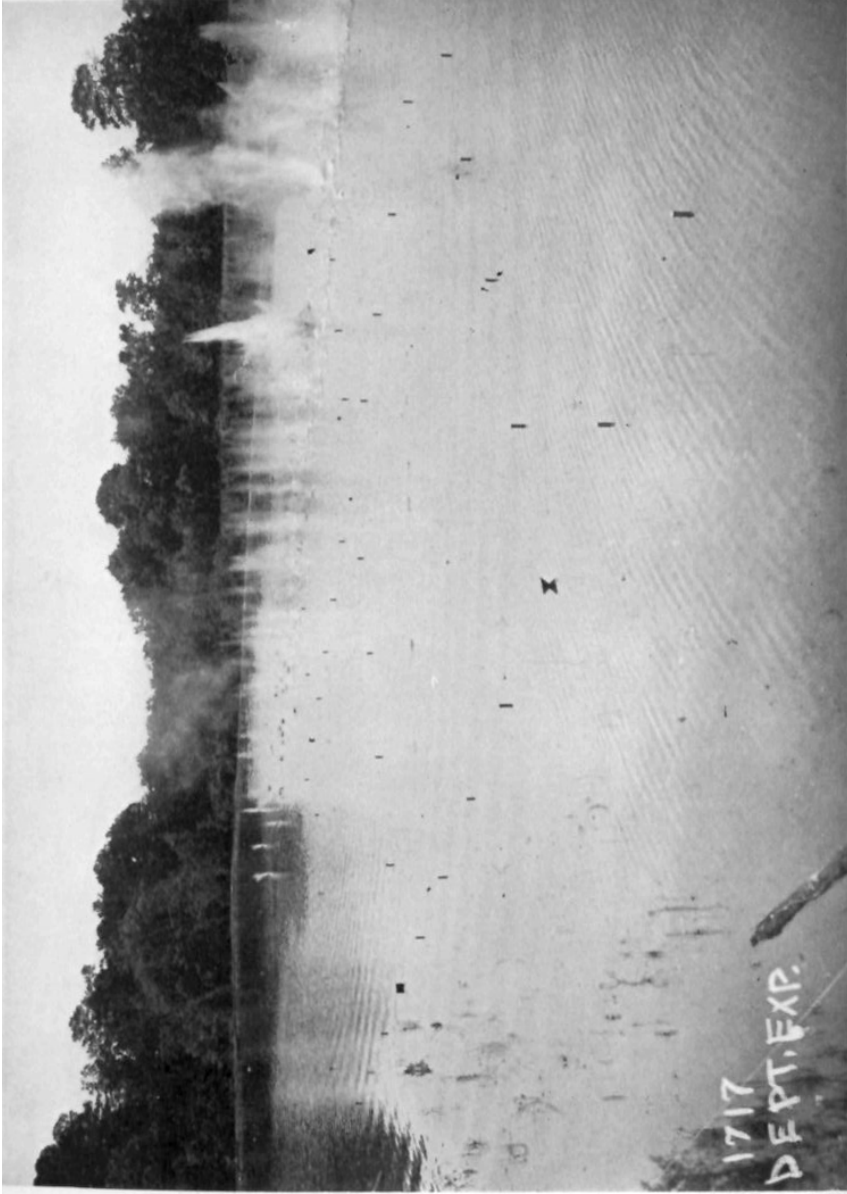
NO. 2—SHRAPNEL PATTERN 75 M/M GUN

All but the extreme short end of the pattern. Range 3600 metres - Height of burst 3 miles - Length of pattern 110 yards - Width 30 yards. Fuse ricochet.
Taken from Tower No. 2.



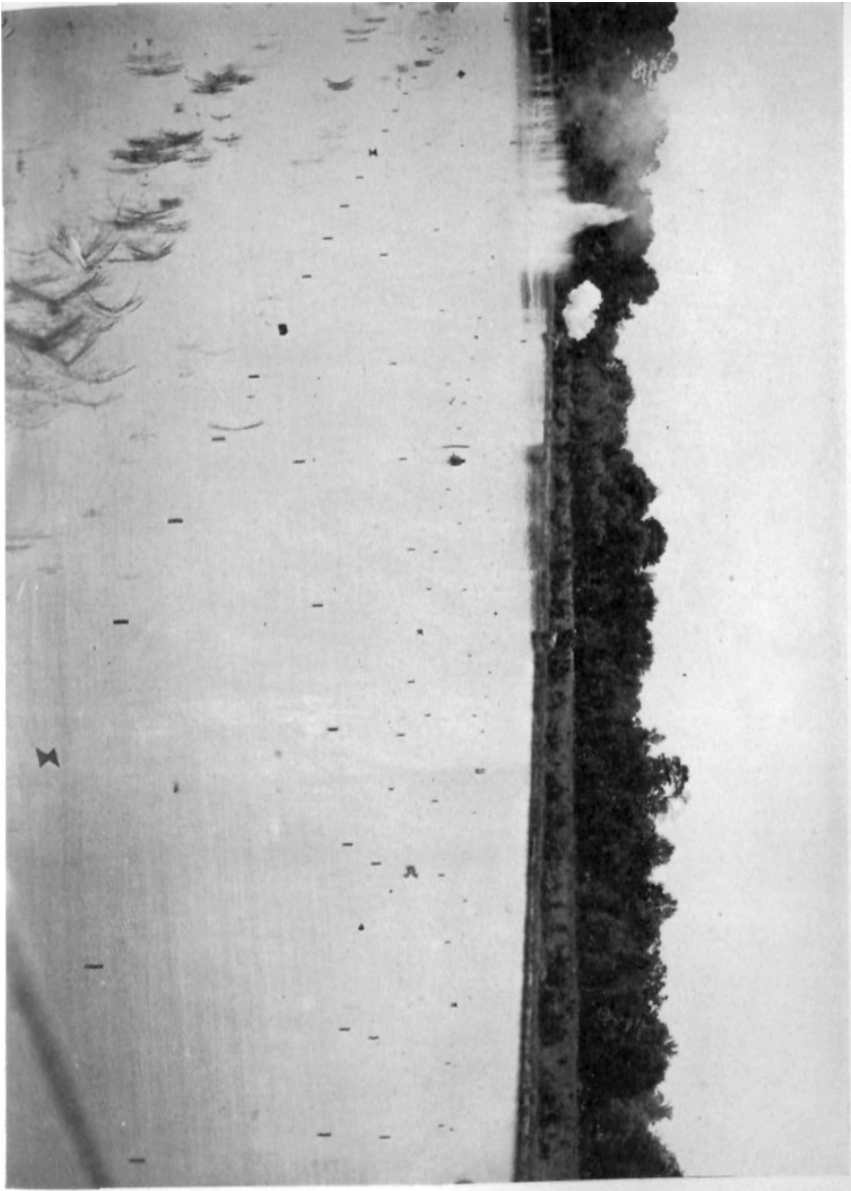
NO. 3

Same round as shown in No. 2 - Exposure taken from No. 1 Tower.



NO. 6—SHRAPNEL PATTERN 75 M/M GUN

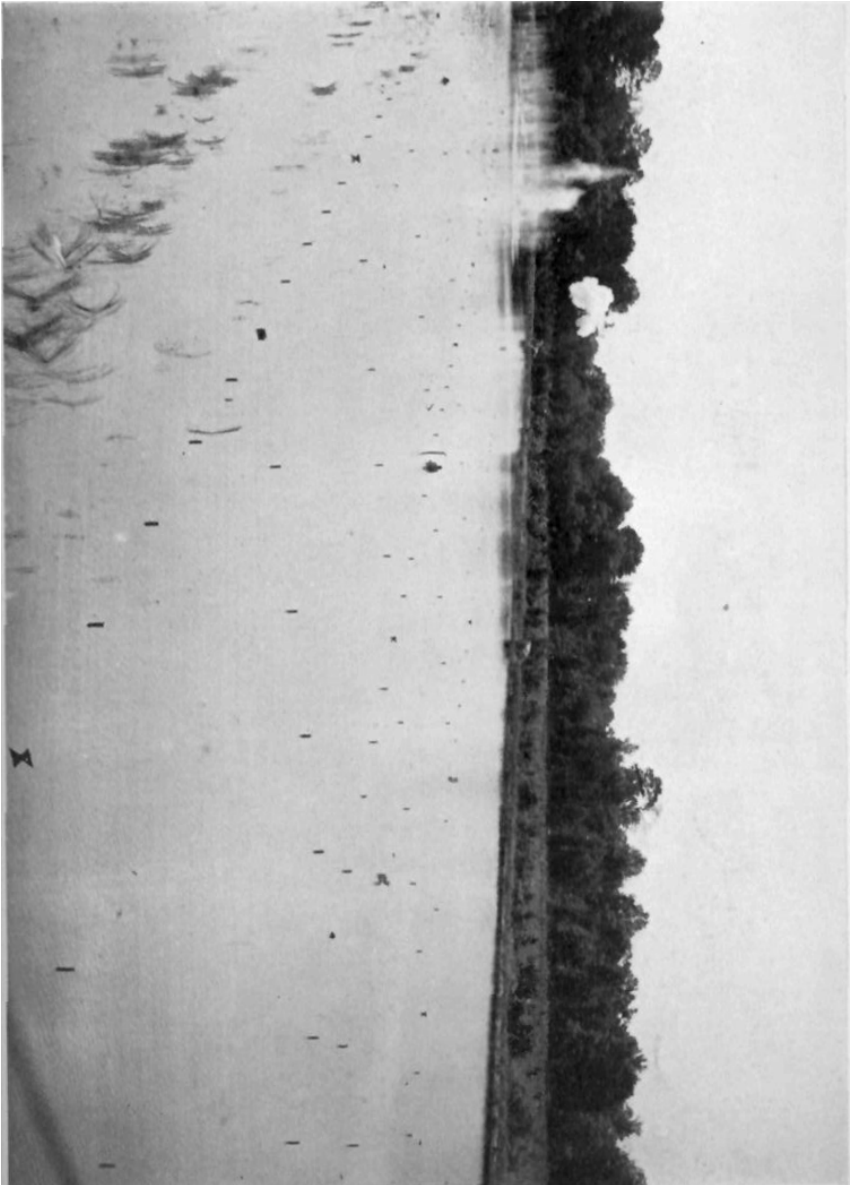
Range 3600 metres - Height of burst 1 mil - Length of pattern 85 yards - Width 20 yards - Notice density of hits as compared with pattern shown in No. 4 and apparently more even distribution than in those shown in Nos. 1 and 2. Taken from Tower No. 2.



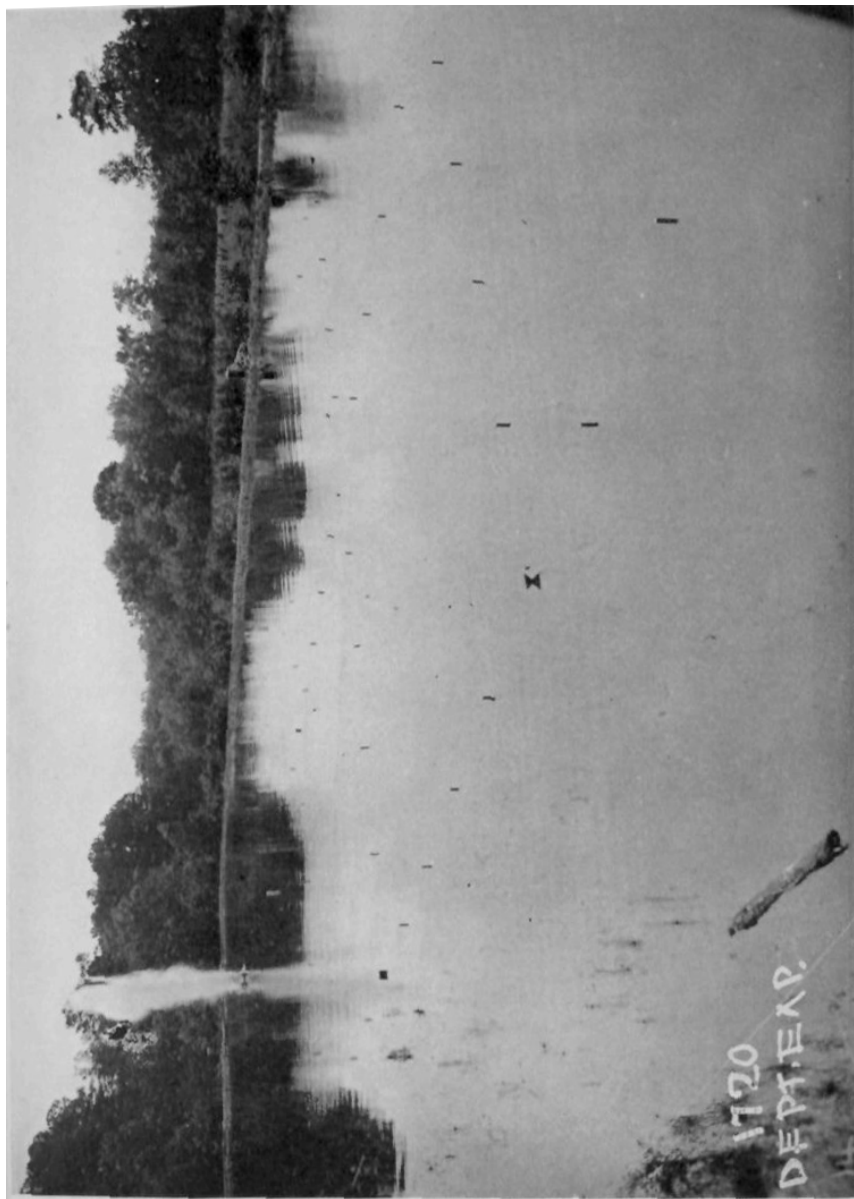
NO. 7
Same as No. 6 but taken from Tower No. 1.



NO. 9—SHRAPNEL PATTERN AND SMOKE BALL 75 M/M GUN
Range 3600 metres—Height of burst, zero—Length of pattern 40 yards—Width 10 yards. Notice disfiguration of smoke ball. The exposure was made a few seconds after the burst occurred and the smoke ball had drifted a short distance.



NO. 8—SHRAPNEL PATTERN AND SMOKE BALL 75 M/M GUN
Range 3600 metres - Height of burst 2 mls. - Taken from Tower No. 1.



NO. 10—PERCUSSION SHRAPNEL 75 M/M GUN
Range 3600 metres. A few ricochets were obtained.

SOME ARTILLERY FACTS ST. MIHIEL, 1914

BY GENERAL J. ROUQUEROL

TRANSLATED FROM THE FRENCH OF AN ARTICLE, APPEARING IN THE REVUE D'ARTILLERIE OF MAY, 1922, BY CAPTAIN PAUL C. HARPER, F. A.

AT THE beginning of the war of position the artillery lacked ammunition and matériel suitable for its missions. The personnel was not familiar with the methods to be employed in a kind of warfare which had not been foreseen at the schools. The German artillery, in most cases, was superior to ours. Under these conditions it was especially creditable to do a good piece of work.

At the end of the war the superiority in artillery had passed to our side. The reasons for this change are well known. They were a perfected matériel, abundance of ammunition, the coöperation of an aviation always more active, and of numerous services perfectly organized to give the artillery all useful information; finally there was the decay of the German artillery, short of replacements for its matériel and limited in its ammunition supply, while its telephone matériel was reduced to a pitiable state.

As a result of this the artillery regulations, based on the experience of the war, bear the imprint of the conditions found in the last period of the struggle. The results of our fire at the end of the war were doubtless considerable, but it is possible that this success was sometimes attributed in too great a degree to the perfection of preparation which some officers consider the guarantee of all essential effectiveness. In 1918 the commander of a heavy battalion once assured us with the greatest conviction that he had destroyed three German batteries in one day on which he had had no observation at all.

Without discrediting the artillerymen of the latter part of the war we must be prepared to find less advantageous conditions at other times, and we must be ready to face conditions which may be worse than those of 1914. It is from this point of view that we must acquaint ourselves with the action of our artillery at the beginning of the war after terrestrial observation had been developed somewhat. It is not a question of criticizing the minute calculation of the elements of fire before beginning an action. It is always advantageous, especially to economize ammunition, to place the first rounds as near the target as possible. But what we must not allow ourselves to believe in the artillery is that perfection of the preparation of fire, thanks to a knowledge of meteorological data, will alone insure effectiveness.

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Observation is so important in firing that an artilleryman who has had little instruction, but is gifted with aptitude for observing fire, can obtain much better results than one who has great technical knowledge without other qualities.

The instances which we shall recount occurred on the front of the Forest of Apremont near St. Mihiel. The artillerymen who were there at the time were not especially expert. They represented the average of their arm. There were among them doubtless some "good heads" who were worth more than heads "well crammed," to use a phrase employed by Monge when talking to the entrance examiners at the École Polytechnique. History repeats itself. There can be no assurance that our cadets will not have difficulties like those encountered in the Forest of Apremont confronting them later. The older officers always hope that the lessons of their experience will not be entirely lost.

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In September, 1914, several batteries of small and large calibre, which found themselves in liaison with front-line troops through local circumstances, often were able to respond successfully to requests for fire by the infantry. The other batteries, that is to say, the greater part of the heavy batteries, did not receive any mission as a rule and simply fired on the inspiration of the battalion commanders or even of the battery commanders without observation.

The terrain was unsuited for the installation of O.Ps. and the closeness of the opposing front lines (40 to 50 metres) in a wooded region made distant observation very uncertain and it was good only from the Fort de Liouville. Finally, the artillery organizations of various calibres on this front, including some high ranking officers, were ignorant of the existence, with two or three exceptions, of the excellent pre-war instructions on the organization of fire. It must be mentioned to the credit of all this personnel that they admitted the insufficiency of their performances. As soon as a proper system was given them they followed it out with remarkable zeal.

To those who saw things close up it was evident that our artillery would do no good until we had good observation. To attain this end it was necessary, under the circumstances, to bring the observatories close to the objectives and to organize a net of fire. About the 25th of October a good part of the batteries were equipped with 1/20,000 maps having numbered squares. These maps were made from tracings of a forestry map found in the neighborhood. Observers were installed in the front-line trenches or in trees nearby. A net of fire was almost completed. The time on duty for the observers was twenty-four hours. On coming off duty they made verbal reports to the artillery commander of their day's observations.

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The influence of this organization was immediately felt from several points of view. The presence in the front lines of artillery officers carrying out their missions under conditions often dangerous right among the infantry troops did more for the liaison of the arms than all the instructions of higher authority. The local command, moreover, took care during the daily tours of duty to establish between officers of all arms habits of sociability which made for smooth relations under all circumstances. The sector commander was informed by the observers regarding all the interesting details of the front line from the point of view of the artillery on our side as well as the enemy's. As he was kept informed at the same time by the infantry commanders as to their point of view, he could intelligently give to the artillery commander the elements of a program of fire for the next day. The batteries of all calibres were provided with plane tables and could make transports of fire easily and take part in concentrations of fire. A rough organization of barrages assured the infantry the support of the artillery.

In saying that our observers shared the life of the infantrymen in the front lines we are not employing a figure of speech. An example was Lieutenant Bertrand. In an attack he was charged with reaching the objective trench as soon as possible with a telephone in order to direct the fire of his battery. To avoid loss of time Bertrand joined one of the attacking platoons. While waiting to install his new post of observation he picked up a rifle. He was killed while firing his rifle among the infantrymen.

Another example was Lieutenant Kammerer who had returned from South America for the war. While he was observing in the front lines he suddenly discovered that the infantrymen on guard around him had disappeared. He was alone and less than 100 metres away he saw a group of the enemy in a trench, the defenders of which had surrendered. Kammerer did not lose his head. He notified by telephone his commander, who immediately laid down a barrage. He then went quickly to the nearest post of command. Confusion reigned there and the infantry battalion commander who occupied it had just had his legs cut off by a shell. With a captain of infantry, Kammerer gathered up a small body of men with some difficulty. The two officers led the men toward the enemy. They captured twenty-three Germans and delivered a dozen Frenchmen who had been taken. Kammerer shot three Germans with a rifle he had picked up on the way. He was killed later in the Champagne.

The idea of preparing each day a program of fire for the next day, as taught at the school of fire at Mailly, did not appear to be suited to the needs of war. At the moment when they were put into effect they gave valuable results. It was a question of opportunity.

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The practice of a daily program made the Germans less aggressive by firing on conspicuous emplacements and works as a result of information and with observation. It gave the infantry confidence in its artillery which fired regularly on objectives reported to be dangerous by the infantry. Finally the artillery acquired a fire discipline of which all the battery commanders realized the necessity. The use of daily programs of fire gradually fell into disuse in proportion as the relations between the arms became more intimate and as the artillery became more expert in the immediate execution of orders.

Single isolated pieces were used to advantage in several cases. We have never hesitated to use a single gun in a case where it could render valuable service. We have regretted none of these operations, nor have they cost us any losses worth mentioning. But these guns were always protected as much as possible before allowing them to disclose themselves by their fire. We shall confine ourselves to citing two examples of isolated guns. The first was a veritable *tour de force* of ingenuity and audacity by Reserve Lieutenant Bascou.

In an attack on the 21st of January, 1915, a 75 gun, emplaced 40 metres from a strong enemy line well supplied with machine guns, fired four hundred high-explosive shells with instantaneous fuses. The enemy parapet, a strong wire entanglement in front of it, and all the small obstacles were demolished in a few minutes to a width of three to four metres. A small column went through this breach and occupied the hostile trench which the enemy had evacuated. It goes without saying that the installation of this gun was studied with the greatest care, prepared during several preceding nights and put in with the greatest precautions so as not to attract the attention of the enemy. It was hidden in a thicket behind a small parapet about 80 centimetres in height. It was fired on a platform provided with a semi-circle of wood to support the spade. Direction was given by prone cannoneers moving the trail with ropes. The shells were spread out on the ground.

This gun had its reservoir pierced by a machine-gun bullet at the end of its firing. It was able to fire a few rounds after this accident. The gun squad had no losses. The only casualty to be reported was caused by a premature burst on the parapet raised in front of the piece. The fragments of the shells that exploded 40 metres in front of the piece did no damage.

The other gun we shall mention had as objectives the bridges thrown across the Meuse by the Germans at St. Mihiel. There were five of them. Very carefully located in the bend of the Meuse, they were concealed from all terrestrial observation. Aeroplane photographs showed only that these passages were echeloned over a distance of about 450 metres. The high command was uneasy

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about these numerous bridges prepared by the Germans and with reason. The bridges had been given as objectives to a battery of 220s firing at 5000 metres and a battery of 155 Longs firing at about 7000. At first it had been peculiar enough to attack bridges of boats and light passerelles with big shells weighing 43 and 100 kilograms, but what was more serious was that the battery commanders fired by the map with control by aeroplane which they could not get more than once a week on an average. These officers knew so little about the results they were getting that one of them announced triumphantly to us one day that he had demolished a bridge, while at the same time an aviator reported to us that all the shells from this remarkable firing had fallen at least 500 metres from the target.

An artilleryman of that sector determined that, although the bridges were not visible, they were grouped in a part of the river which was almost straight. The two banks of the Meuse formed a large cut, visible from all points, at the bottom of which were the bridges. A solution resulted immediately from these facts. A line plotted on the map at right angles to the general direction of the bridges cut into our lines. All that was necessary was to put a field gun on this line and have it fire in jumps of about 50 metres on the whole stretch occupied by the bridges, starting with a range that was sure to be short. The piece to which this mission was given was securely installed in a railroad embankment. Its fire was echeloned between 4500 and 5200 metres. It used up as many as five hundred rounds on several days for the twenty-four hours, but usually less than this number. It was immediately taken under fire by 150s and 210s, but fired just the same day and night from an embrasure in the counter-slope. The Germans at first fired zone fire without exact adjustment. After some days of firing a man was seen after dark lurking around in the vicinity of the piece, but he was not caught. After that the German fire became more accurate, confirming the opinion that the Germans had been informed of the exact location of the piece by a spy. This fact was established, moreover, at other points in this sector by the capture of spies employed on this service.

A joker calculated that the Germans consumed daily on this one gun alone ten times its own weight in shells. It was at last put out of action by a 150 shell exploding on the embrasure without causing any casualties. The piece was replaced and the firing continued. According to the statements of prisoners a number of wagons on the bridges were thrown into the river and the bridges were broken. The resulting difficulty of supplying the enemy troops across the river in the bridge-head caused a reduction in the number of troops occupying the left bank. It must be added that this

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firing was interrupted because of a change in the command and was later resumed again with a 90-mm. gun. This last piece was installed in a new emplacement about 100 metres from the first. When it fired, a battery simulated with grenades camouflaged its position to the enemy observers. This gun was never touched.

The special firing of which we have given examples permitted us to get gratifying results from our weaker matériel. It helped to give us the impression that we were gaining the upper hand of the Germans.

As a picturesque case we shall cite two battery commanders, one French, Reserve Lieutenant Daval, and the German Captain Steinbrücke, two very good artillerymen, who daily fought an unusual combat with the 75 against the 150. Their observers in the front lines were often less than 100 metres apart. Every time that Steinbrücke would open fire Daval sent him a volley and got one in return, saying with reason that the first volley was the only one that would have effect on the personnel who would not wait for the second to take shelter. The nickname given Daval by the Germans was a compliment to his efficiency. They called him "naughty Gussie."

In February, 1915, Reserve Lieutenant of Infantry Delavie, a professor of electricity, invented a means of intercepting enemy telephone communications at a distance. The Germans had not the slightest suspicion of this. One day Daval opened fire on Steinbrücke, who told his observer at once in these words: "Naughty Gussie is firing on me, but it is all right, he is firing 100 metres over." Thanks to Delavie this information went at once to Daval, who shortened his fire 100 metres. Almost immediately Steinbrücke announced the result through the same channel as before: "Naughty Gussie has shortened his fire, the shells are falling in the battery, the door of my dug-out is blown in, I have six wounded. I have ceased fire and sent every one to cover." Daval ceased fire also.

This special firing did not distract the attention of the artillerymen from more general problems. Here is how the questions of barrages and concentrations were handled. It should be noted that the organization of which we shall speak was in use at the end of 1914. At this period the authors were in the nature of pioneers in this field. The plan of the barrage took in all the field guns on the front. They were not used exclusively for this, but the barrages had priority over all other missions. The pieces were provided with short platforms having semi-circles marked with the mean direction of the barrage. A small firing board with a map and a table of the elements for the barrage was kept at each piece. So much for the batteries.

The range of the barrage was fixed at 100 metres only beyond our front lines. The rate of fire was ten rounds per gun for rapid

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fire. On request this fire would be repeated. All requests for a barrage had to be complied with in two minutes at the maximum after receipt of the request. The barrages had a double verification every day by battery; a tactical and a technical verification. The first consisted of a request for a barrage at any moment whatever of the day or night from a front-line commander, ending with the word "exercise." In this case the fire was limited to one round per piece. That sufficed to maintain vigilance in the batteries. It was very rare that the delay of two minutes was exceeded. The technical verification was of the elements of fire. This concerned the artillerymen exclusively.

The telephone was supplemented by red and green rockets. The Germans, who discovered our instructions for the use of these rockets, occasionally managed to make us put down barrages to no purpose. The telephone, generally in working order on such occasions, permitted the error to be quickly corrected. Communications by optical apparatus came too late.

The concentrations of fire were very simply arranged. Each battery had in its field of fire the data on a certain number of points. They were constantly being verified. A combined map showing the fields of fire of all the batteries showed at a glance what batteries could fire on a given point.

The order for a concentration of fire required, in the batteries concerned, the calculation of a slight transport of fire. Exercises with a few rounds only from time to time resulted in very successful concentrations being laid down. The maximum delay allowed for all the batteries affected to get into action was fifteen minutes. It was very rare that more than ten minutes was used.

We attribute to a very opportune concentration of fire the check of a German attack on the Bois Brûlé in November, 1914, although at that time the mechanism for concentrations had not yet been perfected. About four o'clock in the afternoon the commanding general of the Eighth Army Corps called his artillery commander. Our lines were being subjected to a heavy bombardment, the usual preliminary, at that time, to an attack. The successful defense of our position by an infantry exhausted from previous combats was very doubtful. "They are going to take a trench from me," said the Corps Commander. "Can't the artillery do something?" "Yes," replied the artilleryman. "What?" "I have not the time to tell you; I must hurry." A half hour later 40 guns of all calibres covered the Bois Brûlé with shells and nipped in the bud an attack which was awaited with apprehension by the defenders of our lines.

CURRENT FIELD ARTILLERY NOTES

General Rouquerol on Firing by Artillery

TRANSLATION FURNISHED BY COURTESY OF MILITARY INTELLIGENCE DIVISION,
GENERAL STAFF, U. S. ARMY

IN the *France Militaire* of May 7, 1922, General J. Rouquerol makes the following comments on a new "Manual of Artillery Firing," the definitive edition of which has been adopted as a result of the experience of the War, and which is shortly to be published for use by the service. The views of General Rouquerol are well worth reading, not only because he is an artilleryman of great value, as his various writings attest, but further, because he takes exception to what he considers the too scientific methods of firing now in vogue in the French Artillery.

The translation of this article follows:

"The new 'Manual of Artillery Firing' was distributed to artillery organizations in 1920 with a view to having it tried out. Headquarters required the opinions of organization commanders before deciding on the final text, which we learn is about to be published.

"The moment consequently seems to be well chosen to investigate the opinion which the majority of the officers of artillery have formed concerning this question. In submitting the 'Manual of Artillery Firing' to examination by the Artillery organizations, the War Department has anticipated the criticisms that might be raised, for in the letter of transmission accompanying this document the question it put whether it would not be more fitting, in a certain measure, to reserve this Manual as a 'teacher's book' for the élite of the Artillery, and to edit a simpler regulation for the use of, and capable of being understood by, the mass of artillerymen.

"It seems that this solution secured many votes.

"The conditions under which this project came to life explain its somewhat encyclopædic and scientific aspect.

"At the end of the War our Artillery had at its disposal an extremely varied matériel, including several models of ultra-modern guns with unlimited ammunition supply, and with a wealth of instruments, specialists, and information that it had never known previously. As the value of our artillery increased, it should be noted, however, that the value of the enemy artillery declined more and more from every point of view. At the end of the War the Germans were no longer able to replace damaged matériel; they were forced to economize their ammunition; their telephonic apparatus was in a pitiful state; their air service for observation was more and more paralyzed.

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"The success obtained by the French Artillery cannot be doubted, but it would be foolish to affirm, in view of the foregoing comparison, that the excellence of the firing methods employed was demonstrated by the experience of the last months of the War.

"We are very far from thinking that the next war will commence where the last one left off. We sincerely believe that in the Artillery, as in every branch of the military art, success must not be hoped for in combat except by the application of simple rules. This idea does not in any way exclude the use of the most perfected instruments, for it must be well understood that the advantage over the enemy as regards questions of technic, has been, and always will be, a cause of superiority which may be decisive.

"As a matter of fact, outside of firings based on direct observation, numerous firing methods indicated in the Manual are incomprehensible for many officers. For example, the preparation of a sheet of calculations including fifteen separate items which the battery commander must fill out with about 100 different items to write. Moreover, this example refers to a relatively usual type of firing.

"A general officer, very expert in technical questions, spoke to us of the opposition which he encountered among his officers to the methods of which we are speaking. He combatted this opposition with conviction and declared that intelligence was not necessary in order to fill up a sheet with calculations prior to opening fire, since it was only necessary to fill in figures and to carry out operations clearly indicated. It is our opinion that officers, changed into simple calculating machines, are exposed to errors all the more serious since their consequences are less apparent to the less brilliant officers.

"We recall the case of a commander of a battery of 155-mm. guns who was firing on St. Mihiel bridges at a range of 7500 ms., using the map. He was so certain of his firing that he reported a destruction of a bridge. This was checked by airplane which reported to us that the nearest points of fall to the target were at least 500 ms. away. Certainly the firing methods at that period were very inferior to those which we are discussing from the technical point of view. But the only purpose of this example is to show how much exaggerated confidence can be placed in calculations that are not understood.

"It is proper to note that the Manual recommends terrestrial observation every time that this is possible. This is an excellent idea, and should put the artilleryman on his guard against the uncertainties of firings where no one sees where the shots are falling. Calculation for the average man has a great force of persuasion and many officers of all arms would finally believe, basing their faith on the regulations, that the knowledge of meteorology, ballistics and

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maps would permit the destruction, with eyes closed, of every target designated to the science of the artilleryman. It would seem that a proper reaction against these exaggerations should be commenced at the Artillery School at Metz.

"When the various models of guns in service at the end of the War are known, the impression is gained that the 'Manual of Artillery Firing' was prepared by the heavy Artillery, but if we are to believe the heavy artillerymen, the long-range firings at the end of the War were most frequently zone firings which did not include careful preparation nor great precision.

"The abundance of the information contained in the Manual, very interesting for very intelligent artillerymen, evokes the idea that this is more a result of a study-room operation than a result of experience gained by actual combat. Without desiring to diminish the merit of this work, it may be noted, *en passant*, that many regulations are the single reproduction of old instructions for siege artillery adapted to modern technical conditions.

"As in the case of all recent manuals, the one under consideration is remarkable for the richness of new terms, which are more harmful than useful, considering the precision of military correspondence. Fifteen kinds of fire are anticipated, harrassing, interdiction, accompanying, protection, raking, etc. The instructions on the "tactics of large units" have added several more; firings of direct support, caging firings. *En resumé*, it must be anticipated that the final regulations on artillery firing will be less scientific and less encyclopædic than the document which has actually been tried out.

"The firing of a gun is as many another thing, a business, an art, or a science, according to the aptitude of the one who carries it out. Scientific calculations, delicate and accurate instruments are necessary for difficult firings, but outside of the fact that these are not the usual type of firings, it is entirely impossible to assume that all officers of a numerous corps will be able to be sufficiently instructed in order to practice with facility. It must be sufficient to include in a book of instructions used by all the officers of the arm, methods capable of being understood by average degrees of intelligence. This, of course, is not a reason for refusing to carry out complicated firings when they are necessary, but they should be treated in a supplement to the Manual for the use of specialists in artillery firing.

"It is not possible that this should be otherwise. The more the technic of the artillery is perfected, the less will it be possible to take no matter who, to do no matter what. This has been the case for a long time. Our readers will certainly recall that the Germans made three breeches in the fortification of Strasbourg in 1871. These

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three firings were all carried out by the same captain of artillery whose technical knowledge was well known. Let us cite another example which is testimony of the professional ability of Colonel Barbier, who at his death was Director of the Technical Artillery Section. As commanding officer of the heavy artillery of a division, he was charged with the mission of attacking a German battery with a 240-mm. railroad gun at a range of 24 kms. He obtained, in an excellent series of shots, several hits and destroyed two large enemy guns out of four. The British Headquarters, which attached great importance to this firing, had placed 100 airplanes at the disposal of the French Artillery Commander for this firing."

Ordnance Notes.

THE ST. CHAMOND RECOIL MECHANISM*

A recoil mechanism must absorb the energy of recoil and gradually bring the gun to rest; absorb the energy of counter-recoil and return the gun from its recoiled position to its in-battery position without shock, and hold the recoiling parts in battery at maximum elevation.

The St. Chamond recoil mechanism has fulfilled these conditions. This mechanism was developed during the war in 1917 for the 75-mm., 1916 American Carriage by Colonel Rimailho of the French Army at the St. Chamond factory.

It is of the hydro-pneumatic type, and is smooth in operation and durable. Further, the use of small forgings for carriages, ranging between 3-inch and 4.7-inch inclusive, is made possible by the use of high pressures in the recoil and recuperator cylinders. The success of this recoil mechanism may be attributed to the development of a specific packing which would hold high pressures, and the function of the counter-recoil.

Fig. 1 is an assembled view of the St. Chamond brake as used on the 75-mm. gun carriage, M. 1916MI. There are three cylinders, the middle one being the recoil or hydraulic cylinder, the right cylinder has an air chamber at its forward end, and an oil reservoir at the rear end. The left cylinder, known as the recuperator cylinder, comprises at its forward end additional air space and has at its rear end the floating piston and regulator for controlling the length of recoil.

The recoiling parts are held in battery by the reaction of air on a floating piston and liquid against a leak-tight recoil piston head, using one piston rod for both the function of recoil and counter-recoil, the floating piston separating the oil from the air. An opening

* Reprint *Army Ordnance*, July-August, 1922.

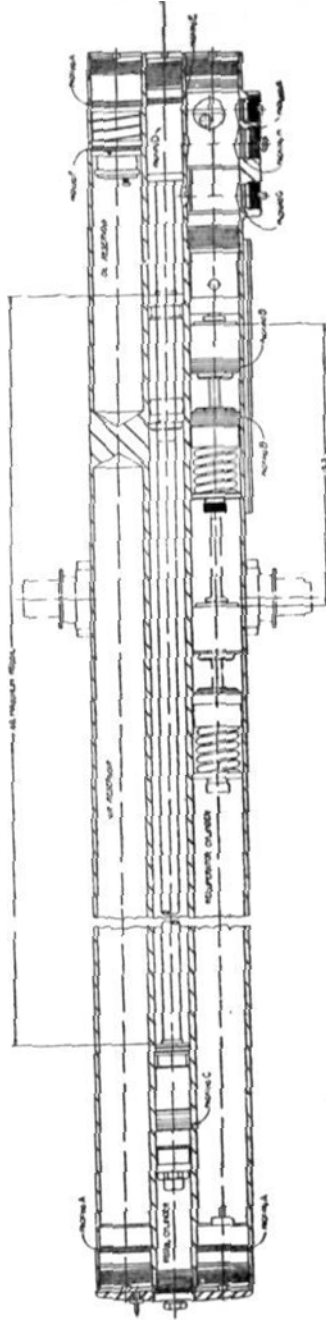


FIG. 1. ASSEMBLY OF 75-MM. RECOIL MECHANISM 1916 M. 1.

Initial Air Pressure 1000 lbs. per sq. in.

Maximum Air Pressure 1500 lbs. per sq. in.

Maximum Hydraulic Pressure 5250 lbs. per sq. in.

Resistance to Recoil at 0-degrees Elevation 4000 lbs.

Maximum Resistance at 53-degrees Elevation 12,000 lbs.

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is provided between the recoil cylinder and recuperator cylinder, in which a regulator valve is placed.

Fig. 2 shows a schematic diagram of the operation of the St. Chamond system for both recoil and counter-recoil.

In recoil the gun moves to the rear, carrying with it the recoil piston

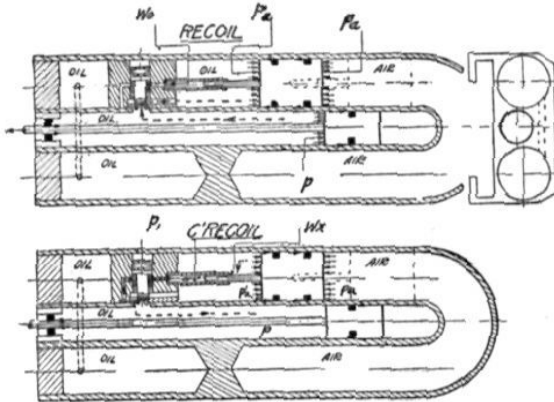


FIG. 2. St. Chamond Recoil System.

(middle cylinder). The pressure in this cylinder opens the regulator valve, the movement of which is controlled by a small coil spring in parallel with Belleville washers. Thus the energy of recoil is absorbed by throttling the

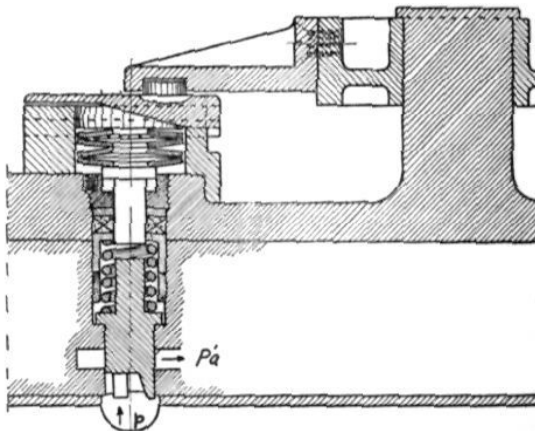


FIG. 3. Regulator Valve and Recoil Control Mechanism.

oil through this spring-controlled orifice. The oil passing through the recoil orifice moves the floating piston forward against the air, thereby increasing the air pressure and storing up energy, which returns the gun. During recoil the oil pressure in the recuperator cylinder is higher than air pressure,

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this drop being due to the floating piston friction. The counter-recoil valve remains closed during recoil.

The recoil regulator valve is closed during counter-recoil. The oil flow during counter-recoil, therefore, is different from recoil. The flow path is through a small channel (W_o) at the inside end of the buffer chamber in the recuperator cylinder and ending in the hydraulic cylinder, as shown in Fig. 2. The throttling during counter-recoil takes place through a constant orifice at the beginning of the counter-recoil channel. The pressure (P_a) on the oil side of the recuperator is lowered by this throttling to a small pressure in the recoil cylinder. The tapering buffer rod on the floating piston in the recuperator causes additional throttling through the annular area between the buffer chamber and buffer rod of the floating piston. Toward the end of counter-recoil, the pressure in the recoil cylinder is thus brought to practically zero. The constant throttling area in the counter-recoil channel is so designed as to cause sufficient throttling to lower the pressure in the recoil cylinder that it may practically balance the total friction, guide and stuffing box, during counter-recoil. At the end of counter-recoil this friction alone brings the recoiling mass to rest when it reaches the battery position.

The essential feature of the St. Chamond brake is the spring-regulated valve where the main throttling occurs. The valve functions somewhat as a pressure regulator since if the pressure is lowered the spring reduces the valve opening, thereby increasing the throttling drop and the pressure in the hydraulic cylinder. The pressure in the recoil cylinder is the sum of the air plus the floating piston friction drop plus the throttling drop through the regulator valve. At short recoil the air pressure is small compared with the throttling drop. The resistance to recoil is large and therefore the recoil pressure large. This requires a large throttling drop and the air pressure becomes small compared with the throttling drop. A large throttling drop requires a very small opening with a large pressure reaction against the valve. To balance this reaction a very stiff spring is required. Such spring characteristics have been met by the use of Belleville washers. At long recoil the resistance is small, therefore the throttling drop is small and requires a large orifice. Since the pressure in the recoil cylinder is small together with a large orifice opening, a weak spring with a large deflection is desirable. Such spring characteristics are best met with an ordinary spiral spring. Hence at long recoil, low elevation, a spiral spring functions alone, while at short recoil, maximum elevation, the Belleville and spiral spring function in parallel. (Fig. 3.)

At short recoil the upper stem of the regulator (Fig. 3) is brought down by the cam at its top until its lower surface is in contact with the top surface of the lower valve stem. Thus the



CRATER AND BURST EFFECT FROM 240-MM. HOWITZER PROJECTILE, CAMP BRAGG, N. C.

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length of recoil is automatically varied by the control mechanism. (Fig. 3.)

155-MM. GUN 8-INCH HOWITZER CARRIAGE MODEL 1920*

An experimental long-range mobile artillery carriage has been recently completed by the Ordnance Department at Rock Island Arsenal and is now at the Aberdeen Proving Ground, Maryland, for test. This carriage, known as the 155-mm. gun, 8-inch howitzer carriage, Model 1920, mounts either a 155-mm. gun or an 8-inch howitzer. The carriage is of the split-trail type with rubber-tired wheels and permits a total movement of the cannon in azimuth of 60° and a maximum elevation of 65°. The recoil mechanism is of the hydro-pneumatic type with a variable length of recoil. In order to increase the rapidity of fire and ease of loading the cannon when firing at high elevations a quick release mechanism is provided for returning the cannon to the horizontal for loading without disturbing the sighting mechanism. The maximum range of the gun with a 95-pound projectile is over 14½ miles and of the howitzer with a 200-pound projectile is over 10½ miles. These ranges are about four miles longer than those obtained with similar artillery of the same calibre during the World War.

The weight of one cannon and carriage in firing position is about 24,000 pounds. For road travel the total weight of one vehicle is lessened by transporting the cannon, which weighs about 9000 pounds, on a separate wagon, although the carriage may be moved for short distances with the gun mounted on it. While the range of these cannon is greater than that of World War cannon of the same calibre, the weight of the assembled unit is actually less.

THE 240-MM. HOWITZER

(See frontispiece)

THE Field Artillery now has organizations equipped with 240-mm. howitzers. This equipment has been recently issued to the 2nd Battalion, 5th Field Artillery, at Camp Bragg, N. C.

The frontispiece of this issue of the JOURNAL shows one of the howitzers in the firing position and the accompanying illustration gives an idea of the crater and burst effect of the projectile.

Reports from Camp Bragg indicate that the personnel, both commissioned and enlisted, are very much pleased with their 240-mm. matériel and are enthusiastic concerning the general performance of the howitzers, in the service of the piece, ease of handling in loading, laying and firing. While the first problems were fired at ranges around 12,000 yards, and were for the purpose

* Reprint *Army Ordnance*, July-August, 1922.

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of familiarizing the personnel in the handling and performance of the howitzers, in the future, advantage will be taken of the unlimited ranges and varied terrain available at Camp Bragg, and problems will be fired at long range with terrestrial and aerial observation.

The description of the 240-mm. matériel is fully covered in the Ordnance Handbook. The 240-mm. howitzer for travelling is split into four loads, platform—top carriage—cradle—howitzer, and each load is drawn by one ten-ton tractor. The heaviest load, the platform, weighs about eight tons and the lightest load, the howitzer, about seven tons. All loads are easily handled on the road by the ten-ton tractors. The howitzer can be put in position and made ready for firing in about four hours from the time of arrival of gun crew and first carriage (platform transport wagon) at position. The maximum range is 16,393 yards and maximum traverse on either side of the centre line of platform is ten degrees. This necessitates accurate designation of missions and location of platforms, so as to be able to fire on objectives designated in mission. In the first firing of these howitzers at Camp Bragg one battery was put in position in sandy soil and one in hard clay. During firing there was found to be less movement on the platform in clay than in sand.

The weight of the shell is 345 pounds. The powder charge is put up in five equal increments giving five charges: charge one using one bag, muzzle velocity 630 fs.; charge two, muzzle velocity 930 fs.; charge three, muzzle velocity 1180 fs.; charge four, 1435 fs., and charge five, 1700 fs.

The ammunition is hauled in trucks to the vicinity of the battery position and thence by shot trucks running on 60-mm. tracks to howitzer position. This necessitates selection of position in vicinity of roads that are passable for ammunition trucks, unless ample supply of narrow gauge railroad track is available for running shot trucks to positions distant from roads. For firing at Camp Bragg railroad track is improvised from 2" × 4" lumber with saplings for cross-ties. Ammunition is easily handled by shot trucks with differential hoist at dump on road and loading crane at howitzer. Fire control, communications and topographical equipment used with the 240's at Camp Bragg is that prescribed for the 155-mm. howitzer batteries. When terrestrial observation is used O. Ps. several miles in advance of the batteries are necessary and this renders communication the most difficult problem the battery commander has to solve, especially when wire is used. At Camp Bragg, satisfactory communication can be obtained using the radiophone of the 109-A sets, with one set at battery and one set at O. P.