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**THE
FIELD ARTILLERY
JOURNAL**

EDITED BY

HARLEIGH PARKHURST

MAJOR, FIELD ARTILLERY, UNITED STATES ARMY

THE UNITED STATES FIELD ARTILLERY ASSOCIATION

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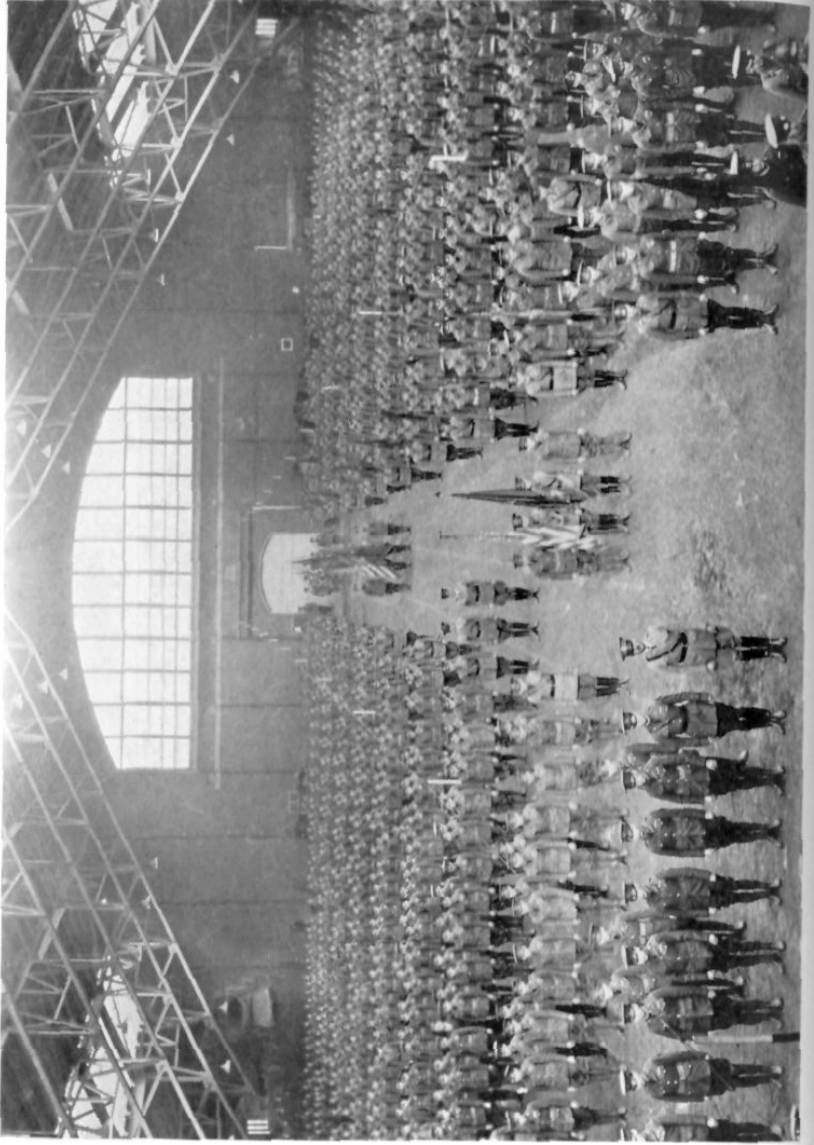
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CORPS DAY AT PURDUE UNIVERSITY

THE FIELD ARTILLERY JOURNAL

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SEPTEMBER–OCTOBER, 1927

NO. 5

MAXIMUM RANGE AND EFFICIENCY OF PROJECTILES

BY LIEUTENANT-GENERAL H. ROHNE, RETIRED, GERMAN ARMY

SUMMARY BY MAJOR EDMUND L. GRUBER, F.A.

[This is General Rohne's closing contribution to the *Artilleristische Monatshefte*, which after twenty years under his editorial guidance, ceased publication with the November-December, 1926, number.—EDITOR.]

SHORTLY after the outbreak of the World War, all the belligerents found the need of greater range for their field artillery cannon. They solved the problem in different ways. Germany increased the length of her cannon, improved the form of her projectiles and used larger powder charges. For the new light field gun, the weight of projectile was reduced 14 per cent., from 6.85 to 5.9 kilograms, but for the new light howitzer no change was made in the projectile. As a result the extreme range of the light field gun was increased 37 per cent., from 7300 meters to 10,700 meters, and that of the new light howitzer 54 per cent., from 6300 to 9700 meters. The larger powder charge used made it necessary to increase the weight of the piece in firing position, the increase being 29 per cent., from 985 to 1325 kilograms for the light gun, and 15 per cent., from 1225 to 1380 kilograms for the light howitzer. France, on the other hand, made no change in powder charge but increased the weight of the 75-mm. projectile 6 per cent., from 7.25 to 8.0 kilograms. In addition, the projectile was given an improved stream-like form with sharper ogive, thus increasing the extreme range 31 per cent., from 8500 to 11,200 meters. Neither the muzzle energy nor the weight of the gun in firing position was increased.

As will be seen, three different ways were adopted to attain greater ranges. In the German light howitzer the muzzle velocity was increased while the weight of the projectile remained unchanged. The French reduced the muzzle velocity of their 75-mm. gun and increased the weight of the projectile. In the German light field gun just the reverse was done. We cannot help but gain the impression that, in general, a thorough study of the problem had not been made. This was to be expected since during a war there is neither time nor opportunity to conduct a careful and detailed study of the many problems involved. The more reason, therefore, for such a study in time of peace.

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Assuming that a projectile of the most favorable form has been adopted, an increase in the maximum range cannot be attained without increasing the muzzle energy, and, therefore, also without increasing the weight of the piece in firing position. For mobile guns this increase in weight of the piece means a loss in mobility; for guns of position it means a more rapid wear of the tube and, hence, a loss in accuracy of fire. Our first problem, therefore, is to determine the most favorable values of muzzle velocity and weight of projectile, that is, the minimum muzzle energy with which a given maximum range can be attained. Having done this we will probably find that the weight of the projectile thus determined will not give us an efficient projectile from the viewpoint of effect at the point of impact or burst. Between these two extremes, that is, the most favorable weight of projectile to attain a given maximum range and the most effective projectile at the target, we will find our solution.

I. *The determination of the most favorable muzzle velocity and weight of projectile to attain the greatest maximum range.*

In order to simplify our calculations, we will assume that the projectile does not reach the higher rarified air strata. The maximum range will then be attained with an angle of elevation slightly under 45° , actually about 43° . This will enable us to use the ballistic tables of Commander Fasella of the Italian Navy, which are based on Siacci's laws of air resistance.

The terms used throughout the study will be represented as follows:

X —the range in km.

v_0 —the muzzle velocity in m/sec.

ϕ —the angle of departure.

p —the weight of the projectile in kg. or grams.

a —the caliber of the piece in m. or cm.

i —the coefficient of form.

n —the sectional density of the projectile = p/a^3 .

c' —the ballistic coefficient which is equal to $n.a/100i$, when a is given in cm.; $p/1000a^2i$, when p is in kg. and a in m.

g —acceleration due to gravity is equal to 9.81 m.

In vacuo, $X = v_0 \sin 2\phi/g$. Since g is constant, X varies only with the initial velocity and the angle of departure. In air, we must consider also caliber, weight of air and the form of the projectile as they affect the ability of the projectile to overcome air resistance. The retardation due to air resistance finds its expression in the ballistic coefficient. The coefficient of form i must usually be determined by experiment and is equal to $p/1000a^2c'$.

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Of the four quantities which determine a trajectory, namely, X , v_0 , ϕ and c' , any three being known the fourth can be solved by means of Fasella's ballistic Tables II and III. Since c' is dependent upon i , a and p (or n), these must be known in order to solve the problem completely. In order to get the necessary data for our study, several examples will be solved.

Example 1. The H shell of the German 10.5-cm. gun weighs 18.7 kilograms. With a v_0 of 650 m./sec. and ϕ equal to $43^\circ 52\frac{1}{2}'$, it attains a maximum range of 14,100 meters. Find c' and i .

Using Fasella's tables, we find $c' = 3.0$; and $i = 0.565$.

Example 2. If i had been 0.896 (the coefficient of form of the old Krupp shell) and all other quantities the same, what would have been the maximum range?

Using Fasella's Table II, we find the maximum range would have been 11,420 meters. Hence, by adopting a better form of ogive, the maximum range has been increased 25 per cent. or 2680 meters without any increase in the muzzle energy.

Example 3. What v_0 must be used in order to attain a maximum range of 14,100 meters with a 16 kilogram shell fired from a 10.5-cm. gun, assuming that i and ϕ are the same as in Example 1?

Using Fasella's Table II, we find v_0 would be 719 m./sec. Since the muzzle energy is $pv^2/2g$, we find that to attain a maximum range of 14,100 meters with a 18.7 kilogram projectile (Example 1), we must develop a muzzle energy of 402.6 metertons, whereas with the lighter projectile of 16.0 kilograms (Example 3), the muzzle energy developed must be greater or 421.6 metertons. This is due to the fact that the heavier projectile can more easily overcome the air resistance.

Example 4. From the above examples we see that there must be a minimum muzzle energy with which a maximum range of 14,100 meters can be attained. What is this minimum muzzle energy?

By solving a series of examples, we can tabulate the results as follows:

v_0	400	500	600	700	800	m./sec.
p	125.5	33.77	21.93	16.78	13.88	kg.
$pv^2/2g$	1023	430.2	402.3	421.3	452.6	mt.

We see off-hand that the minimum muzzle energy is attained when v_0 is greater than 500 and less than 700 m./sec. By solving between these two values, we find the minimum muzzle energy of 395.6 meter-tons will be developed with a v_0 equal to 590 m./sec. and a projectile weighing 22.3 kilograms. Now, whereas this minimum muzzle energy can be attained with the smallest powder charge and the least wear of the tube, it may not be the most favorable when we consider the efficiency of the projectile. By increasing

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v_0 by 50 m./sec. to 640 m./sec. and using a lighter projectile weighing 19.2 kilograms, we would have increased the muzzle energy to 401.2 meter-tons, an increase of only 1.2 per cent. By reducing v_0 50 m./sec. to 540 m./sec. and using a heavier projectile weighing 27.2 kilograms, we would have increased the muzzle energy to 404.2 meter-tons, an increase of only 2 per cent. The question of the most efficient projectile will be taken up later.

II. *The determination of the most favorable muzzle energy (v_0 , c' and p) to attain the greatest possible range.*

Since the ballistic coefficient c' can be expressed in terms of weight of projectile p , caliber a , and coefficient of form i , we will approach our problem by first determining the most favorable values of c' and v_0 for 43° angle of departure, based on a particular caliber and coefficient of form, and for several maximum ranges. Having done this with the aid of Fasella's Table III, we can then determine by interpolation the weight of the projectile for every caliber and coefficient of form.

In order to have our table in convenient form, we will adopt a caliber of 10 cm., a coefficient of form of 1, and a range of 10 km. Since $p = 1000a^2ic'$, this equation will reduce to $p = 10c'$, because $a = 10$ cm. and $i = 1$.

Our data can be tabulated for the range of 10 kilometers as follows:

v_0	400	500	600	700	800	m/sec.
c'	3.522	2.078	1.597	1.346	1.184	
p	35.22	20.78	15.97	13.46	11.84	kg.
$pv^2/2g$	289.1	264.8	293.0	336.1	mt.

From the above we see that the minimum muzzle energy with which a maximum range of 10 kilometers can be attained is somewhere between the values of $v_0 = 400$ and 500. By calculating between these two values, we find the minimum muzzle energy will be 261.2 meter-tons, corresponding to $v_0 = 470$; $c' = 2.32$; and $p = 23.2$ kilograms.

In the same manner we can determine the minimum muzzle energy and corresponding initial velocity and ballistic coefficient for maximum ranges of 12, 15, 20, 25 and 30 kilometers. The results are tabulated in Table I below.

TABLE I.

Maximum Range km.	Initial Velocity m/sec.	Diff. per 1 km. m.	Ballistic Coefficient c'	Diff. per 1 km. mt.	Muzzle Energy mt.	Diff. per 1 km. mt.
10	470		2.32		261.2	
12	535	32.5	2.91	0.295	424.5	81.7
15	615	27	3.84	0.310	739.8	105.1
20	720	21	5.34	0.300	1411	184.2
25	805	17	6.79	0.290	2236	165
30	875	14	8.22	0.286	3209	194.6

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With the aid of Table I, we can determine by simple interpolation, the most favorable values of v_0 and c' for any caliber. The corresponding weight of projectile p , can then be determined from the equation:

$$p = 1000 a^2 i c' \text{ when } a \text{ is expressed in meters or} \\ = 0.1 a^2 i c' \text{ when } a \text{ is expressed in centimeters.}$$

Example 5. It is desired to attain a maximum range of 16 kilometers with a 10.5 cm. projectile having a coefficient of form of 0.43. What are the most favorable values of v_0 and p ?

From Table I we see that irrespective of caliber, v_0 must be $615 + 21 = 636$ m./sec.; and $c' = 3.84 + 0.3 = 4.14$. The weight of the projectile $p = 0.1 \times 10.5^2 \times 0.43 \times 4.14 = 22.82$ kg. The muzzle energy will be $pv^2/2g = 470.5$ mt.

Knowing the muzzle energy, we can quickly determine the approximate weight of the gun tube and of the gun in firing position. The practice is to allow for the gun tube one kilogram weight for every 360 meterkilograms of muzzle energy, and for the gun in firing position one kilogram weight for every 130 meterkilograms of muzzle energy. Therefore, in this case, the gun tube will weigh $470,500/360 = 1306$ kg.; and the gun in firing position will weigh $470,000/130 = 3620$ kg.

Example 6. What are the most favorable values of v_0 , p and muzzle energy for a 28-cm. howitzer that must attain a maximum range of 10.1 km.?

From Table I we find:

$$v_0 = 470 + 0.1 \times 32.5 = 473 \text{ m./sec.} \\ c' = 2.32 + 0.1 \times 0.295 = 2.35.$$

The weight of the projectile will depend on its form, that is, the coefficient of form i :

$$\text{For } i = 1 \quad \text{we have } p = 184.25 \text{ kg.} \\ = 0.6 \quad = 110.55 \text{ kg.} \\ = 0.5 \quad = 92.15 \text{ kg.}$$

The corresponding muzzle energy will then be 2101, 1261 and 1050 meter-tons, respectively.

Examples 5 and 6 show clearly that the most favorable values of v_0 and p , from the viewpoint of the minimum muzzle energy developed, may be very unfavorable when we consider the efficiency of the projectile. The 10.5-cm. gun projectile weighing 22.82 kilograms is too heavy; the 28-cm. howitzer projectile weighing 92.15 kilograms is too light. This can be seen when we determine the sectional density n , of the two projectiles from the equation:

$$n = p/a^3 = 22.8/10.5^3 = 19.7 \text{ for the 10.5 cm. projectile} \\ = 92.15/28^3 = 4.2 \text{ for the 28 cm. projectile.}$$

The sectional density measures the efficiency of a projectile.

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Its most favorable values are between 12 and 16. A high sectional density is desirable in projectiles that must have penetrating power, and in shrapnel where a heavy bullet content is desired. A very high sectional density increases the gas pressure in the tube, and means a very long projectile requiring a strong twist of rifling, or a projectile with thick walls leaving little space for an adequate high explosive bursting charge. Except for shrapnel, the sectional density of which may be as high as 17, a high sectional density is desirable only for armor-piercing projectiles. But even for these a sectional density of 14 is suitable. The Krupp Navy shell which were so effective at the Battle of Jutland had a sectional density of 13.8. The French 75-mm. high explosive shell has a sectional density of 12.6, and whereas its high explosive content is large and produces great moral effect, its fragments are too small and have a small effective radius. On the other hand, the German 7.7-cm. high explosive shell has a sectional density of 15, resulting in a small high explosive content and insufficient moral effect. Howitzer, and especially Trench Mortar high explosive shell have a still smaller sectional density, usually from 10 to 12. This subject of the most suitable sectional density for different types of projectiles should be very carefully studied by means of tests with static bursts.

From Examples 5 and 6, we see that the projectile which theoretically gives us the greatest maximum range with the minimum muzzle energy, may be very unsatisfactory from the viewpoint of effect at the point of impact or burst. For the gun in Example 5, the caliber for the desired range is too small; for the howitzer in Example 6, it is too large. Krupp formerly made a 28-cm. howitzer that attained a maximum range of 10.1 kilometers with a shell weighing 340 kilograms. This shell had a sectional density of 15, which is high and indicates that the projectile was designed for penetrating strongly protected cover. In order to obtain the desired penetration with a low remaining velocity, it was necessary to have a high sectional density. The muzzle energy developed by this howitzer was 2000 meter-tons, or almost twice the amount deduced as the minimum.

There is still another method for determining the pertinent ballistic data, which is simpler and more rapid. If we take Table I and plot the maximum ranges X as abscissa and the corresponding ballistic coefficients as ordinates, and join these points, we will obtain practically a straight line. The equation of this line is fixed by the coördinates of its terminals, or:

$$c' - 8.22 = \frac{8.22 - 2.32}{(30 - 10)} (X - 30),$$

from which we have,

$$c' = 0.295 X - 0.63 \tag{1}$$

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But c' can also be expressed in terms of a , n and i , as follows:

$$p = 10^3 a^2 i c' \quad (p \text{ in kg., and } a \text{ in meters})$$

Also

$$p = na^3 \quad (p \text{ in gr., and } a \text{ in cm.})$$

Expressing both in the same denomination, we have:

$$\begin{aligned} p &= 10^5 a^2 i c' \\ p &= 10^3 na^3. \end{aligned}$$

Combining these two equations, we obtain:

$$c' = \frac{na}{100i} \quad (2)$$

Combining equations (1) and (2), we have:

$$na = (29.5 X - 63) i \quad (3)$$

in which, if any three quantities are known, the fourth can be solved.

Now, knowing a and n , we can determine p . The values of v_0 and X are obtained from Table I. Knowing the coefficient of form i we can then find the corresponding maximum range. A few examples will explain the method.

Example 8. Determine the most favorable weight of projectile having $i = 0.43$, for a 8.35-cm. gun which must attain a maximum range of 13.8 kilometers with the least muzzle energy.

From Equation (3),

$$\begin{aligned} n &= \frac{(29.5 \times 13.8 - 6.3) 0.43}{8.35} = 17.72 \\ p &= 0.001 \times 17.72 \times 8.35^3 = 10.31 \text{ kg.} \end{aligned}$$

From Table I we find the most favorable v_0 for a maximum range of 13.8 km. to be $535 + (1.8 \times 27) = 582$ m./sec.; and the corresponding muzzle energy is $\frac{5822 \times 10.31}{2g} = 178.0$ mt.

The above values have been chosen because they are very close to those of the 8.35-cm. Skoda gun. This gun fires a 10-kilogram projectile with a v_0 of 600 m./sec., and attains a maximum range of 13.8 kilometers. The muzzle energy developed is 183.5 metertons, or 3 per cent. greater than the minimum. Notwithstanding the light weight of the 8.35-cm. Skoda projectile, its high explosive content is great, which makes the projectile very effective.

Example 9. We desire to use a projectile having a sectional density of 15, coefficient of form 0.5, and attain a maximum range of 14 kilometers with the least muzzle energy. What must be the caliber?

From Equation (3),

$$a = \frac{(29.5 \times 14 - 63) 0.5}{13} = 11.67 \text{ cm.}$$

The projectile will weigh $0.001 \times 15 \times 11.67^3 = 23.8$ kg.

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From Table I, we find the most favorable v_0 for a maximum range of 14 kilometers is $615 - 27 = 588$ m./sec., and the corresponding muzzle energy is equal to $\frac{588^2 \times 23.8}{2g} = 420$ mt.

General Herr, in his recent well-known book "Artillery: Past, Present and Future," page 169, calls for a new 75-mm. gun weighing 1500 kilograms in firing position, with an 8-kilogram projectile and a maximum range of 14 kilometers. The sectional density of such a projectile would be $8000/7.5^3 = 19$, which is very high. Since X , a and n are known, we can find the coefficient of form i from Equation (3) to be $\frac{7.5 \times 19}{29.5 \times 14 - 63} = 0.406$, which is

very low. The corresponding muzzle energy would be $\frac{588^2 \times 8}{2g} = 141$ mt.

It is very doubtful if either of the above guns can meet the requirements of actual test. The 11.67-cm. gun would no doubt be very effective since, with a projectile weighing 23.8 kilograms and a sectional density of 15, the high explosive bursting charge will be about 2.5 kilograms. A coefficient of form of 0.5 is also attainable, but the weight of the gun in firing position would be too heavy, about 3100 kilograms. The objection to General Herr's gun is the high sectional density of the proposed eight-kilogram projectile fired from a 75-mm. gun. The high explosive bursting charge would be too small and the gun would require a strong twist of rifling, producing a high pressure in the tube. It is also very doubtful whether a coefficient of form as low as 0.406 can be attained. Now it is quite possible that General Herr would be satisfied with a projectile weighing less than eight kilograms. If he accepts a projectile weighing 7.5 kilograms, the sectional density will be 17.8, still somewhat high for a high explosive shell. But in this case the coefficient of form would be only 0.381 which I consider impossible of attainment. I do not mean that a maximum range of 14 kilometers cannot be attained with a light gun. From Example 8 we have seen that the Skoda gun almost attains this range. But this question will be discussed in more detail later.

Example 10. What is the maximum range with least muzzle energy of a 15-cm. projectile weighing 55 kilograms with coefficient of form of 0.45?

The sectional density would be $55 \times 1000/15^2 = 16.3$.

From Equation (3),

$$X = \frac{15 \times 16.3 + 63 \times 0.45}{29.5 \times 0.45} = 20.5 \text{ km.}$$

From Table I, we have for this range:

$v_0 = 720 + 0.5 \times 17 = 729$ m./sec., and the corresponding muzzle energy is $729^2 \times 55/2g = 1490$ mt.

Example 11. What coefficient of form must the 7.2 kilogram

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high explosive shell of the German 7.7-cm. gun, Model 1916, have to attain with the minimum muzzle energy the same maximum range as the French 75-mm. gun which General Herr gives as 11.2 km.?

Sectional density of the 7.2 kilogram shell will be $\frac{7.2 \times 1000}{7.7??} = 15.8$.

From Equation (3), we have:

$$i = \frac{7.7 \times 15.8}{29.5 \times 11.2 - 63} = 0.456.$$

As far as I know, none of the belligerents developed during the war a projectile with so low a coefficient of form. Skoda has since done so in its 8.35-cm. projectile.

From Table I, we have for the 7.2-kg. shell of the 7.7-cm. German gun: $v_0 = 470 + 1.2 \times 32.5 = 508$ m./sec. The corresponding muzzle energy will be $508^2 \times 7.2/2g = 94.7$ mt., which is 13 meter-tons less than the allowable muzzle energy actually developed.

Example 12. The projectiles of the first rifled guns introduced in the German field artillery had a coefficient of form of 0.896. With what caliber and weight of projectile could guns of this model have reached a maximum range of 10 kilometers with the least muzzle energy? What would such a gun weigh in firing position?

From Equation (3), we have:

$$a = \frac{(29.5 \times 10^6) 0.896}{9} = 23.1 \text{ cm.}$$

$$p = \frac{9 \times 23.1??}{1000} = 111 \text{ kg.}$$

From Table I, we find that the $v_0 = 470$ m./sec., and the corresponding muzzle energy would be $\frac{470^2 \times 111}{2g} = 1250$ mt.

In those days, the quality of steel used was quite low, so that the gun tube would have weighed 1470 kilograms, and the gun in firing position 3290 kilograms.

As a matter of curiosity we could also solve the problem for the old smooth-bore guns firing spherical projectiles having a low sectional density of 3.66 and a high coefficient of form of 1.4. To attain a range of 10 kilometers with such a gun and projectile would have required a caliber of 89 cm. and a projectile weighing 2550 kilograms.

III. *Determination of the muzzle velocity and weight of projectile with which a cannon of a particular caliber and stipulated muzzle energy can attain the maximum possible range.*

Heretofore, our problem has been to determine the values of v_0 and p corresponding to the minimum muzzle energy for a given maximum range. We can also reverse our requirement, that is,

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determine the values of v_0 and p corresponding to the maximum range for a given muzzle energy. To show how Table II is constructed, we will determine the maximum range that can be attained with a muzzle energy of 1500 meter-tons. From Table I we see that the required v_0 must be greater than 720 m./sec. We first make several trial calculations, say for $v_0 = 720, 730$ and 740 , using a caliber of 10 cm. and a coefficient of form of 1. We then determine the different values of $p = \frac{1,500,000 \times 2g}{v_0^2}$, from which we obtain

$c' = p/10$. For example:

v_0	720	730	740	m./sec.
p	56.77	55.23	53.75	kg.
$c' = p/10$	5.677	5.523	5.375	

Entering the ballistic tables, we find the corresponding maximum ranges:

X	20,570	20,585	20,575	m.
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From inspection we see that the required values are $X = 20,585$ m.; $v_0 = 730$ m./sec.; and $p = 55.23$ kg.

In the same way, other values are calculated for values of muzzle energy differing by 25, 50, etc., meter-tons. The results are tabulated in Table II.

TABLE II.

Muzzle Energy mt.	Muzzle Velocity m./sec.	Diff. per 100 mt. m.	Ballistic Coefficient c'	Diff. per 100 mt.	Maximum Range m.	Diff. per 100 mt. m.
25	290		0.583		4205	
50	320	120	0.958	1.40	5586	5524
100	360	80	1.514	1.11	7155	3138
150	395	70	1.886	0.74	8217	2124
200	430	70	2.116	0.46	9068	1702
250	460	60	2.318	0.40	9826	1516
300	480	40	2.554	0.47	10510	1368
350	497.5	35	2.775	0.44	11150	1280
400	515	35	2.96	0.37	11750	1200
500	550	35	3.24	0.28	12790	1040
750	610	24	3.98	0.28	15090	920
1000	650	16	4.64	0.26	17090	800
1500	730	16	5.52	0.18	20580	698
2000	805	13	6.09	0.11	23690	622
2500	850	9	6.79	0.14	26390	540
3000	880	6	7.60	0.16	29010	524
3500	905	5	8.38	0.16	31380	474
4000	930	5	9.07	0.14	33670	458

The use of Table II will be shown by the following examples:

Example 13. Given a 15-cm. projectile, allowable muzzle energy 400 meter-tons, and a coefficient of form equal to 0.5, what is the maximum range that can be attained and what are the corresponding values of v_0 and p ?

We must first convert the given muzzle energy to the terms of our table which was constructed for a caliber of 10 cm. and a coefficient of form of 1. We do this by multiplying the given

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muzzle energy by $10/a^2i$, and obtain 355.5 meter-tons as the value with which to enter the table. From Table II, we find:

$$\begin{aligned}v_0 &= 497.5 + 0.055 \times 35 = 499 \text{ m./sec.} \\X &= 11,150 + 0.055 \times 1200 = 11,710 \text{ m.} \\p &= 400,000 \times 2g/499^2 = 31.5 \text{ kg.}\end{aligned}$$

Example 14. With what v_0 and p will the new German 7.7-cm. gun and 10.5-cm. howitzer, Model 1916, attain the maximum range? Assume that the present allowable muzzle energy is not increased and that the projectiles have the coefficient of form of the present improved C projectiles.

(a) *7.7-cm. Gun.*—Coefficient of form of the C projectile is 0.535. The allowable muzzle energy is 109 meter-tons. The tabular muzzle energy will be 343.6 meter-tons. Entering Table II with this value, we find:

$$\begin{aligned}v_0 &= 480 + 0.436 \times 35 = 495 \text{ m./sec.} \\p &= 109,000 \times 2g/495^2 = 8.72 \text{ kg.} \\X &= 10,510 + 0.436 \times 1200 = 11,673 \text{ m.}\end{aligned}$$

The present maximum range is 10,700 meters, so that we can increase the range 937 meters by increasing the weight of the projectile from 5.9 kilograms to 8.72 kilograms. But this will give us a very high sectional density which will reduce the size of the high explosive bursting charge. The French 75-mm. long range high explosive shell introduced during the war weighed 7.98 kilograms and had a sectional density of 18.5. This shell was apparently unsatisfactory since General Herr, on page 169 of his book, now asks for a lighter projectile.

(b) *10.5-cm. Howitzer.*—The coefficient of form of this C projectile is 0.526. The allowable muzzle energy is 145.9 meter-tons. The tabular muzzle energy will be 215.6 meter-tons. Entering Table II with this value, we find:

$$\begin{aligned}v_0 &= 460 + 0.016 \times 40 = 461 \text{ m./sec.} \\p &= 145,900 \times 2g/461^2 = 13.5 \text{ kg.} \\X &= 9826 + 0.016 \times 1368 = 9848 \text{ m.}\end{aligned}$$

The present maximum range is 9700 meters, so that we can increase the range by adopting a projectile of smaller sectional density equal to 11.7. This would mean less striking energy and fragment effect than can be obtained with the present high explosive shell.

Example 15. As a matter of interest let us investigate two modern cannon about to be adopted in Denmark. Both are medium artillery to be hauled by motor transport. One is a 10.5-cm. gun, 48 calibers long, and the other a 15-cm. howitzer, 17 calibers long.

(a) *10.5-cm. Gun.*—It weighs 4650 kilograms in firing position and fires a 16.4-kilogram projectile, sectional density 14.2, with v_0 equal to 840 m./sec. The muzzle energy developed is therefore 590 meter-tons. The maximum range at elevation 43° is 17.7

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kilometers. Hence, the coefficient of form is 0.48. The projectile is 4½ calibers long, boat-tailed, and has an ogive on a radius of 5 calibers.

Our tabular muzzle energy will be 1115 meter-tons. Entering Table II with this value, we find:

$$v_0 = 650 + 1.15 \times 16 = 668 \text{ m./sec.}$$

$$p = 590,000 \times 2g/668^2 = 25.9 \text{ kg.}$$

$$X = 17,090 + 1.15 \times 698 = 17,803 \text{ m.}$$

In other words, we can increase the range 103 meters by adopting a projectile 9.5 kilograms heavier. But this projectile would be too long and have a very unfavorable sectional density.

(b) *15-cm. Howitzer.*—The actual caliber is 14.91 cm. This howitzer weighs 4550 kilograms in firing position and fires a 41-kilogram projectile with v_0 equal to 580 m./sec., developing a muzzle energy of 703 meter-tons. In addition to the projectile of the same form as the 10.5 gun projectile, another shell is being tested for the howitzer having a length of 4.8 calibers and an ogive with a radius of 10 calibers. Assuming the first projectile, we obtain a tabular muzzle energy of 659 meter-tons. Entering Table II with this value, we find:

$$v_0 = 550 + 1.59 \times 24 = 588 \text{ m./sec.}$$

$$p = 703,000 \times 2g/588^2 = 39.9 \text{ kg.}$$

$$X = 12,790 + 1.59 \times 920 = 14,253 \text{ m.}$$

In other words, the adopted values of v_0 and p very closely agree with the theoretically most favorable values.

Example 16. The Krupp naval guns of all calibers are very uniform in type and have been constructed to obtain maximum effect. Their projectiles all have a fairly uniform sectional density, varying little from 13.8, and a coefficient of form equal to 0.7. When fired from a gun 40 calibers long, they all have $v_0 = 840$ m./sec. In Table III below, the actual maximum ranges for these Krupp guns are given. For purposes of comparison, the maximum ranges that can be attained theoretically with the most favorable values of V_0 and P , and the resulting sectional density are also given.

TABLE III.

Caliber cm.	7.5	10.5	15	21	28	30.5	35.56	38.1	40.46
Weight of projectile. p in kg.....	5.8	16	46	125	300	390	620	760	920
Allowable muzzle energy, mt.	208.6	575	1654	4495	10790	14030	22300	27330	33090
Present maximum range, km.	11.67	13.93	16.80	19.96	23.31	24.47	26.50	27.38	27.99
Greatest attainable range with V_0 and p. km.	12.82	15.04	17.44	20.27	23.50	24.60	26.50	27.39	28.29
Difference in km.	+ 1.15	+ 1.11	+ 0.64	+ 0.31	+ 0.21	+ 0.13	± 0	+ 0.01	+ 0.30
Most favorable V_0 , m/sec.	557	609	658	723	802	820	851	861	872
Most favorable P. kg.....	13.19	33.34	75.0	167	320	409	604	723	836
Sectional density of P.....	31.2	28.8	22.2	16.7	14.9	14.4	13.5	13.0	12.5

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From Table III it will be seen that for calibers under 35.56 cm., the greatest maximum range corresponding to the most favorable values of V_0 and P can be attained only by increasing the present weight of projectile and reducing the initial velocity; also the smaller the caliber the greater the change. For projectiles under 21 cm., the sectional density will attain impossible values, making detonating and fragment effect almost nil for smaller calibers. In other words, *an increase in maximum range can be obtained only at the expense of the efficiency of the projectile*. For calibers between 35 and 36 cm., the values for maximum range and projectile efficiency agree with those calculated as most favorable. But for calibers over 35.56 cm., an increase in maximum range can be attained only by decreasing the weight of the projectile and increasing the muzzle velocity. This is undesirable for these larger calibers because, while we would thereby be increasing the detonating effect, the penetrating power, for which these guns are designed primarily, would be reduced.

The examples given above show the intimate relation between maximum range, caliber, and effect of projectile (sectional density). If we demand an increase in maximum range for a small caliber gun, based on the allowable muzzle energy, the sectional density of the projectile must be increased, thus reducing the detonating and fragment effect of the projectile; see examples 5, 9, 14a and 15a. Our only solution then is to provide two projectiles, using the heavier one for distant objectives. Thus, General Herr proposes carrying a special 75-mm. high explosive shell weighing nearly 8 kilograms for combating targets at ranges between 7 and 14 kilometers. For ranges under 7 kilometers, a lighter shell weighing 5.315 kilograms will be used.

On the other hand, if we demand a smaller maximum range for our large caliber howitzers, the theoretically most favorable projectile from the viewpoint of range will be too light and have insufficient sectional density; see examples 6 and 14b. Our solution then is either to increase the weight of the projectile, thereby also increasing the weight of the piece in firing position, or to reduce the caliber.

Previously I have shown that for every type of projectile there is a certain sectional density most suitable for the efficiency of the particular projectile. I estimate that shrapnel should have a sectional density of 16, trench mortar and gas shell 12, and armor-piercing and high explosive shell somewhere between these two values. This is only an estimate and should be determined accurately by tests.

From Table III, we can determine the most suitable caliber for a particular maximum range and type of projectile. For example,

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we can determine that for a range of 15 kilometers, a caliber of 11.8 cm. is the most favorable for shrapnel having a coefficient of form of 0.5; and that a caliber of 15.6 cm. is most favorable for high explosive shell.

The determination of the most favorable caliber is of great importance when new armament and ordnance projects are being considered. But as a rule, for financial reasons and because armament is not replaced very often, we are committed to a particular caliber. Ammunition reserve on hand also ties us down to the old calibers. When designing new armament, we must decide in the first place whether we place more weight on long range or on the efficiency of the projectile. Usually our decision will be a compromise. Take, for example, the 75-mm. gun proposed by General Herr. He fixes as a limitation that the gun shall not exceed 1500 kilograms in firing position. That fixes the allowable muzzle energy at 187.5 meter-tons. The coefficient of form of the projectile will probably be about 0.5. Our tabular muzzle energy will then be $\frac{187.5 \times 100}{7.5^2 \times 0.5}$

= 666.5 mt. Referring to Table II, we find:

$$\begin{aligned} v_0 &= 550 + 1.665 \times 24 = 590 \text{ m./sec.} \\ p &= 187,500 \times 2g/590^2 = 10.53 \text{ kg.} \\ X &= 12,790 + 1.665 \times 920 = 14,322 \text{ m.} \end{aligned}$$

This would require a projectile with a sectional density of 25, which is impossible of attainment. Let us fix the condition that the gun is to fire both shell and shrapnel of the same weight 6.33 kilograms and a sectional density of 15. The initial velocity v_0 will then be $\sqrt{\frac{187.5 \times 2g}{6.33}} = 762 \text{ m./sec.}$

Using our ballistic tables we would then find that this would give us a maximum range of 13,077 meters. If we chose a 6.5-kilogram projectile, our v_0 would be 752 m./sec. and the maximum range 13,110 meters.

IV. *Application of the above study to an entirely new project for Field Artillery.*

In the past it has been customary to first fix the caliber of the gun. If we now impose the additional condition that the gun must attain a certain maximum range with the least muzzle energy, we will have, as shown in the examples, a very mobile piece but a very inefficient projectile. What we should strive for is the most effective projectile and an adequate mobility of the piece. In any project for Field Artillery, the first condition to be fixed should be the weight of the piece in firing position, *i.e.*, its mobility. From this we can then determine the maximum muzzle energy that is permissible. After this we determine the initial velocity and weight of projectile corresponding to our allowable muzzle energy, and last of all we determine the caliber. The caliber must be such that it will give us an efficient projectile, *i.e.*, the projectile must have

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a suitable sectional density. In this way we will obtain a maximum range that is less than the theoretically attainable one, but one that is the best for effect of projectile at the decisive ranges. Let us explain the steps by taking an example.

We are about to design a light field gun which in firing position cannot exceed 1380 kilograms in weight. By experience we know that for each kilogram of weight in firing position we can allow 125 meterkilograms in muzzle energy, from which we determine our allowable muzzle energy as 172.5 meter-tons. In the past the next step in ordnance design has always been to fix the caliber, usually about 7.5 cm. This is putting the cart before the horse. What should be done next is to fix the weight of the projectile. Let us see what happens in each of the cases outlined.

(a) *Fixing the Caliber at 7.5 Cm.*—Our tubular muzzle energy will be $\frac{172.5 \times 100}{7.52 \times 0.5} = 612$ mt. Entering Table II, we find:

$$\begin{aligned} v_0 &= 550 + 1.12 \times 24 = 577 \text{ m./sec.} \\ p &= 172,500 \times 2g/577^2 = 11.27 \text{ kg.} \\ X &= 12,790 + 1.12 \times 920 = 13,820 \text{ m.} \end{aligned}$$

This would give us a projectile of impossible sectional density, and one too heavy for a light gun, thereby reducing the number of rounds that could be carried with existing means.

(b) *Fixing the Weight of the Projectile.*—The weight selected should facilitate service of the piece and be effective at the point of burst. Experience has shown that an 8-kilogram projectile is not too heavy for good service of the piece and that a projectile of this weight produces adequate effect for a light gun. Our shrapnel, M 73, weighed 8 kilograms and the present 18-pounder British shrapnel weighs 8.4 kilograms. Our v_0 will then be $\sqrt{\frac{172.5 \times 2g}{8}} = 650$ m./sec. Now before we fix our caliber, we must decide upon the sectional density our projectile must have, because this determines its efficiency. Since our light gun is to be equipped with both shell and shrapnel, the sectional density will be about 15. It would be preferable to make the shell a little longer than the shrapnel so as to have an adequate bursting charge. We will therefore take 14 as the sectional density in our calculations. This will reduce the maximum range a little. For a sectional density of 14, the caliber $a = \sqrt[3]{p/n} = \sqrt[3]{8000/14} = 8.32$ cm. Going to the ballistic tables and assuming a coefficient of form of 0.5, we obtain a maximum range of 12,520 meters which is 600 meters less than can be obtained with the heavier (1500 kg.) 7.5-cm. gun previously discussed firing a 6.5-kilogram projectile.

Since the weight of piece in firing position cannot be increased, and presumably the best form of projectile has been used, a greater

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maximum range can be attained only at the expense of efficiency of the projectile, *i.e.*, either by increasing the v_0 and reducing the weight of the projectile, or by leaving these unchanged and increasing the sectional density, which makes our projectile less efficient.

Had we adopted a lighter projectile, say 7.25 kilograms, which is the weight of the French 75-mm. shrapnel, our results would have been as follows:

$$\begin{aligned}v_0 &= 668 \text{ m./sec.} \\ \text{Caliber} &= 8.03 \text{ cm.} \\ X &= 12,590 \text{ m.}\end{aligned}$$

The slight gain in range would not compensate for the loss in efficiency of the projectile. The number of rounds that could be carried would be 10 per cent. greater. Had we increased the sectional density to 15, keeping the same v_0 and weight of projectile, our caliber would have been 8.0 cm. and our maximum range 12,920 meters. This is an appreciable increase in range (400 meters), but the sectional density would be too high for an efficient high explosive shell.

A gun is designed to stand the maximum strain that will be put on it in firing. This strain corresponds to the muzzle energy required to attain the maximum range. For mid and short ranges, a smaller muzzle energy would be adequate and thus permit us to lessen the strain and wear on the matériel. This reduction in muzzle energy for shorter ranges can be accomplished in two ways: Either use a lighter projectile, or use the normal projectile with a smaller powder charge for the shorter ranges. General Herr proposes the first way, that is use a heavier projectile weighing 8.0 kilograms for all ranges over 7 kilometers and a lighter projectile for ranges under this. He probably has serious misgivings as to the efficiency of the 8.0-kilogram 75-mm. shell. The lighter high explosive shell promises better effect. I prefer the second alternative. There would be no change in the projectile which would have the same efficiency at all ranges. The only question to determine would be the normal and super charges. Our normal charge would correspond to the muzzle energy which we find would best preserve our matériel. By reducing the muzzle energy 50 per cent. to 85 meter-tons, we would add greatly to the life of the matériel and tube. This muzzle energy corresponds to a v_0 of 450 m./sec., and a maximum range of 9000 meters. Since dispersion increases rapidly at extreme ranges, the normal charge would be used for targets up to 8000 meters and beyond that the super charge for the maximum attainable range would be used.

Considering now the light field howitzer. It should have the same weight in firing position and hence also muzzle energy, as the light gun. Its projectile should be twice as heavy, namely 16

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kilograms. With a sectional density of 14, this would give us a caliber of 10.45 cm., or practically 10.5 cm. Since the muzzle energy of this howitzer is a little greater than the muzzle energy of the present 10.5-cm. howitzer, its v_0 will be 460 m./sec. as against 427 m./sec. of the existing howitzer. The maximum range will be 10,500 meters as against the present 9700 meters. The number of charges should be so chosen that an angle of fall of at least 30° can be obtained at all ranges over 3000 meters.

I have assumed that the Field Artillery will be armed with both light gun and howitzer. This suggests the question, why not have only one type of cannon for light Field Artillery. That condition existed in most countries after the war of 1870–1871, particularly in France and Germany. The necessity for a howitzer did not manifest itself until after the Russo-Turkish War of 1877. At the siege of Plevna, the Russians, although superior in number, made several unsuccessful assaults on the Turkish position. The failure was ascribed to the inability of the Russian artillery to reach the Turks in their trenches. After the war there was a general demand that Field Artillery take under effective fire personnel seeking cover in field trenches. Later when protective bomb-proofs made their appearance on the battlefield, there was an additional demand that Field Artillery also be able to destroy these. This could be done only by a direct hit with a projectile having a curved trajectory and a large angle of fall. This led to the introduction of the light field howitzer in Germany.

The German 10.5-cm. howitzer gave extraordinary service during the World War. Everywhere the troops preferred it to the light gun. Its superiority was due not so much to its curved trajectory and greater angle of fall, as it was to the superior efficiency of its projectiles which were twice as heavy as those of the light gun.

In the course of time, better protective cover was provided so that the light field howitzer lacked the power of destruction. This led to the introduction of the heavy field howitzer. Thereafter, the light field howitzer was given the same mission as the light field gun. It was superior to the latter in counterbattery. The light gun had an advantage in shrapnel effect against personnel in the open, but as the war became stabilized, the gun could make less use of shrapnel time fire. Unprotected targets became fewer and, due to industrial mass production, the time fuse became poorer almost to the point of worthlessness. In 1914, the 7.7-cm. high explosive shell was unsatisfactory because of its poor fragmentation and deficient moral effect on detonation. During the course of the war these deficiencies were corrected; the bursting charge was quadrupled but even then the 7.7 high explosive shell was only half as effective as the 10.5-cm. high explosive shell.

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Two types of cannon in any category are justified only when the effects produced by them are so different that the one must supplement the other, and neither one can do the work of the other. To accomplish this to-day, it would be necessary to overcome the existing deficiencies in the gun shrapnel and the howitzer shell. We should develop for the shrapnel a durable, fool-proof mechanical time fuse that will be unaffected by weather; and for the shell an appreciable increase in the size of the bursting charge. So long as these things cannot be accomplished and the shrapnel is to be dispensed with in a war of movement, it would be advantageous to replace the light gun and howitzer by a single type of cannon.

This single type of light artillery should combine the good properties of the light gun and the howitzer. If we adopt a 12-kilogram projectile for this new cannon, with a sectional density of 14, the caliber will be about 9.5 cm., with a v_0 of 531 m./sec. and a maximum range of 11,500 meters. This is 500 meters greater than the maximum range of the howitzer discussed above and 500 less than that of the gun. The efficiency of the projectile would also be half-way between the two. The need for long range fire and for a powerful effect is exceptional and, when required, the heavy field artillery must be counted on to do the work. This single type of cannon for light artillery should also have a number of charges established on the same principles as mentioned above for the howitzer.

Conclusions.—There is a close relationship between muzzle velocity, caliber, weight and form of projectile to attain a certain maximum range without undue wear and strain on the matériel. While a particular muzzle velocity and weight of projectile may be very favorable for increasing the range, they may often be very unfavorable for the efficiency of the projectile. When designing a piece of artillery whose weight is limited by the conditions of mobility, the first considerations are not the caliber and the range, but always the purposes for which the cannon is to be used and the efficiency of the projectiles in carrying out this mission.

The examples presented make this clear.

FRENCH ARTILLERY

A LECTURE DELIVERED AT THE COMMAND AND
GENERAL STAFF SCHOOL IN MAY, 1924

BY MAJOR EMMANUEL LOMBARD, FRENCH ARTILLERY

(Continued from the March-April, 1927, issue)

WE HAVE studied the situation before the war, during the war, and after the armistice. Let us see now what the conclusions of the experts seem to be concerning the essential features of up-to-date matériel, its transportation and its distribution in the large units.

Such conclusions are not unanimous. Experts do not always agree. Even questioning line officers about the drawbacks or advantages of their matériel does not always enlighten one, because conditions were so different on the various parts of the front, in the various phases of the fight and even according to the particular missions. And experts (I refer not only to the Artillery technician, but to the General Staff man, the Transportation man, the skilled battery or regimental commander) would not be the worthy representatives of their branches, were they not prejudiced, to a certain extent, in favor of their own specialties.

A few years ago a famous Board was convened by a friendly country to define the characteristics desired in artillery matériels. At the head were men who in addition to their remarkable personal qualifications and experience, had had the privilege of close association with the best experts of the Allied armies.

Their program, a clear-cut, logical and practical one, has since been the object not only of much discussion, but also of rather important modifications. And one easily conceives how much more difficult it is to express definite rules concerning a country like France which has to build, store and maintain a great amount of matériel to be kept ready for an immediate emergency, when there will practically be no time to complete or modify the armament.

These considerations explain the diversity or divergence of opinion as expressed in books, pamphlets and official reports.

Another difficulty results from the psychology of the "man in the street" who, after all is as interested as anybody else in the proper organization of the Army in the ranks of which we will have to fight.

Before 1914 he had read in the newspapers about great maneuvers, *i.e.*, strategy, offensive, movements, tournaments. He understood that thanks to clever dispositions of a general plan, and shrewd displacements, famous chiefs could, with troops in inferior numbers, play with their enemy as easily as a cat plays with a mouse.

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Then the War came and our man took his share in the struggle. Successively the light howitzer, the minnenwerfer, the grenade, the gas shell, the tank, the bombs, the Berthas reveal to him their impressive power; even a few hundred yards of barbed-wire entanglements stop the most enthusiastic drives and the best elaborated plans. In the trench he discusses with the other poilus the subject of matériel: "Why haven't we got the same weapons as the Germans? Why does not our Artillery reduce the enemy's to silence?" And no longer do they believe that the position they hold is a sure guarantee of further advances and victories. But they put all their hopes in some newly invented and secret device, which the enemy ignores and which will find them helpless.

The morale of the doughboy had consequently to be reënforced by the action of obvious, powerful matériel, and that of Artillery was the most needed.

It had first to destroy the lines he is going to storm, then to overcome the artillery of the enemy; at hour "h" it should deliver a precise, close and violent rolling barrage; all strong obstacles, all machine gun nests or fortified shell holes have to be annihilated when he reaches them; otherwise he thinks that "something is wrong."

But should he succeed in storming a first line of trenches, then a few hectometers further he finds another line just as strong as the first, but intact and inexpugnable. "Why is there no gap into which he can throw himself? Why has he to dig a hasty shelter under the well-adjusted fire of apparently powerful and undisturbed artillery of his foe? Were his own guns out of breath? Could they not follow his courageous advance?"

Hence part of the importance attributed to matériel; hence all the complications. We all remember the often discussed question of infantry weapons and the infantry accompanying gun. As we give predominance to one or the other of the factors: precision, range, power, mobility, little vulnerability, ammunition supply, good telephone communications, the problem assumes different aspects and requires different solutions.

At least there are a few essential points which seem to rally a great majority of voices. Let us examine them in detail.

ELEVATION

After excesses in one direction, the tendency has always been to indulge in excesses in the opposite direction as correctives. And this remark holds true in the gun designing art as well.

We have already seen that the prevailing ideas before 1914 were in favor of extreme tactical mobility and rapid adjustment of fire by direct observation. On account of its very flat trajectory and

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the independent line of site with which it was provided, the field gun could be easily fired at all ranges, up to the limit of practical visibility. Simple formulas took care of the "masque" or the "defilement" and also of the slight differences of site existing between the gun and the target at normal firing distances and in an average rolling country.

To use the maximum range allowed by the tube would have meant a stress on the matériel and the use of quadrants and of firing tables. As for highly defiladed objectives, a device such as a plaquette placed on the shell increased the air resistance and thus provided an increased angle of fall for a given distance.

But during the war the 75-mm. had soon to be fired at range greater than 8 kilometers. A reduced charge gave the required angles of fall at short distances. The 105-mm. gun revealed its value not only as a high-powered rifle, but also as what might be called a long-range howitzer. The 155 G.P.F. with a split trail could fire with angles of elevation up to 42°.

Counterbattery work, interdiction fire, required more and more range; and we had to use naval guns and coast guns on railroad trucks. We shall see in a later paragraph the advantages and defects of these.

Classification of Guns, Howitzers and Mortars.—The experience of a big war inevitably brings modifications to universally accepted definitions. A rifle of 1914 may be called a howitzer in 1919, and a howitzer a mortar. For not only the classification according to length in calibers has to be modified but even that according to angles of elevation. Just as a baritone secretly desires to sing tenor roles, we find the rifles using the same angles of elevation as howitzers, and howitzers firing with muzzle velocities which in the well-classified period prior to 1914, were one of the distinctive features of field rifles.

TRAVERSING

Since Colonel Deport created, many years before the war, the split-trail matériel, the question of large horizontal fields of fire has been discussed most extensively and voluminous books have been written on that very subject. Without getting into the theoretical fight, let us see what happened during the war.

Our sturdy, reliable but clumsy de Bange guns could not be easily shifted from one target to another, as their traversing was obtained by means of crude devices such as hand levers. In defensive sectors the 75-mm. guns, those jacks-of-all-trades, had often to cover areas more than 50 degrees in width. Navy guns, seacoast guns mounted on their sliding railroad carriages did splendid and even quick work as long as such work was within their traversing possibilities. But unless they were displaced on their

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"épi," a slow and complicated process, their horizontal ambition was in many cases limited to one single degree!

Therefrom came a violent reaction, and it looked for a while as if any respectable gun should be able to fire into the fourth dimension!

Unfortunately other factors have to be considered, such as: weight, mobility, means of transportation, without forgetting appropriations—and those factors oppose a stubborn resistance not only to the creative imagination of inventors, to the ambitions of designers, but also to the legitimate requirements indicated by the High Command and by the Artillery experts.

The problem has consequently to be solved in a different way, dependent upon whether the gun is a first-line gun or one placed in the extreme rear lines. Reduced traversing is acceptable with the first-line guns, provided they are light and can be displaced easily by hand.

Mechanical or automotive traversing must be provided for long-range and high-powered pieces of ordnance. Should we succumb to the temptation of coining a popular formula, we could say: "The longer the range, the wider the field."

A concise formula containing a sound principle. It is also obvious that high-powered and long-range guns are very scarce and that such weapons placed in rear of the fighting lines will have to cover a very large area on account of their small number, of their range and of the scattered locations of the targets which are worthy of their potential attentions.

To illustrate the above principle let us say in a schematic way that we shall allow:

30 degrees for divisional artillery, which means covering 6 kms. at a range of 10 kms.

45 degrees for corps artillery which means covering 10 kms. at a range of 15 kms.

60 degrees for army artillery, which means covering 20 kms. at a range of 20 kms.

Heavy high-powered matériel should deliver all around fire, whether mounted on special railroad trucks or firing from a platform.

As for anti-aircraft artillery, it is obvious that it should have a field of 360 degrees.

MOBILITY AND POWER

The experience of the war has also shown that some of our matériels were deficient in power but that practically no complaint had ever been made about their mobility (unless when before starting a drive, a sector commander or the chief of an organic artillery could not get the additional support he had been longing for).

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Even during the hasty retreat of 1914, where the lack of matériel was cruelly felt, few examples are given of artillery coming too late into action.

The lack of power, and more especially of range, has not only been a moral wrecking defect, but the source of real disasters. This is why the power and consequently the weight of the matériel had to be increased and will be increased still more in the future.

Will that additional weight make mobility insufficient? If we consider strategical mobility, that is aptitude to be displaced from one part of a front to another or from one theater of operations to another, all matériels should be so designed as to be readily transported either by railroads or on roads. Some matériel of reënforcement, possessing very high power and consequently scarce in number, should have that mobility developed to the utmost degree: such are high-powered railroad artillery, large motorized mortars and howitzers. Another type of matériel (the 75-mm. of the R.G.A.) has to reach, in large quantities and with short delay, any point of a theater of operation and should, therefore, have special strategic mobility. The portée system seems to be a very good solution if not the solution, provided one knows what work 75-mm. portée can do and what good care must be taken of it.

Quite different is the tactical mobility which means the ability to get into action, to negotiate all kinds of terrain, to change emplacements and to easily shift from one target to another.

That notion of mobility has followed an evolution since the beginning of the war: without being critical or ironical, I remember what happened during the maneuvers in 1912 and 1913 when after a few minutes all artillery was supposed to have made a reconnaissance, to have brought the batteries into position and delivered immediately a torrential fire at any target.

In 1914, after ten weeks of fighting, 75-mm. batteries had abandoned trotting except for very short periods to get out of shelled areas. The howitzers paced quietly on the roads on specially chosen itineraries so that they could progress at about two miles an hour, all cannoneers walking behind the platoons in the most disillusioned but resigned way.

And those experiences have once more raised the problem of traction which we have solved in the following way:

Divisional artillery and other matériel weighing not in excess of 4000 kilograms will be horse drawn, since with this method of transportation the speed is as great as that possible by infantry;

Medium caliber artillery will be tractor drawn.

Heavy caliber artillery will be transported on railroad trucks (sometimes firing from same).

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Accompanying guns should be mechanically drawn, since horse-drawn guns are conspicuous, and vulnerable both to explosive and gas projectiles.

Unfortunately, as soon as we have found a good tactical solution, we have to acknowledge that it is sometimes defective from the strategical point of view. The same sad remark can be applied conversely to a good strategical solution.

For instance, caterpillar tractors have no strategical mobility. Four-wheel driven tractors have very little tactical mobility.

The expedient of providing the ordinary tractor with detachable tracks has not yet given satisfactory results.

Quite different is the theatrical demonstration before enthusiastic and admiring civilians to whom some stunt performances will appeal, and on the other hand the positive test of a few hundred miles without going to the stable (I mean the shop) to get the engine cleaned, polished, petted, relaxed and invigorated.

In the field, tracks cannot be removed, sprockets will be clogged with dirt; connections will get loose . . . and illusions will fade away.

I cannot omit to mention, for calibers between 6" and 8", the solution consisting of using a compound system of tractors and caterpillars (these latter being carried on a truck or a trailer during road transportation). Unfortunately the road speed with such matériel remains limited to 10 kilometers which does not allow more than a 100-kilometer trip per day.

To obtain strategical mobility use: railroad cars, portée trucks, and four-wheel drive tractors which will take heavy, medium and light artillery from 100 to 300 kilometers in a day.

To reënforce an organic artillery on shelled terrain: caterpillar tractors, self-propelled mounts, and 60-centimeter narrow-gauge trucks which will take care of all classes of guns.

To pursue an enemy we require horses and caterpillar tractors which will carry the light guns and medium howitzers that are able to take care of all normal objectives and obstacles.

Here simplification is practically impossible and the art of the command consists in getting the right proportion of each kind so that during every phase, the maximum efficiency is obtained.

RAILROAD ARTILLERY

Much has been said against railroad artillery as far as its employment with the troops on the field is concerned.

Those among you who were over there during the action have heard it strongly criticized: A.L.G.P. was called for a while "Artillery de luxe for people having lots of pull." Let us see what the main criticisms against it are.

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1. It cannot follow the troops during an advance and therefore its only use is for siege or stabilized warfare.

This is absolutely true if we consider the first matériel used on the French front in 1915–1916. That matériel had been created for the destruction of fortified positions and in order to save time and to simplify the machining of elevating devices, in order to avoid the manufacture of recoil systems, of platforms, a matériel lacking tactical mobility had been improvised in a relatively very short time. That matériel was absolutely fit for its object, but when operations took an unexpected turn, a most favorable one, such monsters were left behind and after having well done, could not take their share in the victory.

In addition many of the railroad matériels were very old models lacking range and unable from their emplacements to follow the progress of a drive until preparation had been made to allow their advance. Economy and lack of more suitable weapons had imposed their employment.

We already see that those objections do not lead us to the conclusion that railroad artillery is a fixed front weapon.

2. Another objection has been that railroad artillery required very long preparation of tracks, the construction of épis (which in addition are too visible), reënforcement of existing tracks, that in addition it congested railroad transportation.

The above criticism reminds me of the Englishman landing for the first time in France at Calais and meeting a red-haired French woman. He carefully entered in his notebook, "French women are red haired."

You know that you have in this country matériel which can by means of outriggers fire from the track itself, without use of a pit, without improving the track, and many of those are all around fire; this is the best answer to such criticism.

As for the heaviest weapons used during the war, as they had no recoil system, and were of the glissement type, an épi alone could give the required horizontal field of fire.

To-day the épi is condemned and there is no use for it except perhaps for the extreme long-range matériel.

3. Difficulties of transportation.

As for the transportation, there never was any trouble bringing them either to the rear of the army to which assigned or to their firing positions. The surprise expected from railroad artillery is not a question of minutes but of days. There is surprise if the enemy finds those guns near their emplacements before he can make his own plans to check their action. A well-studied plan of concentration which will always be executed before the transportation of troops, ensures a timely assembly of railroad artillery.

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Do not let us forget in addition that we save space on the roads, suppress a large amount of depots in rear of the troops, that we save the human matériel generally needed to shift the ammunition from the railroad to the trucks and from the trucks to the caissons, and that railroad gun crews are about three to four times less numerous than those of the other artilleries.

Should it be used only exceptionally and therefore be considered as a desirable dessert to a substantial meal, or will it be limited to extremely powerful guns, and thus be an artillery of the highest power and range and consequently very scarce in number?

In the discussion of the requirements we shall see what policy has been adopted, at least temporarily.

A NEW WAR

Artillery Experts Versus G-3 Tacticians and G-4 Specialists

Anybody who has had the privilege of belonging for very active operations to an army corps and to be in touch with army headquarters G-3 and G-4, knows that the G-3 experts are first of all tacticians and according to their views, artillery should be almost able to fly, otherwise they consider it as a cumbersome impedimentum without efficiency, As to the G-4 expert, he is always worrying and we cannot help sympathizing with him: for, in preparations of attacks like those of 1917, he had to take care of the ammunition supply of eighteen different calibers; but as mortars and howitzers do not fire the same shell and charges as rifles, and as in addition there were, for instance, six models of 155 howitzers and from four to seven zones requiring different powders, we may assume that there were practically sixty different calibers and about seventy kinds of fuses.

I remember an American officer who, in charge of ammunition supply during the war, resented the complication of such a minute and thorough system of ammunition. "Of course if things could be made perfect," he said, "the 155-howitzer battery commander should have percussion fuses of four or five kinds—one with long delay (15/100), one with reduced delay (5/100), one with surface delay (called also zero delay and amounting to 2/100), one nearly instantaneous like the red-nosed one. Then he would have a super-instantaneous which make five. If you add one or two kinds of explosive time fuses and those that prime shrapnel shells, we find him at the head of a whole 5 and 10 cents department store or, if you prefer a more elegant comparison, displaying on his palette all the colors which can nuance the blows he is going to pound artistically on the enemy's dugout.

"If you consider distance, he must have B.S.P. powder for the five lower charges and B.G. 5 for the high-powered ones.

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"But think of the distributing agency, in rear, which had not only this 155 C.S. to take care of, but 155 St. Chamond also, and maybe 155 S.F. and maybe 155 S. 1904, plus all the 155 long, as numerous in varieties, and eating as diversified if not as palatable a food. Think that this is only one of the 60 or 80 calibers he may have to take care of!!

"There is enough, without taking into account other worries, to drive a man mad. But sorting is nothing, what about distributing, what about recuperating, what about salvaging, what about constituting the ammunition dumps."

In order to simplify the ammunition, one might consider the adoption of one shrapnel, one steel high-explosive shell and one semi-steel shell for each weapon of each caliber, one instantaneous fuse with a device for short delay, one double-action fuse (time fuse), and for matériel having either large angle of fall or great remaining velocity, a fuse giving delays up to 25/100 of a second (this in case of heavy calibers only).

The use of aliquot charges would avoid errors and effect large savings either in wasted matériel or in the transportation of useless elements to the rear.

However the problem remains a complicated one. The technicians tell you, for instance, that a 105-howitzer will not have the range of a 120 and will often be insufficient to destroy the obstacle that a hard digging adversary will have prepared.

He will tell you, too, that troops fighting an enemy having a 120 or 4.7" howitzer will have a moral preponderancy on your divisional artillery which will be outranged by them.

But the G-3 man wants you to be in action as soon as the infantry advance is checked and what can you say to him when he tells you that the 120 mm. weighs about half a ton more than the 105 and therefore will have difficulty in negotiating shell holes, etc.

All this shows that the general staff has to decide where to accept a loss either in speed or in range, or even in variety of ammunition. He has to take the responsibility of the decision and to accept the blame if he fails.

For future staff officers such as you are and some of whom will I hope accede to the highest ranks, there is ahead a large scope of personal study in order to be ready some day to give well-balanced and sometimes unpopular advice or orders.

Up to the present time, in certain armies that are studying carefully their post-war problems, one of the chief objects is simplicity which means a few calibers, one large unit having a gun of caliber K and a howitzer of caliber L; and the next higher unit a gun of caliber L and a howitzer of caliber M, which seems logical and simple.

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If in addition, the same shells might be used in L gun and L howitzer; if the charges are divided in aliquot elements, an enormous step toward simplification has been made. The artistic technician will not be entirely satisfied. The overlapping law of the successive charges may not satisfy him entirely. But when later on the battlefields he ceases to worry about missing the right charge or the right fuse, he will recognize the advantage of a sound, and simple ammunition supply.

To conclude, the French Army has retained as current calibers: 75, 105, 155, 220, 240, 305, 340. It intends to do away with calibers such as 80, 90, 95, 100 (120), 200, 270, 293, 320.

THE PRESENT NEEDS

A. *Divisional Artillery*.—The 75-mm. is still able, in spite of its venerable age, to carry out its mission of direct support of infantry. To be perfectly fit it should have more range and be able to fire at about 12 kilometers. Its projectile, though very light, is efficacious and its ammunition is handy, light and consequently may be supplied in large quantities and fired at a high rate of speed. These two points are among the most important and have often been forgotten by those who recommended a larger caliber.

The divisional howitzer is a 155-mm. but the C.S. is too heavy, its great power is absolutely wasted; its ammunition is heavy and consequently scarce. A lighter howitzer such as the 120 S. or a 105-mm. seems to be the solution. Whether the divisional artillery should keep three battalions of 75-mm., two of howitzer or a different proportion can be only decided by those who have the last word on possibilities of fabrication, of ammunition supply, of transportation and other highly important factors. At least the ratio 3-2 has found many partisans.

The very first heavy field artillery gun which we possessed at the beginning of the war, the 105-mm. S. is endowed with power, range, mobility and great angles of fall. This gun, which has not a very definite place in the gamut of matériels which belong to the various large units, could be used, temporarily at least, both as a long-range field gun and field howitzer until the two former matériels are really up to date. Then for reasons of simplification, it should be removed. Economy often leads to parcimony.

Hence rejuvenated howitzers, museum rifles and the use of the queerest devices to increase the possibility of the guns.

B. *The Army Corps*.—The Artillery of the Army Corps has to destroy strong entrenchments, shelters, dugouts. It has to deliver counterbattery fire and we find two matériels of the same calibers, which is a great advantage: the 155 C.S. and the 155 G.P.F. which also provisionally could be used for those two missions, but

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the 155 howitzer should have greater range. The Army Corps may also include Divisional Artillery matériel for reënforcement.

C. *R.G.A.*—Here we find all the matériels which belong to the division and the Army Corps (such matériel being used as reënforcement) plus the heavy tractor-drawn artillery, the railroad artillery, etc.

In a general way, we need there:

- (a) Heavy mortars to destroy concrete vaults, forts, etc.
- (b) Long-range guns of sufficiently high caliber to obtain effects of penetration at long distances.
- (c) Very long-range guns for interdiction.

Minimum calibers of 370 mm. to 400 mm. are needed for the first; 240 to 305 for the second; ranges of at least 50 kilometers for the third.

Such matériels are generally to be placed on railroad mounts.

I hope I have not dwelt too much on the technical points during this lecture. At the same time I see that a great part of the time of your programs is devoted to the careful and minute study of artillery problems, either in the offensive or in the defensive, either in stabilized phases or in open warfare.

Also great importance will be attached to the solution of actual artillery problems in the field exercises which we are all going to attend on the Platte River in a few days. All this demonstrates that in the mind of the commanding officer and of the professors of this School, there is no question but that officers of a large unit staff should know very precisely the important characteristics of the organic artillery matériel, should understand the rules of its tactical employment and never forget its limitations. They also should be aware of the conditions existing in foreign armies.

This is why I was given the opportunity of speaking to the future staff officers of the United States Army about the French Artillery. Let me thank you for the privilege and honor thus bestowed upon me.

DESCRIPTION OF MINIATURE .22 AND .30 CALIBER FIELD PIECES AND .22 CALIBER BATTERY, TOGETHER WITH NOTES ON THE METHOD OF USE

BY MAJOR FRANCIS T. COLBY, F.A.

[The miniature pieces and battery described were evolved by Major Colby and made at the Springfield Arsenal. As stated in the article, it was the purpose to utilize to the maximum extent, parts then available. Obvious improvements in minor respects can later be effected by making special parts and movements.

While these devices are still in the experimental stage, and are now being sent to the Field Artillery Board for their action, they are believed to be of sufficient interest to justify publication at this time. At the request of the JOURNAL, the author furnished this description.

This is obviously an extension of the sub-caliber idea and provides a means of training at times and places not possible with the usual sub-caliber equipment. Due to the recent drastic reduction in the service ammunition allowance, it becomes increasingly necessary to supplement, with other means, the use of service ammunition.

For the use of the National Guard and the Reserve, a device the mechanism of which resembles actual firing, and one which can be used in an assembly room, is particularly desirable.—COLONEL D. W. HAND.]

I. PURPOSE OF THIS MATÉRIEL

1. THE purpose of this matériel is: (a) To make training in the conduct of field artillery fire and the use of the field artillery sight possible where field artillery matériel is not available or cannot be conveniently used.

(b) The use of sub-caliber eliminates the large service target range and the large service cartridge. It is the purpose of the matériels mentioned above to eliminate the cannon, and to fire adjustments with actually observed shots from the smallest matériel possible.

(c) Limitations of this Matériel in Training: Use of this matériel is limited to percussion fire and no attempt is made to simulate time fire.

II. MOUNT

2. All three of these matériels are mounted on the same type of tripod and are interchangeable by merely removing and replacing bolts "A" and "B", Fig. 1. The remarks as to the tripod therefore apply to all of them.

III. MATÉRIEL

A. *Miniature Field Piece, Caliber .30*

3. This matériel consists of the regulation infantry caliber .30 rifle mounted on a machine gun tripod and equipped with a regular field artillery panoramic sight. The artillery sight traverses with the rifle by both quick and slow motion adjustments. The rifle is

DESCRIPTION OF MINIATURE .22 AND .30 CALIBER FIELD PIECES

elevated independently of the sight by an elevating mechanism having clicks for each mil of elevation or depression. There is a sight scale or range drum marked with fictitious ranges, which can be set at any range announced by the officer firing. In brief this matériel functions like a miniature field piece and will answer to the commands of the officer conducting fire exactly like a regulation field piece firing sub-caliber.

4. In detail the rifle is mounted on the tripod by passing bolts "A" and "B", Fig. 1, through bushings in the rifle made to receive them. The sight shank carrying the panoramic sight is screwed to the side of the tripod and may be dismounted if desired. The panoramic sight fits into a slot at the top of the sight shank and is held in place by a wing nut. After the tripod has been set up the miniature piece is pointed to the desired part of the range in deflection by loosening the locking device "D", Fig. 1, which gives quick motion traverse. The locking device "D" is then partly screwed down, which engages the slow motion traversing mechanism, and the piece may be traversed by the slow motion handle "E", Fig. 1. When set at the desired deflection the locking device "D" should be screwed home in order to avoid lost motion. In order to lay the piece on the desired part of the range in elevation, locking device "C" is loosened which gives quick motion elevation. Locking device "C" is then screwed home and slow motion elevation is given by turning elevating device "G". Turning to the right elevates, turning to the left depresses. There is a click for each mil of elevation or depression. Range drum "F" moves as a collar independently upon elevating device "G". It is marked in fictitious ranges from 2000 to 5000 yards. The instructor or the officer firing having announced an estimated or range finder range to the target as, say 3000 yards, this range drum is turned to 3000. From there on the problem is conducted by the usual commands for changes of range, 4 mils being used to simulate 100 yards change in range. If it is desired to simulate fire with the gunner's quadrant, an arbitrary elevation is first announced and thereafter changes are made by the clicks in the elevating device which correspond to the one mil divisions on the range drum.

5. Although the range drum has been marked with the first two digits of ranges from two to five thousand yards, it is thought that in practice these markings will very seldom be used as it is quicker and simpler merely to remember the announced initial range and to make range changes by the clicks of the elevating device in series of four clicks for each 100 yards, thus merely substituting the sense of feeling and hearing for that of sight.

6. Use: The miniature field piece caliber .30 is for use on a regular outdoor sub-caliber range upon which field pieces firing subcaliber

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cartridges would normally be used. A battery of the miniature field piece is intended to carry on the same training that would be carried on if the 75 or 155-mm. were present, firing sub-caliber, including adjustments with lateral observation. In this type of training the cartridge preferred is the Infantry Gallery Practice caliber .30 cartridge shooting a lead bullet with a velocity of 1100 feet per second. For extremely small sub-caliber ranges the caliber .30 adapter (Marble Mfg. Co.) using the caliber .32 Colt automatic cartridge may be used. Some of the circumstances under which this matériel is thought to be desirable are:

(a) When field guns are not available but a sub-caliber range can be constructed.

(b) Where field guns are available but where their use would be inconvenient due to other employment, to a shortage of personnel or to the difficulty of getting them to and from the range and the labor of cleaning, etc.

7. The tripod for all three of these matériels is the same. In setting it up considerable difficulty will be found at first in getting the legs in the desired position so that the traversing mechanism is horizontal or nearly so. For this reason marks have been put on the adjusting nuts "H", Fig. 1, so that at least one position where the traversing mechanism will be laterally level, can easily be found. The leveling of the traversing mechanism in the direction parallel to the line of fire is very simple and is controlled by the locking device.

B. Miniature Field Piece, Caliber .22

8. This matériel is exactly similar to the caliber .30 above described, except that the .22-caliber gallery practice rifle (obsolete), using .22-caliber adapters, is used in place of the .30-caliber rifle. It is intended to issue with each tripod one .22 and one .30-caliber rifle which are interchangeable.

9. Use: This matériel is for use:

(a) Under the same conditions and circumstances as the caliber .30 but where a smaller sub-caliber range only is available. For this type of training the caliber .22 short cartridge should be used.

(b) In armories of the National Guard and in Drill Halls of the Regular Army, replacing the field piece for sub-caliber firing against large vertical steel panoramic targets such as are in use by the National Guard in the First, Second and Sixth Corps Areas. It is thought that there are many occasions when due to shortage of personnel or for other reasons field pieces cannot be conveniently used. This matériel, because of its lightness and the small amount of personnel necessary to operate it, may be used to advantage. For this type of training the caliber .22 short cartridge with spot light bullet should be used.

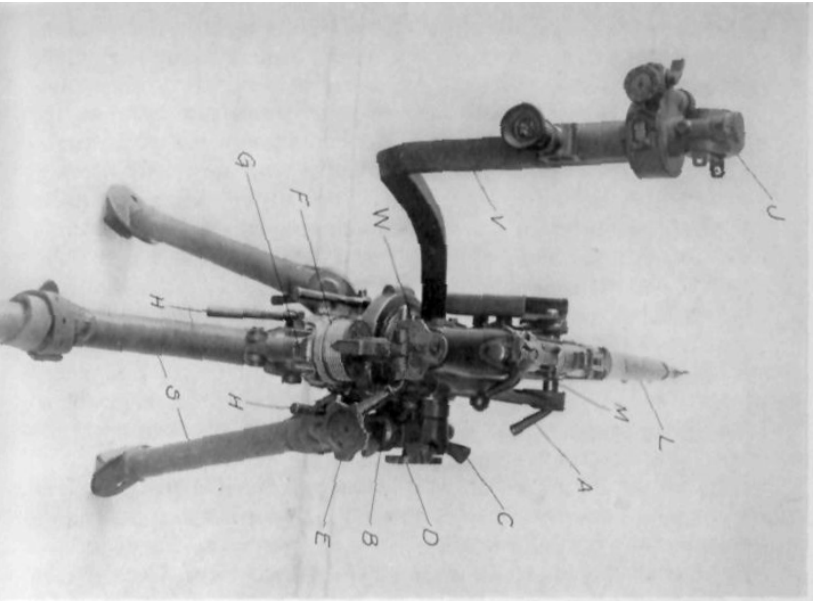


FIG. 1.—MINIATURE FIELD GUN, CALIBER .22 OR .30

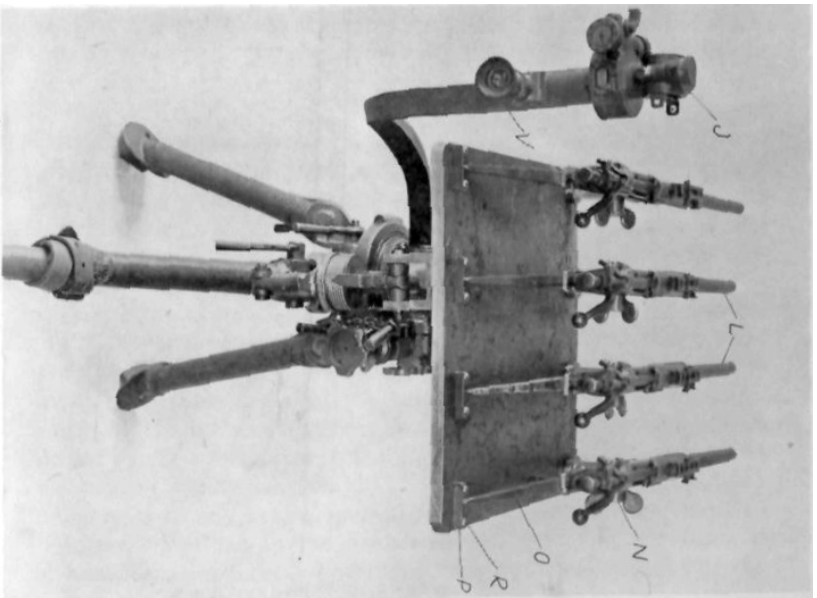


FIG. 2.—MINIATURE BATTERY, CALIBER .22

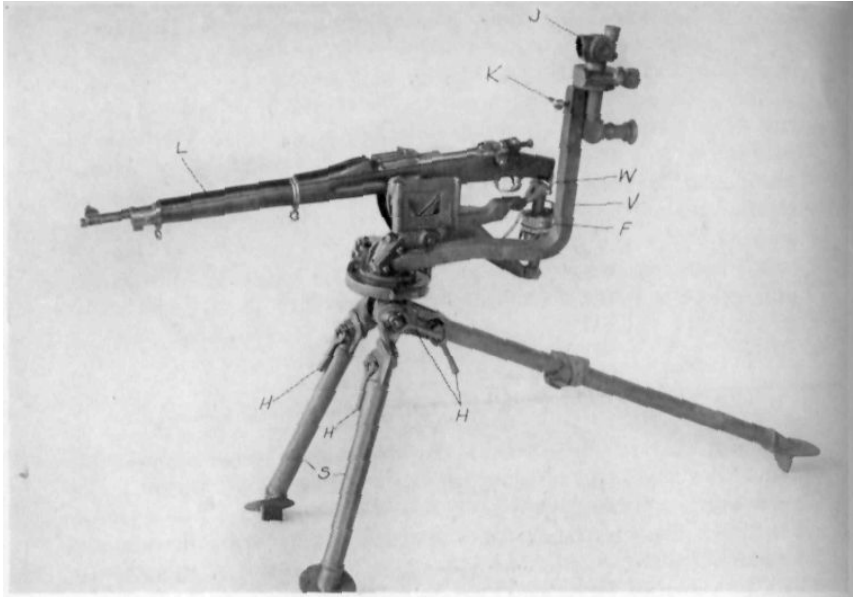


FIG. 3.—MINIATURE FIELD GUN, CALIBER .22 OR .30

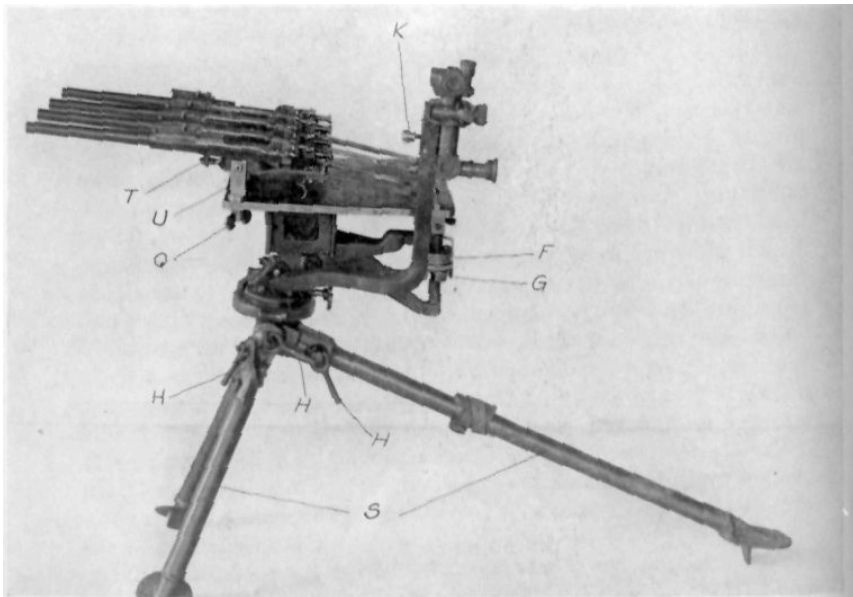


FIG. 4.—MINIATURE BATTERY, CALIBER .22

DESCRIPTION OF MINIATURE .22 AND .30 CALIBER FIELD PIECES

(c) For use in training Reserve Officers in the Instruction Room. It is intended to fire a battery of these field pieces against a vertical steel target about 6' long by 5' high, having still or motion pictures thrown on it, thus varying the target in proportion to the number of lantern slides available. The idea behind this type of training is to stimulate interest through the actual firing of ammunition and the adjustment of fire on many types of targets and many types of terrain, with increased speed and volume of training as compared to the black board and the terrain board. In short, it supplements the black board and the terrain board. The ammunition should be either the spot-light short or B. B. caps.

C. Miniature Field Battery, Caliber .22

10. This matériel consists of four caliber .22 rifles stripped, with barrels cut to 12", mounted on a steel plate, Figs. 2 and 4. The plate carrying these rifles is mounted on the tripod by engaging bolts "A" and "B", Fig. 1, in attachments on the bottom of the plate carrying the battery. The battery traverses and elevates exactly as described above, and is controlled in the same manner by the Artillery Sight. In order that the four barrels may be synchronized in elevation, they are individually mounted on an elevating mechanism held in place by large wing nuts "N", Fig. 2. To synchronize the four pieces for range, these wing nuts "N" are set up as tight as possible with the fingers, then tapped with the Babbitt metal hammer. A shot is fired with No. 1 gun and then with No. 2 gun. The barrel or trail of the No. 2 gun is then tapped with the Babbitt metal hammer until No. 2 gun corresponds in elevation to No. 1 gun, and so on with Nos. 3 and 4. Wing nuts "N" are then set up hard with blows of the Babbitt metal hammer and the battery is synchronized for elevation and thereafter elevates as a whole by the tripod elevating mechanism.

11. In order to provide for opening and closing the sheaf, the four pieces are mounted on pivots through the carrying plate and are controlled by large wing nuts "Q" on the bottom of the plate. These wing nuts are set up with the fingers and the Babbitt metal hammer so that the individual pieces may be traversed by taps from the Babbitt metal hammer in the same manner that a machine gunner taps his machine gun for traverse.

12. Each gun is provided with a trail "O", Fig. 2, which extends to a deflection scale "P", Fig. 2. These sight scales are graduated in mils and extend 30 mils each side of zero. When the battery has been adjusted for parallel fire the sight scales "P" may be set at zero to correspond with the end of the trail by loosening screws "R", Fig. 2. The use of these deflection devices for individual elevation and traverse is not difficult after a little practice

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in tapping, and considerable accuracy can be obtained. They were adopted for reasons of cheapness and simplicity, and could be greatly improved at increased expense by putting in individual elevating and traversing worms.

13. Use: The miniature battery is intended for use in the instruction room against lantern slides and motion picture targets. It is intended to embody the principle of fire of the field battery with the smallest possible matériel operated by one man. It is thought that it will be valuable in the training of Reserve Officers where matériel has to be moved to a temporarily occupied room or hall and where it would be difficult to move a battery having four separate pieces each mounted on its own tripod. The ammunition recommended is the .22-caliber B. B. spot light.

IV. TARGETS

14. Sub-caliber ranges for use when these matériels are used out-of-doors need little description. They are the same as those which the Field Artillery is accustomed to build for sub-caliber practice. With the small matériels very small ranges can be used to advantage, even down to 30 yards. It will be noted that lateral adjustments are possible only with the out-of-door ranges, and it is therefore desirable that an effort be made to obtain an out-of-door range for instruction in lateral observation.

15. The indoor targets for use with the spot light explosive bullets may be divided into three classes, namely:

(a) First, large panoramic targets for use in National Guard armories or in drill halls of the Regular Army where a range of from 50 to 100 yards can be obtained. These targets will vary in size from 30 to 100 feet in length and from 5 to 15 feet in height. They should carry a landscape painting showing varied types of terrain, which when looked at through the observing instruments, give the appearance of a natural landscape in depth. The actual objectives fired at may advantageously be put in with colored chalk and thus varied from day to day. In constructing these targets it should be remembered that any dent reduces the efficiency of the burst and they should therefore be thick enough so that they will not be dented by the bullets. When ordinary commercial sheet steel is used a thickness of about $\frac{3}{16}$ inch or $\frac{1}{4}$ inch should be used. It will be found that the .22 short spot light cartridge is ideally suited to this type of target and at about 100 yards gives dispersions corresponding to field artillery dispersions. At shorter ranges the dispersion is less satisfactory.

(b) Second, permanent steel targets to be used in lecture halls and instruction rooms where instruction in fire is habitually held and where there is no need of providing a target which is dismountable

DESCRIPTION OF MINIATURE .22 AND .30 CALIBER FIELD PIECES

and portable. These targets should be at least 6 feet long by 4 or 5 feet high, and larger where possible, and should be set up at a range of not less than 10 yards and preferably farther. They should be constructed of steel at least 3/16 inch in thickness. This type of target should have a frame of boards going around the outside edge, and extending toward the miniature matériel about 2 feet. This frame is intended to catch the spatters from the small explosive bullets which would otherwise fly about the room and damage the ceiling and walls. Two feet is sufficient to catch these spatters provided the steel in the target is thick enough not to be dented by the bullets. If the bullets dent the target, however, even slightly, the angle at which the pieces fly back is greatly increased. It will be found that most of the spatters strike the frame within 6 inches of the plate, and it is desirable to line the frame along the inner 6 inches with tin to prevent the frame from wearing down during extended firing. The spatters of the bullets are small and quite harmless except within a few inches of the target. The entire target should either have a panoramic landscape picture painted on it permanently, or should be painted white if lantern slides and motion pictures are to be used. The firing on such pictures is infinitely preferable to a painted panorama, because the pictures can be changed to give all sorts of landscapes and battle scenes. It should be noted that ordinary oil paint will shine and is not desirable. A dull paint without oil is essential to good pictures. A small can of paint and brush should be kept near the target so that the marks of the bullets can be frequently painted over.

The use of motion pictures for moving targets is very interesting as well as instructive, but it will be necessary to obtain special pictures because the average motion pictures are taken too close up to represent the necessary artillery ranges, and the personnel which is to be fired at moves too rapidly across the screen. The type of picture desirable is one taken at a long distance where the moving target has an angular movement in mils per second which would be normal with moving targets at artillery ranges. Such pictures could quite easily be taken on the Fort Sill range, and copies of the film together with projectors issued to those stations where indoor instruction in fire is habitually given, such as Regular Army Schools, Officers' Schools at Garrisons, National Guard Armories and permanent lecture halls for the Organized Reserves. The question of a satisfactory projector is merely a matter of using a lense with a focal length adapted to the size of the steel target and to the length of the hall in which it is to be used.

For the still pictures any of the standard lantern slide projectors are satisfactory provided the picture thrown, roughly corresponds to the size of the steel target and does not vibrate. It will be noted

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that in firing on lantern slide pictures, if the aiming point used is part of the picture the problem will not be interfered with by any movement of the lantern, causing a movement of the picture on the screen; whereas if the aiming point used is an object not part of the picture any motion of the projector will cause an error in fire. The ammunition recommended for this type of training is the .22-caliber B. B. spot light, or the .22 short spot light.

(c) Third, portable and dismountable vertical steel targets for use with the Organized Reserves, where the place at which instruction is given frequently changes or is only temporarily used for military purposes. Under these circumstances it is desirable to have a target which can be taken to the Reserve Officers' meeting place and be set up for use during the period of instruction and then be dismounted and removed. To meet this requirement two types of portable steel targets have been developed for issue with the miniature matériel. These targets are much more expensive to build than the type previously described and they should not be issued except where the fixed type of target is impracticable.

16. The dismountable targets are constructed as follows: Six steel plates 50" long and 12" wide are fitted together by the use of angle iron and wing nuts on the back, giving a target 72" long and 50" high. This target is framed with 1' boards, which are extended by lighter boards to give a 2' depth of frame. The boards used in making the frame comprise the elements of the 1917 rifle chest in which the targets are to be packed and issued. When one of these targets arrives so packed, in order to set it up the model 1917 rifle chest which contains it should be dismounted. Large screws have been provided so that the dismounting is easy. The two ends of the rifle chest carrying the handles are then laid aside until it is desired to repack the target. The top, bottom and sides of the rifle chest, together with two additional pieces are then formed into a frame 72" by 50" which is laid upon the ground. The steel plates, which are numbered, are then attached to the frame one at a time. After No. 1 has been screwed to the frame with screws provided for the purpose in holes that correspond to holes in the edge of the frame, No. 2 plate is placed in position along side of it, with the edge of the angle iron closing the joint between the two plates. The angle irons are then fastened together by wing nuts provided for the purpose and the plate is screwed down to the frame. This process is continued until all of the plates have been attached to the frame.

The target is now complete except for setting it in position and adding the 1' extension of the frame. If a strong table is available it may be lifted and stood on the table. If there are facilities for hanging the target from above, two rings will be found at the upper corners to which ropes may be attached. If hanging the target or

DESCRIPTION OF MINIATURE .22 AND .30 CALIBER FIELD PIECES

placing it upon a table are not feasible, then two legs with transverse supports will be found in the box. These legs screw on with four screws to each side of the bottom of the target. Transverse supports also have four screws. The target may then be raised and set up in position on its own feet. There will now be found remaining six light boards which have screw holes and screws to attach them to the frame, prolonging its depth to 2'. These should be screwed in position. Their purpose is to take up any bullet splatters which are not caught by the 1' frame. They will not be necessary in rooms such as temporary barracks where the interior finish will not be injured by a few bits of lead. A small can of paint and brush will be found in the box for use in painting over bullet marks.

17. When it is desired to dismount the target, lay it face down on the floor, remove the steel plates from the frame, re-assemble the frame into the 1917 rifle chest and pack the steel plates, legs and side pieces in the box. Wedges will be found to prevent the steel from shifting.

18. The two types of targets mentioned are identical except for the weight of the steel. In the lighter type, steel of .120 inch (slightly under $\frac{1}{8}$ inch) is used. In the heavier type, .185 inch (approx. $\frac{3}{8}$ inch) is used. The heavier type will withstand the .22 caliber short spot light cartridge. The thinner type will withstand the .22 caliber B.B. spot light cartridge, but not the .22 caliber short. The B.B. cartridge is entirely satisfactory for indoor work and it is thought that the lighter target will be found preferable in combination with this cartridge. The heavier target while more robust, weighs too much for easy portability.

NOTE: The strikers used in the .22 caliber rifles are .010 longer than the regulation striker. This is in order to compensate for worn rifles and faulty headspace adjustments which are present because the rifles used are old rifles. Care should therefore be taken not to mix the strikers issued with this matériel with ordinary issue strikers which may or may not function properly.

V. CARE OF MATÉRIEL

19. The barrels of this matériel should be promptly cleaned after firing and vigorously brushed out with the brass brushes. This is because the use of the lead bullet in the .30 caliber tends to foul the bore and the use of the B.B. cap is highly corrosive and requires more care than other ammunition. The .22 caliber adapters should be frequently cleaned and kept oiled, otherwise they will jam and not function satisfactorily. They are perfectly satisfactory if kept clean.

THE PRACTICABILITY AND APPLICABILITY OF HIGH BURST RANGING WITH THE 75-MM. GUN AND 155-MM. GUN

BY MAJOR JOHN C. WYETH, F.A.

I. GENERAL REMARKS

HIGH bursts ranging is a comparatively recent development of a method of adjusting fire upon a target which is hidden from the available observation posts of the battery delivering the fire. As far as the writer has been able to ascertain, from the rather limited amount of writings upon this subject, nothing of this sort was used in the United States army before the World War. The Germans seemed to have given this matter some attention before the war or at least shortly after its beginning. This method of adjusting fire was effectively used by them upon the allied forces. The British and French, following the lead of the Germans, early in the war developed effective methods of adjusting fire by high bursts, and in turn these methods were adopted by the artillery of the American Expeditionary Forces after the arrival of our army in France.

Several different methods have been developed and all give satisfactory results within certain limitations of range and deflection. Some of the earlier methods required rather elaborate organization and the use of special instruments whose position were accurately located by surveying methods. This in turn required personnel of special technical training. In some cases the use of charts was required. These necessitated the services of draftsmen and required considerable time and painstaking labor to prepare.

Later development has had for its purpose the simplification of methods of high burst ranging and these efforts have been in a large degree, successful.

The greatest obstacle to simplicity has been the lack of a shell fitted with a time fuse. The need for such a fuse is felt for other reasons than that of high burst ranging alone. Most artillerymen agree without question, that such a fuse would be of great value in many situations. From the restricted point of view of high burst ranging alone, a time fuse which when assembled with the shell gave it the same ballistic properties as the percussion fuse, would be most desirable and give the highest degree of simplicity in its employment. This thought leads naturally to that of a combination time and percussion fuse. Whether or not such a development takes place, is in the hands of the Ordnance Department. Further

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discussion of this particular point at this time and place is not desirable or necessary.

As matters stand with regard to ammunition at present available, all high burst adjustment must be made with shrapnel. If the nature of the target requires the use of shell in the ensuing fire for effect, then it is necessary to perform certain computations to determine the corrections which must be applied to the firing data in order to secure the proper trajectory for the shell.

II. METHODS OF ADJUSTMENT

It now appears best to describe and analyze the methods of high burst ranging. No attempt will be made to discuss all known methods. The methods developed at The Field Artillery School are in all respects the simplest methods so far used and discussion will be limited to them. One of the greatest advantages of these methods, three in number, is that all the means for their accomplishment exist within a battalion of field artillery. At times it might be advantageous to secure the aid of a flash ranging battery but this is not at all necessary. This brings to mind the fact that any method of fire adjustment which is independent of agencies outside of the battalion, is of great value. At times it is necessary to enlist such aid, as that of the air corps for instance. In theory coöperation between separate arms or even of separate units of the same arm should offer no difficulty, but all will admit that in practice such perfect coöperation is often difficult to realize. Another advantage of high burst ranging is that it can be employed at night with almost the same ease as in daytime. In hazy weather, excepting of course when vision is completely impossible, except for very short distances, it may be easier to adjust at night than in the daytime. This is because a bright flash will show up well in the dark when white smoke may be almost invisible in a light gray haze.

In order to keep clearly in mind just exactly what high burst ranging is, it may not be amiss, here, to give a clear, concise definition of it. High burst ranging is simply a special application of the principles governing the use of an auxiliary target. The auxiliary target, in this case, is a point in the air determined originally by the intersection of the lines of sight of two observing instruments. This is the basis of all methods here discussed. The various methods differ only in the manner of computing the corrections to be applied after the adjusting point has been determined, in order to bring the fire for effect upon the target.

The selection of the adjusting point is governed by certain considerations. It must of course be visible to the observers and it should be so selected as to be well above any obstacles that might be in the vertical plane containing the line of sight. Its selection

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is also governed by the limitations laid upon all auxiliary or witness targets; *i.e.*, it must be within 300 mils, in deflection, of the target and its range must not exceed $\frac{4}{3}$ of the range to the target nor be less than $\frac{3}{4}$ of this range.

The point selected may be directly above the target, but to insure surprise effect it is better to have it at a different range or deflection or both.

In all cases the position of the observers, that of the gun, the target and the adjusting point must be accurately located on a firing chart or good map of a scale of 1:20,000 or greater.

One observer should be posted so that his displacement from the line of fire as viewed from the adjusting point is not in excess of 100 mils. This gives him axial observation. The other observer should have a greater displacement, the greater his displacement the better, up to 1600 mils. This will reduce any errors made in plotting or in the setting off of the proper azimuth on his instrument. The axial observer is best located when he is in prolongation of the line of fire and close in rear of the gun.

Hereafter the axial observer will be referred to as O_1 and the lateral observer as O_2 .

The target, the base piece, O_1 , O_2 , the projection of the adjusting point upon the horizontal and any reference points that it may be desired to use, are accurately plotted upon the firing chart.

All the necessary altitudes and ranges can be taken from the map or determined by topographical means. From these and the plotted reference points, each observer can be given an angle of site and an azimuth measured from some easily distinguishable reference point, which will cause his line of sight to pass through the adjusting point selected. All firing should be with the gunner's quadrant.

The next step is to obtain bursts within, and preferably near the center of the field of view of the observers' instruments. When this is done, an adjustment is obtained by trial fire, followed by improvement fire. O_1 observes these bursts for height and direction and O_2 for deviation in the direction of range. Based upon their sensings a mean point of burst is obtained. Any burst which will unduly influence the location of the mean point of burst is disregarded and another round fired to replace it. At least six, and preferably twelve, rounds should be used to determine the mean point of burst. A more detailed discussion of the foregoing may be had from Field Artillery School Notes, Book II, Chapter VII. (Revised 1927.) It does not seem necessary or desirable to go into further detail here. Having determined the mean point of burst, an adjusted elevation is obtained from it, as well as an adjusted deflection. These of course apply to the shrapnel fired.

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The initial range for the shell and fuse it is desired to use, may be found by one of the methods given below.

1. From the adjusted elevation, subtract the algebraic sum of the mean point of burst, the false site,* and the actual site of the target. The range corresponding to this elevation is the initial range to be used with shell but must be corrected for the site of the target.

The above method as given applies only when the adjusting point selected is vertically above the target. If it were at a different range and deflection, the following additional corrections would have to be applied to the adjusted elevation for shrapnel:

(a) The adjusted elevation must be decreased by the number of mils necessary to bring the mean point of burst to the same altitude as the guns. Make a ratio of the range corresponding to this elevation over the map range to the adjusting point. Apply this ratio to the map range of the target and then correct it for the site of the target. This will give the elevation to be used in firing for effect on the target.

(b) In changing the deflection to fire for effect, the shift must be made from the mean point of burst and must be equal in amount but opposite in direction to the shift made from the direction of the target to the adjusting point. This automatically takes care of any deflection corrections necessitated by the atmospheric conditions existing at the time. If the adjusting point is at a different range than the target, the difference in drift for the two ranges must be taken into consideration.

It then becomes apparent that it is simplest to use a point directly over the target. However, it is often undesirable to do this. The next simplest method is to select the adjusting point at the same range as the target but having a different deflection.

The above method is often called the "False Site Method." Its application is based upon the principle of the rigidity of the trajectory. As is well known, this principle is not absolutely correct, but holds within very close limits for a small displacement of the trajectory, especially for flat trajectories.

This method is the simplest and easiest to apply and has given very satisfactory results with the 75-mm. and 3-inch guns at ranges up to 6000 yards.

2. The second method might well be called the "Corrector Method."

The mean point of burst is determined as in the preceding case. Now determine the height, in mils, of the mean point of burst above

* False site as used in this article is defined as the vertical angle between the plane of site of the target and the plane of site of the adjusting point.

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the guns. This is done as follows: First, take the algebraic sum of the false site and of the site of the target. Second, increase or decrease this sum by the number of mils the mean point of burst is above or below the adjusting point. The result will be the number of mils the mean point of burst is above the guns.

Now from the firing tables take the range corresponding to the quadrant elevation of the piece. Determine the range midway between this range and the map range of the adjusting point. With this as an argument, take from the tables the displacement of the height of burst *in mils*, for a change of 5 points on the corrector scale. Divide this into the number of mils the mean point of burst is above the guns. Multiply this result by the number of yards the burst is displaced in range by a change of 5 points on the corrector scale, using the same range as argument as was used in taking from the tables the displacement in height of burst. The result is the distance in yards beyond the projection of the mean point of burst upon the horizontal plane through the guns at which the trajectory pierces this plane.

Decrease the range corresponding to the adjusted elevation by the amount just determined. It will be the initial range for shell. The elevation for shell corresponding to this range must be corrected for the site of the target.

This method assumes that the trajectory is a straight line from the mean point of burst to the point in which it pierces the horizontal plane of the guns. This of course is not true. This method will always give a correction which is slightly too great. Some idea of the degree of accuracy of this method may be gained from the following:

Assume that we have determined that the mean point of burst is 19 mils above the guns and that the map range to the mean point of burst is 4000 yards. The actual elevation of the piece is the elevation for 4000 yards plus 19 mils, disregarding corrections for the moment. This, as will be seen by consulting the firing tables, is the elevation for 4400 yards. Hence the distance to the point where the trajectory pierces the horizontal plane through the gun is 400 yards beyond the projection of the mean point of burst on this plane. Using a range of 4200 as an argument, we find that the displacement in height of burst for a change of 5 points on the corrector is 4.22 mils and that displacement in range for the same change is 89.8 yards. Applying the rule given above we have $(19 \div 4.22) \times 89.8 = 404.3$ yards approximately. This is very close to 400 yards. If the interpolation were carried to the nearest tenth of a mil, the result would have been 407 instead of 404.3 yards. As the probable error at 4000 yards is 17 yards, it is evident that this method gives quite accurate results.

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3. The third method of obtaining the initial elevation for the fire for effect could be called the "Position Correction Method." The procedure is as follows:

Determine the difference in altitude in feet between the adjusting point and the gun. From the firing tables, take out the position correction that must be applied in order to cause the trajectory to pass through the point immediately below it and in the horizontal plane of the gun. Determine the adjusted shrapnel range and subtract from it this amount. Correct this range by the position correction for the target and the result will be the initial shell range.

This method is perhaps more laborious than the others but it is apparent that it is the most accurate. It is based upon position correction tables which take into consideration all changes in elevation due to position. It does not introduce the inaccuracies involved by the application of the principle of the rigidity of the trajectory or those mentioned under the discussion of the "Corrector Method."

For longer ranges this method would be the most appropriate when the greatest possible accuracy is required.

It will have been noticed that heretofore no mention of corrections for meteorological conditions has been made. Such corrections would be unnecessary if the projectile used in adjustment and fire for effect were the same. However, when they are different all of the above methods may be refined by applying meteorological corrections to the adjusted shrapnel range, using this to find the initial range for the shell and then applying meteorological correction to this.

When adjusting by high burst, as in all cases when the fire for effect cannot be observed, a range one fork or one-half fork over and short of the initial range should be included in the fire for effect. Just what limits should be used depends upon the accuracy of all the data involved. Likewise a deflection of 5 or 10 mils on each side of the adjusted deflection should be included.

The difference in drift between shrapnel and shell should always be included in the final deflection even when meteorological corrections are not made.

High bursts may also be used to establish a point which may be used as a witness target. This method may be of value when the terrain is such that no good witness target exists upon it, or when it is desirable to have a witness target that can be used at night. The procedure of establishing such a point follows:

Assume that an adjustment has been secured upon a target invisible from terrestrial observation posts and that the adjustment was made with shell. All arrangement as to observers and all data except that pertaining to the adjusting point must be known and

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plotted as described before. Increase the elevation of guns and fire a round of shrapnel with a fuse range corresponding to the adjusted shell range and with a corrector setting near the middle of the scale. Thereafter change only the site in order to obtain bursts sufficiently high to be seen by both observers. The observers should have their instruments referred to some plotted reference point and when they see the first burst they clamp their instruments so that the crosshairs intersect upon it. Following this a series of six or twelve rounds is fired without change of data and the deviations of each burst recorded. O_1 observes for height and direction and O_2 for deviations in the direction of range. The azimuths of both instruments must be recorded.

When it is again desired to fire upon the same objective the instruments are set up in all respects exactly as when the referring adjustment was made, with the exception that corrections are made to place the intersections of the cross-hairs upon the mean point of burst as determined in the referring adjustment instead of upon the point of burst of the first round of that series. From this point the procedure is exactly the same as that of an original adjustment.

For simplicity's sake the method just described is that for a point immediately above the objective. It is not, however, necessary that the referring point be so limited. Any point within the limits of range and deflection prescribed for a witness target in general may be used.

The necessary changes are quite obvious and nothing further need be said about them except in one particular. If the range of the referring point is different from that of the target, it is necessary to obtain the ratio of the adjusted range to the map range in each instance that the witness point is used. Under varying weather conditions this ratio will not always be constant and the ratio used upon one occasion will not of necessity be the correct one to apply upon a subsequent occasion.

III. APPLICABILITY OF HIGH BURST RANGING METHODS

All of the foregoing description and discussion has been confined to an exposition and analysis of certain methods of high burst ranging. It is now necessary to consider when, where and to what type and caliber of gun they are applicable. The discussion would not be complete without consideration also, of when the methods could be applied, but also when it would be preferable to apply them in preference to other methods of adjustment.

It is an invariable rule that when observed fire can be placed upon a target, that this kind of fire and no other should be used. By observed fire is meant fire that can be observed both during adjustment and fire for effect.

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Unfortunately the conditions which permit of observation of fire are very often lacking. The best conditions obtain when the individual actually conducting the fire and immediately commanding the fire unit also does the observing. Lacking this, the next best condition is that in which the battery commander receives reports as to location of bursts from some other individual, such for instance as an auxiliary observer on the ground or an aerial observer.

There are, however, many inherent difficulties in observation from airplanes and balloons, particularly in the former case, and at best neither is entirely dependable over any great period of time. For these reasons then it is necessary to have some scheme upon which to fall back when all means of direct observation fail. Such a scheme presents itself in the methods of high burst ranging.

Again it may be desirable to use high burst ranging methods even when fire for effect can be observed. This would be particularly so when the element of surprise is paramount. By adjusting upon a point not directly over the objective, a rapid burst of fire at an effective range might be placed upon a target with a highly devastating effect. This would be especially so in case the fire for effect was conducted with gas shell. The moral effect in any case would be very great.

The value of the methods of high burst ranging for use at night have already been mentioned and need no further discussion.

Like all means of conducting fire other than by direct observation by the battery commander, there are certain essential conditions which must be fulfilled in order to permit adjustment by high bursts. In the first place, an accurate topographical map must be available and preferably of a scale of 1:20,000 or greater. In the absence of this, the means must be at hand for obtaining the topographical data which ordinarily would be taken from the map. One essential which would be most often lacking is the necessary time involved in such procedure. Granted sufficiently accurate topographical data, all the other essentials would ordinarily be at hand. These consist of two properly adjusted battery commander telescopes, a firing chart and communication between observation posts and the battery. These always exist within a battalion of field artillery.

The desirability of using the same projectile for adjustment and effect has already been discussed sufficiently. It has been shown also that the lack of such a projectile is by no means an unsurmountable obstacle. It therefore follows that any gun which fires both shrapnel and shell can be used for high burst ranging provided that firing tables containing the necessary data are at hand. There is also another provision that must be included here from a practical standpoint. The variation in the height of burst of the shrapnel must not be so great as to require an excessively large number of

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rounds to be fired in order to determine a mean point of burst with the desired degree of accuracy and the zone of dispersion must be sufficiently small to be included within the field of view of the observing instruments.

All these conditions are satisfied by both the 75-mm. gun and the 155-mm. (G.P.F.) gun. A number of problems have been fired with the former at The Field Artillery School and the above theoretical conclusions have been well substantiated in its case.

Only one problem, in which the position correction method was used, has been fired there with the 155-mm. gun. This was at a range of over 10,000 yards. The center of impact of the fire for effect was 12 yards over and 2 yards left. This seems to indicate that from a practical standpoint this weapon is well adapted to the employment of high burst ranging methods. This confirmatory evidence is scant of course and should be substantiated if possible by additional problems.

IV. CONCLUSION

Heretofore the subject of high burst ranging has been regarded by many as a highly involved and complicated process. This is no doubt due to some of the earlier methods employed and the method used to present them. It has been shown that satisfactory methods are in existence which are in no sense complicated. All artillerymen should be conversant with these methods and understand the relative merits of each so that in any situation he can determine whether or not to employ high burst adjustment and which of the methods to use.

TREASON!

BY LIEUTENANT J. L. CHAMBERLAIN, JR., F.A.

THE General saw it and spoke to the Colonel,
The Colonel saw it, his face was grim,
The Major was summoned to see the horror,
His face grew pale from the shock to him,
His eye gleamed with stern determination,
"Our country's honor's at stake," said he,
"I'll summon the Captain." And *he* came running
And when he had looked, he sent for me.
It required no words of explanation,
The horrible, terrible deed was done.
Giving birth to a bale of "reply by endorsements,
In reply refer to File two-o-one."
The General now is sleeping better,
The Colonel has gotten a good night's rest.
The Major's condition is vastly improving.
The Captain's crisis has turned for the best.
And I—well, the medico's optimistic,
And changed my diet from milk to mutton.
So, everything's back to its normal status,
For the off lead driver's sewed

on

his

button.

FIELD ARTILLERY: PAST, PRESENT AND FUTURE

BY GENERAL HERR OF THE FRENCH ARMY

[This is the third installment of the translation of General Herr's book.—EDITOR.]

CHAPTER II, CONTINUED

THE FIELD ARTILLERY DURING THE WAR

IV. STABILIZATION (CONTINUED)—1917

A. FIRST ATTEMPT TO BREAK THROUGH—THE GREAT SPRING OFFENSIVE

DURING the winter of 1916–1917,* the French High Command in concert with the Allies, drew up a program for a great offensive to be delivered in the spring, with the object of definitely breaking through the enemy front.

By the end of 1916 manufacture of matériel and ammunition had been considerably increased. By January 1st, 1917, we already had 469 batteries of heavy field artillery and counted on having over 500 by spring. There was a daily delivery of 175,000 75-mm. and 40,000 155-mm. shell.

The complete project comprised a succession of attacks along the line from north to south, commencing with the British Army and continuing step by step all the way to Italy and even to the Balkans.

The program for the attacks to be delivered by the French Army was based on the quantity of artillery available.

With these means, the French High Command figured on being able to make:

1. A strong attack between the Avre and the Oise on the front, Roye-Lassigny-Ribécourt, with the object of absorbing all enemy reserves remaining available after the series of British attacks.

2. A great attack immediately following the above to be delivered on the Aisne front with the object of definitely breaking through the enemy front.

3. A bold and energetic exploitation in order to complete the disorganization of the enemy.

Changes which took place in the French High Command led to considerable modification of the original plan. The attack on the Roye-Lassigny front was to be a secondary attack only, with the object of attracting the enemy's attention while the main attack was launched on the Aisne front.

Accordingly, in January there commenced the preparation of the two attack fronts for the offensive which it was desired to deliver as soon as possible so as not to allow the enemy to take the initiative as in the year before at Verdun. All available artillery was employed and as there was not yet enough to provide both fronts with the desired amount, it was decided that most of the heavy field artillery would be rapidly moved to the Aisne after it had finished its mission north of the Oise and would successively participate in both battles, thus playing for the first time its new rôle as a general heavy field artillery reserve.

However the German High Command which had seen its effectives

* Conference at Chantilly, November 15 and 16, 1916.

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melt away at Verdun and on the Somme the year before, and knew the cost of such a defensive battle as it had had to fight in July, did not wish to expose its army to a similar destruction. On February 26th it commenced a general withdrawal before the British and on March 17th, a day before our artillery was to open fire, it executed the same maneuver all along the front from Arras to Vailly, before the British and French armies.

This maneuver saved the German Army from the destruction which threatened it, and the withdrawal to the Hindenburg line, which was shorter than the front previously occupied, made available considerable reserves to the German High Command. However, the German withdrawal, although hindering the secondary attacks, did not affect the main attacks which were to be delivered by the British in Artois and by the French on the Aisne.

In spite of the serious political situation existing in France during the latter part of March and the early part of April, the High Command stuck to the broad lines of its plan.* Furthermore, since the secondary attacks would be useless, the effectives which were to participate in them were for the most part freed and permitted the British to strengthen their Artois offensive and the French to extend their attack from the Aisne to the Champagne.

The offensive was launched on April 9th by the British, then on April 12th, 16th and 17th by the French armies successively. The objective proposed was the destruction of the principal mass of the enemy forces on the western front. To accomplish this it was necessary to break through the enemy's front, then to engage the enemy reserves, and finally to advance our forces in strength on to the enemy lines of communications. It was in truth a decisive battle including an energetic exploitation with large reserves, accordingly implying depth and continuity of action.

On the Aisne the attack preparations were rapidly completed by the deployment of a part of the heavy field artillery which became available from the old front, Roye-Lassigny-Ribécourt. We thus were able to have on a front of 40 kilometers, about:

2000 75-mm. guns

1930 heavy cannon

17 railway cannon

1650 trench mortars,

or:

one 75-mm. gun per 20 meters front

one heavy cannon per 21 meters front

one trench mortar per 25 meters front,

a density greater than we had been able to provide up to this time.† Furthermore modern cannon, non-existent in 1915, still rare in 1916, here entered in the following proportions:

25 per cent, of the heavy field guns.

55 per cent, of the heavy howitzers.

The artillery preparation commenced April 7th; it was to last five days and, in accordance with orders, was to be executed in depth

* Council of War at Compiègne, April 6, 1917.

† The ammunition stocks accumulated for the attack were upwards of 24 million 75-mm. shells, and 9 millions of shells for heavy cannon.

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and was to be put down simultaneously on all enemy positions within range. Unfortunately the weather was frightfully bad. Airplanes could rarely get up and the visibility was so poor that, in spite of all the devotion of pilots and observers, most of the artillery adjustments could not be accomplished. The very complete destructions demanded of the artillery could not be accomplished in the allotted time and, to give time to complete them, the attack was postponed from day to day until April 16th at 6 A.M.

Another thing still more serious: no one kept the attack secret. The press wrote about it openly and it was discussed publicly. An order which fell into the hands of the Germans on April 5th, through the capture of a noncommissioned officer, apprised them with certainty of the date and hour of the attack. Therefore the enemy was in no way surprised and could make all desired arrangements. Accordingly, when the attack was launched at 6 A.M. April 16th, it found an alerted enemy who received it with murderous fires. The two flanks advanced in spite of everything, but the center was completely checked. Although we took 10,000 prisoners the first day, the result did not at all correspond to our hopes. However the High Command decided to continue the effort on the Aisne while on the right mounting a methodical operation, supported by more than 500 heavy cannon, for the capture of the Moronvilliers heights.

The whole of the end of April and the beginning of May was filled with violent and very costly fighting along the Aisne. May 4th and 5th, a large operation, prepared by an intense bombardment favored by good weather, gave us the Moulin de Laffaux, the entire Chemin des Dames crest and the Craonne plateau. The enemy at first made vain efforts to reconquer the lost terrain, then became resigned and the battle gradually died away.

In the meantime, on the right, very difficult operations continuing in the Moronvilliers region until May 20th ended in assuring us definite possession of all the hills. There also, towards the end of May, the fighting died away.

This great spring offensive gave us some very important positions and used up the enemy who left in the hands of the Allies, 50,000 prisoners, 450 cannon, and nearly 1000 machine guns. But it was not the overwhelming success, the great decisive victory, which public opinion expected.

LESSONS

Relative to field artillery the Battle of the Aisne brought out a certain number of lessons which were immediately drawn from the data on hand and which we used to our profit.

Depth of Action Requires an Increase in Means.—The experience of 1916 permitted us to determine with sufficient accuracy the quantity of artillery necessary to prepare, under favorable conditions, the attack of *one* enemy position.

In 1917 the High Command wished a deep preparation simultaneously covering the *successive positions* making up the enemy defensive organization. As shown by the figures we have given on the densities of the artillery deployments in the Somme offensive in 1916 and in that on the Aisne in 1917, it is incontestable that the High Command brought notably superior means into play in 1917, and that these means

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were more modern. But experience showed in a peremptory manner that these means were still insufficient. Obligated to distribute its efforts over two and sometimes three positions echeloned to a depth of 7 or 8 kilometers, the artillery could do so only to the detriment of its action on the first lines, which became insufficient. From which the final unsuccess of the attack.

It is quite evident that the necessary condition for taking the second position is that beforehand one becomes master of the first position. The legitimate desire to give depth to the attack should not, under any pretext, lead to a neglect of the first part of the battle. The calculation of the number of cannon to deploy and of the ammunition stocks to provide should be made accordingly; the artillery means necessary to accomplish the preparation in depth must be added to the matériel required for the destruction of the first position and should not in any case be taken from this latter.

It is true that the reduction of the French front, due to the relief of our VI and X armies south of the Somme by the British and to the liberation, because of the German withdrawal, of a good part of our I Army between the Avre and the Oise, made certain means available. However, these means were essentially *effectives in personnel* and the *matériel* which we possessed in the spring of 1917 was not yet in keeping with the grandiose plan conceived by the High Command. The High Command's error precisely, was that it estimated that the Franco-British effectives in personnel would unquestionably reach their maximum during the early part of 1917 and could not but decrease from then on: it based its whole plan on the *apogee of effectives*, when it should first have considered *the state of its resources in matériel*. In April, 1917, the Allies were not yet in a position to provide their armies with the matériel necessary to rapidly dislocate, over extensive fronts and to great depth, the enemy fortified zone. On the contrary, a year later, the hour was to strike when matériel had reached the peak of its development, and, in spite of the considerable usury in effectives, an analogous plan was to become legitimate and was to be crowned with success.

Surprise is Essential for Success.—1. Strategic surprise must be sought by dissimulation of preparations for attack. Some of these preparations, because of their importance, such as great railheads, large ammunition depots, important medical installations, flying fields, firing tracks for railway artillery, cannot be concealed from the enemy. However, there remains the resource of organizing everywhere and of preparing the whole front for a large offensive. The adversary thus will remain to the last moment undecided as to the region where the attack will really be launched.

2. Strategic surprise depends also on the way in which the attack is kept secret: the indiscretion of staffs, the premature issuing of orders, newspaper publicity, render all other precautions vain: they were fatal to us in April, 1917.

3. Strategic surprise being attained, it remains to assure tactical surprise. This latter is absolutely incompatible with a long artillery preparation. It is absolutely necessary that the artillery be not deployed till the last moment when it should be put into action and used to the limit. These conditions were not fulfilled in 1917. A still high proportion

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of slow fire matériels, the state of our firing technique which was not such that the artillery could fire without observation, thus making it the slave of weather conditions, the excessive work demanded of the artillery for a preparation over several successive positions with an inadequate number of cannon, all these reasons led to excessive length of the preparation.

To sum up, the check of the great spring offensive may be attributed to three principal causes:

An armament still insufficient to open the necessary breeches in the enemy's fortified system. This armament lacked the numbers necessary to assure rapidity of action, and the range necessary to give depth of action;

An incomplete equipment in certain parts of the front, which still required a great deal of preparative work to be ready for attack;

The total absence of any surprise effect.

Use of the R.G.A.L.—The A.L.G.P. provided 17 long range matériels for the April attacks. Out of the existing 87 battalions of tractor-drawn heavy field artillery, 84 took part in the battle. These battalions alerted at the last moment towards the end of March, simultaneously executed important strategic movements, in the case of certain units amounting to over 250 kilometers, and went into position on the Aisne. This first experience in the use of the R.G.A.L. on a large scale was conclusive; it made the mobility of the tractor-drawn matériel appreciated and the lessons learned furnished a basis for the drawing up of the march regulations for these matériels (May 30, 1917).

The employment of this powerful artillery, although marking progress over the errors of the preceding year, was still subject to some of the faults previously noted. The Command still did not know how to use these long-range cannon; it had a manifest tendency to delegate their control to the lower echelons of command. A matériel whose field of fire at average good ranges, exceeds the front of a large unit, should by all means be kept under the control of the superior echelon, and one should not see, as occurred on the Aisne, 280-mm. mortars with a range of over 10 kilometers, attached to a division, which used them to accomplish destructions and even interdiction at ranges between 3 and 5 kilometers, missions better fulfilled by division matériels, the 75-mm. gun and the 155-mm. howitzer.

MEASURES TAKEN TO CORRECT DEFICIENCIES

Attacks with Limited Objectives.—The sad deception of our failure in April led to a crisis in the Army's morale whose consequences could well have been fatal, and it was necessary first of all to avert this crisis.

Two events of capital importance also marked the first half of 1917:

The entry into the War of the United States (April 6, 1917).

The collapse of the military power of Russia (March-July, 1917).

But the efficacious coöperation of the United States could not be counted on for eighteen months, while the defection of Russia was to have immediate consequences.

From these three considerations, the French High Command drew the following conclusions:

There was no longer possibility of obtaining a rapid decision in 1917: it was necessary to await exact orientation on the turn of events

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in Russia and on the armed aid which could be given us by the Americans. It was therefore necessary to return to the war of attrition, and, while wearing down the enemy, to reconstitute a solid, trained and confident army, and to provide this army with all the modern equipment which it still lacked by hastening to a definite conclusion our artillery programs and by pushing the construction of tanks.

Consequently, until the new order of things should arrive, only *attacks with limited objectives*, against judiciously chosen points, should be executed. These points should be such as the enemy had imperative reasons to hold, where we would be accordingly sure that he would utilize, in a crisis, a large number of effectives: his losses would thereby be increased so much the more and his usury would be the more rapid. As for us, we would attack with a minimum of infantry, but on the other hand with a maximum of projectiles. The experience acquired since the beginning of the war showed that if enough field artillery is used a certain success can be counted on, limited, it is true, in depth, and without strategic import, but easy of accomplishment and little costly in human lives. A few successes of this kind, obtained with insignificant losses in infantry, would restore confidence to the army while at the same time accustoming our young soldiers to war and contributing to the training of our troops.

These ideas of the High Command were outlined in a certain number of documents which set forth:

The new offensive tactics to be adopted (Directive No. 1, May 19, 1917);

The equipment which must be provided throughout the whole front as a primary condition for freedom of maneuver and to assure surprise in case of the offensive, and the proper use of reserves in case of the defensive (Note of June 4th on the application of Directive No. 1);

The method of training small units of all arms, large units, and staffs (Directive No. 2, June 18th);

Finally the principles for the execution of attacks with limited objectives (Directive No. 3, July 4th).

Relative to field artillery in particular, these various instructions set forth the end to attain:

From the tactical standpoint, the rapid entry into action of large masses of artillery and the rational organization of their action, was to be studied. These results were to be attained by exercises in reënforcement having for their object the training of the troops, the habituating of the Commands of large units in the organization of artillery command on the battlefield, and in the tactical employment of these masses of artillery;

From the technical standpoint, the processes of preparation of fire were to be perfected: a methodical preparation of fire, verified by some adjusting shots, as few and as discreet as possible, should permit of the very rapid opening of immediately effective fire.

Progress in the Accomplishment of the Program of May 30, 1916.—Some new modern matériel began to arrive in the armies, notably the 220-mm. howitzer, Model 1915, in March, 1917, the 145-mm. gun, Model 1916, in April, then the 155-mm. gun, G.P.F., in June.

During the early part of the year, there were no large quantities of

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the modern matériels delivered and the regimental depots could organize the new battalions without difficulty. However, it was foreseen that in the future deliveries would be at a greater rate and that the depots would be swamped. To avoid this danger, a War Department order of April 7, 1917, prescribed the creation of two Heavy Field Artillery Training Centers, one at Noailles and the other at Saint-Dizier. The field artillery officers and the motor transport officers for the tractor-drawn battalions were to be furnished by the Vincennes School which had been running since March, 1917.*

Creation of the Director General of Field Artillery Training (D.G.I.A.) and of the Central Field Artillery Board (C.C.A.).—All the offensives in the fall of 1916 and spring of 1917 had confirmed, as concerns field artillery, the increasing importance of the arm in battle.

Moreover the matériel was all being changed; tactical tendencies were in evolution; technical processes were being perfected; personnel effectives were rapidly increasing. The High Command felt more and more the necessity of supervision of the diffusion of new ideas in the armies, of preserving unity of doctrine and of directing its development, of assuring that the arm was so employed as to give best results, and especially of maintaining intimate contact and constant coordination between the front, where the arm worked, and the zone of the interior where its matériel and troops were prepared.

General Petain was among the first to understand the essential rôle in battle to be played by the field artillery; at Verdun, the year before, he had started the field artillery along its new road; he was responsible for the creation of the Center of Artillery Studies. When General Petain became Commander-in-Chief of the French Armies, he estimated that a central organization acting in his name was indispensable to get the best results. He reported to the War Department, May 22, 1917, that he was creating for this purpose the office of a Director General of Field Artillery Training (D.G.I.A.) in which he was placing General Herr. He at the same time requested that this General be accredited to act with the War and Navy Departments and with the Armament Department.

Carrying out the views of the Commander-in-Chief, the Minister of War, May 24th, created in Paris the Central Field Artillery Board (C.C.A.) to act under the Chief of Staff and whose presidency was also assigned to General Herr. The mission of this Central Field Artillery Board was to carry out all studies relative to field artillery fire, such as might be instigated either by the Chief of Staff or requested by one of the Departments cited above, to whom the Board thus acted in the rôle of technical adviser. These studies were to be investigated from the triple standpoint of methods of fire and the rational use of matériel and ammunition. The Board was also charged with training in the Zone of the Interior. The Board included in its personnel, qualified representatives of the supply services of the field armies and of the Zone of the Interior; it thus assured liaison between these, allowing the Zone of the Interior to keep in close touch with requirements at the front, and to coordinate its efforts in order to fulfill these requirements. We will take occasion later to touch on the invaluable services rendered by this organization. It is astonishing that it took

* This School was reorganized February, 1918, into an Automotive Artillery Training Center, common to the tractor-drawn and the portée artillery.

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three years of war to open the eyes of the High Command to the need of such an organization. It is hoped that the lesson will not be forgotten.

B. "LIMITED OBJECTIVE" ATTACKS (JULY-DECEMBER, 1917)

Flanders (July 31st).—The first limited objective attack for the French armies was in the British operation for disengaging the Ypres salient, participated in by the French I Army.*

The British as well as the French prepared these attacks in the minutest detail, and supported them with formidable arrays of field artillery. The I French Army placed in action on a 4-kilometer front:

240 75-mm. guns
373 heavy cannon,

or a total of one cannon per 6.5 meters front (153 cannon per kilometer), not including trench mortars.

After an artillery preparation of over two weeks,† which turned all the enemy defensive installations upside down, the infantry's task was easy: in spite of the obstacle offered by the marshy terrain, our troops advanced rapidly, even going beyond their assigned objectives for the day. On our right, the British likewise made a considerable advance, amounting at certain points to 3 kilometers.

In a series of methodical attacks of the same character, delivered at variable intervals up until the end of October, our troops always took their assigned objectives with light losses. In November the Ypres salient was freed, the hills which overlooked it were reconquered, and the enemy was pushed back into the low marshy plain.

Verdun (August 20th–26th).—While these attacks were going on in Flanders, an operation along the same lines was prepared at Verdun on a front of 17 kilometers, with the idea of enlarging the gains we had made in the latter part of 1916 and of reconquering the outlying observation points of the region. The artillery deployed on this 17 kilometer front comprised:

948 75-mm. guns,
1318 heavy cannon,
66 railway cannon,

or a total of one cannon per 7 meters front, not counting trench mortars of which there were 247.

The artillery preparation began on August 13th. Hindered at first by bad weather, it had to be prolonged throughout seven days. However, conducted with perfect method, it accomplished remarkable results; the enemy trench system was leveled, machine guns were buried, batteries were destroyed or at least silenced, great dugouts were caved in.

The morning of August 20th the infantry attack was launched. It rapidly reached the assigned objectives with few losses. The following

* The British had already delivered an attack conducted according to the new principles: the attack of the Messines-Wytschaete ridge, June 7. On a front of 16 kilometers they deployed artillery comprising 1600 light field and 800 heavy field pieces, a total of 2400 cannon, or a little over one cannon per 7 meters of front (150 cannon per kilometer).

† The length of the preparation was intended to be thirteen days; successive delays, due to bad weather, finally brought it to sixteen days.

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days, some islands of resistance were captured, and finally on August 26th we occupied very approximately the line we held before the first German attack on February 21, 1916. The German High Command was forewarned of the attack and had brought up some fresh divisions to parry it. However these counter-attack troops were decimated before their engagement by the intense fire we put down on the rear areas, and could not intervene in time.

Ammunition consumption surpassed anything that had previously been seen. From July 13th to 27th there were fired in round numbers:

3 million rounds of 75-mm. ammunition,
1 million rounds of heavy artillery ammunition,

representing a total of 120,000 tons. These 120,000 tons required for their transport 360 trains of 30 cars each. There was an expenditure of 6 tons of ammunition per running meter of front whereas the year before, at Verdun or on the Somme, the expenditure never surpassed 1 ton per meter front.

La Malmaison (October 23rd).—The so-called "La Malmaison" operation was for the purpose of pushing the enemy back over the Ailette, our spring attacks having failed to dislodge him in the Laffaux-La Malmaison region, where he still held the Chemin des Dames. Preparations for this operation extended over a long time, and all the lessons learned in the two preceding attacks were applied. There were on a front of 10 kilometers, about:

624 75-mm. guns,
986 heavy cannon,

or a total of one cannon per 6.2 meters front, not including trench mortars of which there were 270.

An artillery preparation extending over six days and nights succeeded in leveling most of the enemy defensive organization; an intense interdiction prevented all ration and ammunition supply. No supplies could be advanced over the Ailette.

Under these conditions the attack, supported moreover by five battalions of tanks, was made on October 23rd without great resistance. Except on the extreme right, all objectives were reached. Moreover on the 24th the enemy who had suffered considerable loss* commenced to evacuate the positions he still held and November 2nd completed his retirement behind the Ailette.

This handsome victory, which allowed us to advance to a depth of 6 kilometers on a 10-kilometer front, remains a model for *limited objective attacks*.

LESSONS

Advantages and Disadvantages of Limited Objective Attacks.—These three battles, Flanders, Verdun, Malmaison, were truly field artillery battles, in which the field artillery personnel effectives engaged often exceeded those of the infantry, in which the number of cannon

* Twelve thousand prisoners, 50,000 casualties (of which 8000 dead were found by us on the battlefield), 200 cannons. Our losses from the 23rd to the 26th did not exceed 8.5 per cent.

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in action reached figures previously unknown,* and in which ammunition without limit was placed at the disposal of the batteries.

Let it be remembered that the results desired by the High Command were to restore to our soldiers the confidence lost in April, and especially to use up the enemy at small expense, while awaiting the entry into action of the American Army. These results were very exactly and very completely obtained. Ludendorff wrote, "These battles on the Western front were very bitter and caused us losses such as the German Army had never before suffered." It is estimated that the total number of German effectives that were engaged in these various affairs, and which were placed out of action for varying periods, was nearly 1,500,000 men (more than 120 divisions).

In April, the objective of the French High Command was the rupture of the enemy front, followed by a rapid exploitation as deep as possible. Perfectly aware of our intentions, the enemy had adopted a very simple and very sure maneuver: he almost completely evacuated his first lines in order to save their defenders from the annihilating violence of our artillery preparation, and he had disposed, outside of the zone beaten by our fire and thus preserved from losses, complete counter-attack divisions, with their artillery limbered. As soon as our assault echelons, winded by their first efforts and disorganized in their passage over a torn up terrain, had progressed beyond the limit of range of our field artillery and were thus deprived of its support, the Germans counter-attacked with these fresh and completely equipped troops.

These tactics were so successful in April that the enemy tried to apply them in the succeeding battles. But the system of "limited objectives" attacks which he did not expect, spoiled his plans this time. Our infantry was assigned objectives located within range of our artillery and always remained under its protection. Not being far from our lines the objectives were reached before the enemy had time to counter-attack. When he finally did counter-attack, our infantry was already installed in the conquered position, well in hand and ready to fire. The German counter-attack battalions, in dense formation, fell under the combined fire of our two arms and were decimated before they could accomplish anything.

When the Germans finally recognized that we had adopted a new method of attack, they changed their defensive methods; having learned the uselessness of their counter-attack divisions and the bloody inefficiency of their counter-attacks, they resigned themselves in Flanders, to trying again to defend their first lines. But our violent bombardments then caused them frightful losses and they could not succeed in stopping our slow progress from objective to objective.

The limited objective system therefore had victoriously proved itself. The experience of several large scale attacks showed that when a sufficient number of cannon are deployed, when an unlimited quantity of ammunition is available, when several tons of projectiles are expended on each hectare of the terrain to be conquered, and if one limits his ambition to taking only a few hundred meters of ground, at most 2 or 3 kilometers, so as not to go beyond the radius of protection

* It has been calculated that if, at La Malmaison, all the artillery matériel present (cannon, limbers, caissons) had been aligned side by side on a single line hub to hub that there would have been what may be termed a *continuous axle*.

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of his own artillery, that one can count with an almost mathematical certainty on obtaining the result sought. It then remains only to bring up the artillery, resupply it with ammunition and begin the same game again. So, by slow degrees, with one preparation after another, with one limited objective after another, slowly but surely, one may perhaps succeed in pushing the enemy back to the frontiers.

Undoubtedly true—but let us see under what conditions and at what cost these tactics will succeed.

1. There must be deployed a quantity of artillery whose density amounts to as much as one cannon per 6 or 7 meters front, or more than 150 cannon per kilometer. If one did not wish to be content with local actions without strategical results but wished to open an important breach in the enemy's front, there would be required a number of cannon exceeding all that the most energetic industry, well supplied with raw material, could possibly furnish.

2. Each step would require enormous quantities of ammunition amounting, as we have seen, to as much as 5 to 6 tons of ammunition per running meter of front attacked. In the La Malmaison affair there were fired:

During the six-day preparation:

17,500 tons of 75-mm. ammunition.

36,000 tons of heavy artillery ammunition,

15,000 tons of trench mortar shells.

And the day of the attack:

5200 tons of 75-mm. ammunition,

7200 tons of heavy artillery ammunition,

or a total of 80,000 tons, the load of 266 trains of 30 cars each. A total of 100,000 tons of ammunition had been brought up, 75,000 tons of which was before the beginning of the preparation. It took thirty-two days to lay in these initial stocks. Before a comparable effort could have again been undertaken all these ammunition reserves would have had to have been reconstituted, which would have taken a month. And the attack was on only a ten-kilometer front!

There are two main disadvantages in all this:

The consecutive attacks can be successively delivered only at long intervals, leaving the enemy time to restore himself, and decisive results can be obtained only after a long time;

No more than it can supply the cannon, would industry be able to produce a continuous stream of projectiles in such enormous quantities.

3. These artillery actions are frightfully expensive. The Verdun attack cost in artillery projectiles alone more than 700 million francs; La Malmaison around 500 million. No matter how brilliant financiering may be, it cannot long survive such prodigalities.

4. These fearful bombardments pulverize everything in their passage, destroy every vestige of habitation, render the soil sterile for several years, transform the country into a veritable desert. What a dolorous result when the battles are fought on the Nation's soil.

The system of limited objective attacks, evolved with the idea of accomplishing a desired result, effectively accomplished this result. It had its hour in 1917; but it never was and never could be anything but a temporary expedient, economical of our soldiers' blood and at the

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same time wearing away the enemy slowly but surely; it was not, nor could it ever be, a method giving decisive results in war. Accordingly some other way must be found to obtain a decision and lead to the end of the war.

However, with these reservations, the system nevertheless furnished useful teachings. It confirmed what was already known of the decisive power of field artillery. It showed that by paying the price, a desired result could be obtained without great cost in human lives. It gave precise data on the proportion of field artillery to use in battle when there are reasons to gain victory by striking with shell rather than with men, and when sufficient matériel is available. Indeed it seems that, in these three battles of 1917, there was realized, perhaps to slight excess, this optimum proportion of field artillery. Let us recall there were sometimes more field artillery men than infantry men in these battles and draw the conclusion that an equality in the effectives of the two arms represents approximately the desirable proportion.

Plans of Employment.—In these gigantic matériel battles, the work of the field artillery became extremely complex, heavy and burdensome; the missions to be accomplished by this arm were so numerous and varied, their execution was so artistic and delicate that to avoid confusion and chaos everything had to be foreseen and minutely planned for: the manner in which each target was to be attacked, the number, kind and caliber of the projectiles it was worth, the most appropriate time for the firing, the order in which the various targets should be attacked, the methods most suitable for the preparation and adjustment of fire and for fire for effect, the assignment of observation posts and of observation aviation, the organization of communications, and ammunition supply. In a word, not a round should be fired which was not planned and prepared for and which did not have a certain rôle to play in the ensemble.

This remark applies not only to the phase of the artillery preparation, but also and with still more emphasis to the phase of the infantry attack which must be protected and accompanied with fire, step by step.

All of these dispositions were arranged by long preparatory work which took hours and even days of study, reflection and discussion and which resulted in the drawing up of a *plan for the employment of field artillery*, a detailed program for the individual action of each battery in coördination with neighboring units, a careful orchestration of the difficult parts which all the artillery instruments were to play in the infernal concert of battle.

The necessity for plans of employment had made itself felt when field artillery commenced to play such an important rôle in battle. As the quantity of field artillery deployed for battle grew and as the field artillery's mission became more extensive and difficult, this necessity for plans of employment became more imperative. Appearing in embryonic form during the great battles of 1915, the plans of employment were developed and improved in 1916*; they reached their perfected development in the limited objective battles of 1917, when sometimes they could even be criticized as being too voluminous and complicated.

* Due especially to the influence of the Center of Artillery studies which standardized it and spread its usage among the officers who came to take the course.

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Certainly such staff plans, which require studies successively revised, which involve exchange of views and continual conferences, in which nothing can be forgotten and nothing left to chance, in which everything is planned and regulated, such plans are applicable only in stabilized warfare and in case of attacks determined on long in advance and for which preparations are made at leisure.* These methods have nothing in common with the rapid processes and the improvisations of moving warfare. However the intensive use of these methods in 1917 was a marvelous intellectual training for our artillery staffs, which were supplied, disciplined, and trained in coördinated and precise work; the taste for method and the need for clearness was impressed on these staffs and they habituated themselves not to neglect a single detail, and became trained to work well and quickly. The fruit of this long intellectual preparation was plucked by our field artillery in the spring of 1918, when it had to face the difficult and always unexpected situations which resulted from the rupture of our front. Each field artillery officer had the plan of employment in his blood, he was so trained in its usage that, no matter what the difficulties of the moment, all the orders which he had to give, either as line or staff officer, proceeded from his pen or his mouth in correct and precise form. Under pressure of the necessities of the moment, the somewhat too strict formalism of the orders of 1917 was almost immediately eliminated to make place for convenience, simplicity and rapidity, and the plan of employment took on the form suited to new conditions.

Observation, Adjustment and Preparation of Fire.—As we have noted apropos of all the operations we have enumerated, artillery preparations had always been of considerable duration: this duration, which was three days in Champagne in 1915, had a constant tendency to increase, and reached, as we have seen, sixteen days in the Flanders battle. This was because the field artillery was required to accomplish destructions, always more numerous and more complete. Each of these destructions necessitated accurate fire which still could only be obtained by direct observation. It also required dense fire involving great ammunition expenditure. These are the two conditions which influenced the duration of artillery preparations and were the causes of its lengthening.

The second of these causes, which had its origin in the quantity of ammunition to be fired, had not so much influence; the number of cannon in line and the proportion of modern rapid-fire matériels was constantly increasing; for these two reasons it was becoming possible to send over in a given time, an always increasing quantity of projectiles.

The real cause of the prolongation of artillery preparations lay in the necessity for *adjusting all fires with direct observation*. Usually ground observation stations were in insufficient number, either because in level country, such as Flanders, they simply did not exist, or because, as was the case in many sectors, the Germans had always made the sacrifices necessary to assure them possession of the dominating terrain where the artillery could find observation posts, or yet because, in the case of penetrating attacks, distant objectives escaped our terrestrial observation merely because of their distance. Accordingly most adjustments had to be made with the assistance of aerial observation. But

* It was in April that the Army of Verdun began to study and prepare for the operation which it was not to execute until the following August.

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this latter gave only limited returns for various reasons: the number of available airplanes was never great enough; good artillery observers were rare; the number of wave lengths available for air to ground communication allowed the simultaneous working of only a limited number of airplanes; also aerial observation is the slave of atmospheric conditions. Enemy pursuit aviation penetrating over our lines a little, can entirely paralyze it.

As long as the field artillery cannot free itself from this tyranny of adjustment by direct observation, the necessity of observing all fires unavoidably prolongs the duration of artillery preparations. This has many defects of which the greatest, unquestionably, is the absolute loss of all surprise effect.*

And still, it was increasingly felt that surprise was the basic condition for any success; that attacks foreseen and awaited by the enemy could only lead to local successes without a future; that, on the contrary, the sudden attack, which completely surprised the enemy, could alone obtain fruitful results, susceptible of opening the way for a rapid and deep exploitation before enemy reserves could intervene, and thus bearing the germ of victory. It was not possible that the artillery, whose power destined it to be the arm of decisive success, should see its worth paralyzed and all its effect done away with by this slavery to observation.

What is this adjustment of fire and why have it? It is to eliminate all the errors resulting from either inexact knowledge of the position of the target, from imperfections in matériel, or from variations in atmospheric conditions which change the trajectory and keep the projectile from reaching the target. In an adjustment with direct observation the errors in range and direction are corrected by observing the points of fall and bringing them on the target by appropriate changes in firing data.

Would it not be possible to calculate before firing all the changes rendered necessary by the conditions of the moment, to apply this *a priori* and to open a surprise fire which would surely cover the target, without having to go through with a preliminary adjustment?

The problem thus propounded certainly has a solution. All the belligerents had been trying since the war began to find this solution. By the end of 1917 the hour had come when the French field artillery had found a solution, which, while not final nor complete, was at least accurate enough to be of immediate use and to serve as the basis of firing methods of a fruitfulness without parallel. This solution was the scientific preparation of fire: a topographical preparation which led to immediately obtaining the distance and azimuth of a target from the map, and to giving the cannon the corresponding elevation and deflection; a ballistical preparation which took into account the wear of the tubes, the variation in powder, and compensated for the resulting loss in muzzle

* It may be objected that the Germans, notably at Verdun, had only short artillery preparations of a few hours. We have already noted that the rapidity of fire of their modern matériels was a great advantage in this respect. But besides they employed methods of fire different from ours. They contented themselves with a few rough adjustments which furnished them the initial data for their fires for destruction; with this data, they then put down deep zone fires, in which the extent of the beaten zone and the number of projectiles fired, compensated for the inaccuracy of adjustment. However this gross method, crude and expensive, did not suit our mentality so fond of accuracy and precision; furthermore it was incompatible with the very limited possibilities of our metallurgical manufacture.

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velocity; a meteorological preparation which eliminated perturbations due to the atmospheric conditions of the moment, temperature and barometric pressure, strength and direction of the wind, rain or fog.*

As early as October, 1917, at La Malmaison, although the method was not yet completely worked out, its application on a large scale was tried. The artillery command foresaw that due to the lateness of the season, short days, storms and fog, the airplanes would be able to fly only a limited number of hours. It would not be physically possible, unless the artillery preparations were indefinitely prolonged, to make all the adjustments and uninterruptedly control all the artillery fires. Accordingly it was ordered that fires be prepared in advance with all the care possible, considering the actual state of our knowledge as to ballistics and meteorology and of the available instruments. The few hours of daylight, instead of being employed for those long shot by shot adjustments, each one of which monopolized the flying capacity of an airplane, were to be devoted to simplified fire control consisting, for the airplane, in observing the relative location of the target and the mean point of impact of a few rapid salvos. In this way, each flight of an airplane would allow the control of a number of fires and the returns from aerial observation would be increased in enormous proportions. In order not to hinder these control fires, fire for effect was to be delivered only when the airplanes were unable to fly, that is to say at night or during bad weather or fog. It should not be necessary to control these fires for effect for they should be delivered with data based on the initial control fires, continually corrected in accordance with the conditions of the moment.

This first trial was crowned with complete success. It verified the correctness and fruitfulness of the method. In particular, the execution at night of fires for destruction was a redoubtable innovation: these fires, of a density necessary for destruction, also increased the efficiency of our interdiction fires; they absolutely blocked the enemy from bringing up supplies or reliefs. Although these fires were delivered after only a simple preparation and after a short control without direct observation, nearly all of them were remarkably adjusted, as was verified after the infantry advance.

After some more research and tests and after a few more refinements were made, the French field artillery, at the beginning of 1918, found itself in possession of a scientific method of fire which opened up for it splendid vistas. This method gave the field artillery the power to always fire, at any time, in any terrain, under any circumstances, and so liberated it from the tyranny of topographical and atmospheric conditions. With these methods fire could be opened almost instantly on any point whatsoever, seen or unseen, simply designated by its coördinates on the map. The field artillery was now particularly

* It is only just to note in passing the part played by the A.L.G.P. in originating, developing and perfecting this new method of fire. From the time it arrived at the front in 1915, the 1st Battalion of 19-cm. A.L.V.F. used scientific processes accurately determining the position of its pieces by astronomical methods, and taking into account atmospheric conditions of the moment in the preparation of fire. To the A.L.G.P. are due the first studies relative to the determination of meteorological corrections and to the measurement of ballistic wind. The A.L.G.P. was the first to teach orientation by astronomical methods and the stripping of firing data. It was the first to bring to light the importance of segregating powder lots and of calibrating cannon, and it was the first to rationally study the complex phenomena of tube usury and of the copping of tubes.

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capable of mass action with concentrations. It was relieved from the slowness and from the indiscretion of adjustment and the fertile field of surprise was opened. To sum up, these firing methods increased to an unsuspected degree the tactical suppleness of field artillery. For this reason the methods had unexpectedly favorable influences on events, providing the High Command with entirely new possibilities of maneuver which permitted it to formulate daring plans.

Evolution of Tactical Ideas: Surprise.—While for reasons which we have noted, the French attacks, preceded always by a long artillery preparation, were foreordained not to surprise the enemy, the idea of the capital importance of surprise as a factor for success grew in all minds.

In September, 1917, the Germans executed on the Duna, with Riga as the objective, an important offensive in which they took a jealous care to assure themselves the benefit of surprise, and were successful in so doing. The attack divisions were kept in a region more than 100 kilometers away until the last moment. They were secretly moved to the Duna only the day before the attack. In the artillery preparation, delivered over a 4500 meter front, by 628 cannon and 550 trench mortars, gas was extensively used. The preparation lasted only three hours and was followed by a fearful attack which in a few days advanced the Germans 50 kilometers from their line of departure.

Based on the same principle, the British delivered a surprise attack in November at Cambrai on a front of 15 kilometers. The operation was prepared with the greatest secrecy, thanks to the numerous woods which aided in hiding preparations, but above all thanks to the strict discretion observed by the British Command.* The attack was supported by 1000 cannon and 360 tanks. The field artillery did not open fire until the assault waves were in motion; the tanks were charged with making breeches in the barbed wire and of opening the way for the infantry. The Germans were completely surprised: the two first lines of their position (the Hindenburg position) were taken without difficulty, and, in a few hours, the advance had penetrated at certain points to 8 kilometers in depth. Never on the western front had the complete rupture of the enemy front been so near to accomplishment. Some errors in planning and execution, independent of the principle itself, prevented this brilliant victory from having future results; nevertheless the employment of surprise assured a preliminary rapid and deep success.

Although the Riga offensive was an affair with a demoralized enemy incapable of holding, and who almost everywhere gave way at the first shock; although the Cambrai attack was finally checked, these two attacks made a profound impression in all military circles.

Moreover the extreme importance of surprise had long attracted the attention of the French Command. In numerous orders and bulletins in 1917 the Commander-in-Chief dwelt on the advantages accruing from surprise in the execution of great attacks. But, if the enemy were to be surprised, destructions of everything by the field artillery must be deliberately renounced, and these destructions must be compensated for by depending largely on other means; tanks for making breeches in accessory defenses and then closely accompanying the infantry; the

* The French High Command itself remained in complete ignorance of the British projects until the very eve of their execution.

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massive employment of gas shells for the neutralization of the enemy's fire and to paralyze the movement of his reserves.

We will see how these ideas crystallized from day to day and imparted their characteristics to all the battles of 1918.

MEASURES TAKEN TO CORRECT DEFICIENCIES

Progress of the Field Artillery.—As we have set forth above, the advances made by the field artillery, by the end of 1917, from the two viewpoints of firing technique and of improved matériel, came at the very hour to render possible the employment of surprise and to assure this employment full success.

Technique of fire, on the one hand, lent itself to doing away with indiscrete adjustments; the reënforcing field artillery required for the attack could arrive the night before the attack, go into position under cover of darkness, and after a simple scientific preparation of fire, suddenly open fire at dawn without having previously revealed its presence by a single cannon shot.

On the other hand, we had on January 1, 1918, 782 batteries of heavy field artillery, of which the greater part, assigned to the R.G.A.L. and kept at the disposition of the Commander-in-Chief, could be rapidly moved from one point of the front to another, and enter into action before the enemy had wind of its arrival.

The number of modern rapid-fire matériels was constantly increasing. Their rapidity of fire rendered possible reducing the length of artillery preparations and permitted of a massive neutralization intended to make up for the inadequacy of destructions.

Finally, the production of gas shells, a powerful neutralizing agent, commenced to reach considerable figures* and our mustard gas shell appeared on our front in June, 1918.

Official Documents of a Tactical Nature.—From the viewpoint of tactics, the lessons of 1917 caused a revision of our documents which resulted in the publication of two Regulations: that of *October 31, 1917, on the Offensive Action of Large Units* and that of *December 20, 1917, on Defensive Action*. These two Regulations were only the codification of the methods and processes which had been successfully used during the past year; they furnished, especially, very complete and detailed information on the preparation and use of plans of employment. They have an interest more historical than practical, for the battles of 1918, for which they supposedly contained prescriptions, resembled those of 1917 so little, that the two Regulations never found occasion to be applied.

Artillery Firing Regulations of November 19, 1917, and Related Documents.—The firing methods which crystallized during 1917 were the result not of improvisation but of a long series of tests conducted at the front and by testing boards, and in which the Center of Artillery Studies took an active part. At various times G.H.Q. had issued fragmentary instructions which disseminated essentials. However, in order to disseminate these firing methods rapidly and completely, the

* Monthly production of gas shell:

July, 1917: 300,000 75-mm. shell, 60,000 heavy shell.

October, 1917: 160,000 75-mm. shell, 250,000 heavy shell.

October, 1918: 720,000 75-mm. shell, 230,000 heavy shell.

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Central Field Artillery Board, issued, under War Department authority, a comprehensive document for all field artillery, which contained the results obtained in three years of war experience. This was the *Artillery Firing Regulations of November 19, 1917*, which laid down and set forth in detail the methods of preparation of fire and the methods of stripping adjustments. *The Manual of the Orienting Officer* supplemented these Regulations and set forth practical details as to execution.

Creation of the Inspector General of Field Artillery (I.G.A.). Transformation of the R.G.A.L. into the General Reserve of Field Artillery (R.G.A.) (January 26, 1918).—We have seen that the creation of the R.G.A.L. was received with a certain amount of suspicion; it was feared that this new organization only constituted "a state within a state"; it was feared that the R.G.A.L. would be inclined to fight on its own hook, independent of all subordination to local commands.

This thinly disguised hostility could not escape the commander of the R.G.A.L. who, during his inspections, had many occasions to appreciate his impotence to give orders or even simple advice on the subject of the use of this artillery. This situation he reported to the Commander-in-Chief and gave as his opinion that the commander of the R.G.A.L. should be a general officer who should be the grand master of artillery, whose supreme authority, extending over all field artillery, at least as to technical matters, would necessarily be more willingly accepted and better respected.

Furthermore the advantages accruing to the tractor-drawn heavy field artillery, by reason of its assignment to the R.G.A.L., were so evident that the Commander-in-Chief felt disposed to grant the desires which the commanders of fortress artillery regiments and horse-drawn heavy artillery regiments had often expressed, that their units might also have the advantage of being included in the R.G.A.L. These regiments were directly under G.H.Q. but not united under a single chief responsible for all of them; there had resulted for them a lamentable situation relative to their matériel and to their morale.

For their part, the trench artillery battalions had been put in the infantry divisions. The trench artillery was thus disseminated into a veritable dust of isolated units, leading to a defective employment of the arm which, while very costly in officers and men, was also the cause of constant and rapid lowering of its tactical efficiency.

It seemed logical to organize all these extra-organic artilleries in one single grouping.

From these facts and ideas was born the new organization authorized by the *Regulations of January 26, 1918*.

To the old R.G.A.L. were added:

The horse-drawn heavy artillery regiments. These were assigned to the 2nd Division;

The fortress artillery regiments and the trench artillery battalions* which formed a new division, the 4th.

The whole took the name of the *General Reserve of Field Artillery (R.G.A.)*.

An *Inspector General of Field Artillery (I.G.A.)*, under the direct

* With the exception, however, of one battery per army corps, which was assigned, not to a division artillery but to the army corps artillery.

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authority of the Commander-in-Chief, was created, replacing the Director of Field Artillery instruction, and with much more extensive duties, as follows:

1. Direction and technical supervision of field artillery training in the armies;
2. Direct command of the R.G.A.

This organization was headed by a Major General with the rank of Army Corps Commander, who was provided with a staff and two general officer assistants. General Herr became I.G.A.

The I.G.A. was charged:

1. With the conduct of studies relative to the technical and tactical employment of field artillery; for this he had a special organization, the *Central Field Artillery Board*, of which he was president and which was stationed in Paris;
2. With the dissemination to all echelons of the information necessary for the proper employment of the arm and, to this end, with the direction of the *Center of Artillery Studies*;
3. With the inspection of the technical instruction of the field artillery and of the services which assisted in the execution of fire.*
4. With inspections, as ordered by the Commander-in-Chief, of the tactical employment of the field artillery in the armies.

He was authorized to deal with the different services and bureaus of the War Department, the Armament Department and the Navy Department, on all field artillery questions requiring relations between the Commander-in-Chief and the Zone of the Interior.

The R.G.A. included all field artillery units which were not included in the organization of large units. It consisted of 4 divisions each commanded by a general officer or colonel:

1st Division: the A.L.G.P.

2nd Division: tractor-drawn and horse-drawn heavy artillery.

3rd Division: the naval units.

4th Division: trench artillery and fortress artillery.

The representatives of the R.G.A.L. in the groups of armies, and in armies, were retained and the representation of the R.G.A. was made positive by the incorporation of the old special R.G.A.L. staffs within the army artillery staffs and the staffs of groups of armies. These officers were charged with all studies and reconnaissances relative to the entry into action of R.G.A. matériels.

It is unquestionable that the creation of the I.G.A. was an extremely fortunate measure with particularly good results. Thanks to the I.G.A. the High Command was henceforth kept in touch with all improvements which should be made in the field artillery either in the domain of tactics or that of technique. Thanks to the beneficent influence of the I.G.A. the technique of the arm constantly improved; firing instruction received a vigorous impulsion in which *unity of method* and the *employment of scientific methods* were emphasized; development of matériel was pushed with the idea of obtaining *increase in range and in power* (especially for the 75-mm. gun) and *increased mobility* (use of track-laying tractors, use of light tractors in portée artillery, adoption of self-propelled mounts, etc.). Tactics kept in step with the improvements in matériel and perfected methods of firing; it was adapted with perfect suppleness to the necessities of the moment.

* Flash ranging, sound ranging, etc.—EDITOR'S NOTE.

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In the defensive, *echelonment in depth* was to be sought. In the offensive, *surprise* was to be obtained by reducing the length of, and even eliminating, artillery preparations, and *power* was to be obtained by the habitual use of concentrations and the adroit handling of the trajectory; *exploitation in depth* was to be accomplished through the mobility of units and by the flexibility of their movements.

It may be said that the creation of the I.G.A. marks the beginning of an era of rapid progress and uninterrupted success for the artillery, an era which ended in the decisive defeat of the enemy. The I.G.A. proved to be a valuable asset in the successful prosecution of the war.

Reorganization of the Horse-drawn Heavy Artillery.—We have seen that the regiments of horse-drawn heavy artillery raised in accordance with the program of August 5, 1915, were comprised of three groupings:

The first two, each of which was intended to constitute the heavy artillery of an army corps, were originally intended to be of identical composition, each with 3 batteries of 105-mm. and 2 batteries of 120-mm. guns;

The third, which was intended to be assigned to the heavy artillery of an army, was to consist of 10 batteries; 2 battalions of 2 batteries each, of 155-mm. guns, and 2 battalions of 3 batteries each of 155-mm. howitzers.

The program of May 30, 1916, had slightly modified this composition, but the impossibility of completing the program in time led to the following temporary dispositions:

On July 12, 1917, the High Command directed that all divisions be progressively provided with 1 battalion of 155-mm. howitzers instead of the two specified in the program of May 30;

On December 28, 1917, the High Command reorganized organic heavy field artillery on the following basis:

The first and second groupings to constitute the army corps heavy field artillery regiments, these to have the same numerical designation as their corps increased by 100; each one of these regiments to consist of: two battalions of 105-mm. guns (or provisionally to retain the 120-mm.) and one battalion (eventually two) of 155-mm. guns. The division howitzer battalions were included in these regiments for purposes of organizational numbering.

The third groupings to be comprised, theoretically, of six battalions; two of 155-mm. guns and four of 155-mm. howitzers.

When the R.G.A. was created, these third groupings were separated from the regiments of the 100 series. They were used to constitute 30 new regiments which were numbered in the 300 series (their old regimental number increased by 200).

It was these regiments of the 300 series which made up the new 2nd division of the R.G.A. Each one was to consist, theoretically, of three battalions, one of 155-mm. guns, two of 155-mm. howitzers. However this composition was never completely realized, for it necessitated the creation out of whole cloth of thirty additional battalions and the country, at the end of its rope, could not furnish the required men and horses.

Creation of the Portée Artillery.—The French Army had entered the war with the corps artilleries each consisting of one horse-drawn 75-mm. gun regiment of four battalions of three batteries.

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Beginning with the winter of 1914–1915 the necessity of giving a provisional artillery to all the new divisions which were being raised, required taking the necessary batteries from the corps artillery regiments which were gradually reduced to two battalions of three batteries each.

This organization lasted until August, 1917. In the meantime the need for light field artillery incessantly increased: it was necessary for attack divisions whose offensive barrages were becoming more and more dense; it was necessary so as to be able to rapidly reënforce fronts attacked by the enemy; it was necessary so as to be in a position to temporarily give supplementary means to divisions required to occupy very extensive sectors on inactive fronts; finally it was necessary to assure the resting, in turn, of 75-mm. batteries.

But it was not practicable to secure the necessary batteries from the division artillery; on the contrary it seemed logical that the corps light field artilleries should play, throughout the army, the reënforcing role which already normally pertained to them within the army corps.

A memorandum from the Commander-in-Chief dated August 8, 1917, prescribed that the corps artilleries should always be considered as subject to being taken away in order to meet temporary requirements on certain parts of the front. In fact from this time on corps artilleries were very rarely left permanently at the disposition of their army corps.

However the supply of horses was diminishing and recourse to mechanical traction to replace them was naturally considered. This replacement quite logically commenced with the corps artilleries. In fact by giving these units automotive transport their strategical mobility certainly was increased and the rapid and extensive displacements required in their new use as reënforcing artillery were facilitated.

In addition the occasion was profited by to bring these regiments up to three battalions in order to make them similar to the division regiments. In the early stages of the transformation, pending the time when the number of trucks would be adequate to complete the equipment, the regiments were equipped with only enough trucks to carry one battalion. Each regiment could thus accomplish displacements of small extent with its own means, the three battalions being moved in succession. In case of a displacement by road over great distances, two of the groups were transported by elements from the motor transport service.

This motorization of the corps light field artilleries, caused at first by the shortage of horses and forage, soon proved to be an extremely fruitful measure whose good consequences were incalculable. The portée artillery, born of an expedient, soon rendered such services that attention was focused on it, and it received important modifications which made of it a remarkable strategical instrument.

THE EXACT DIFFERENTIAL EQUATIONS OF A TRAJECTORY IN TERMS OF THE HOAR CURVILINEAR COÖRDINATES

BY FIRST LIEUTENANT WILLIAM E. ROTH, 120TH F.A., W.N.G.

[The author is studying for a doctor's degree in theoretical mathematics at the University of Wisconsin. This paper is the outcome of his work as a member of the Marquette Ballistics Research Group, whose meetings were conducted by Major R. S. Hoar, Ord. Res., and J. J. Amand, formerly Master Computer in the Ordnance Department. Major Hoar during the emergency was on duty as a member of the Ballistics Section, Ordnance Department, and is the author of the Ordnance Textbook "A Course in Exterior Ballistics." This treatise is endorsed by Major Hoar and it is believed to contain material not before treated.—EDITOR.]

THE usual differential equations of motion of a projectile are approximations referred to Cartesian coördinates in which one variable is measured in the direction of fire along a line tangent to the earth at the gun and the other vertically from this line. Gravity is considered as acting perpendicularly to the horizontal axis at every point, which really is the case only at the gun. The point of fall in such a coördinate system is below the horizontal axis; the amount, depending on the range, is corrected by continuing the trajectory beyond the point where it crosses the axis to a point where it should reach the curved surface of the earth. The change of gravitational attraction with altitude is also disregarded in some theses on exterior ballistics. The errors introduced by such approximations may, in most cases, be less than a probable error as obtained by actual firings; but this does not justify inaccuracies in the mathematical exposition of the theory. Furthermore, future developments in long range and in high angle firing may render the old methods of trajectory computation obsolete because the desired precision cannot be obtained by them. The Hoar¹ system of coördinates, which will be employed in the present paper, makes the derivation of the exact differential equations of motion of a projectile possible, and moreover, the results so obtained may be expressed in a form that is easily applied to trajectory computations. From the mathematical standpoint the work is exact for a stationary earth and for a projectile in which the effects of axial rotation are disregarded; in practice it has the added inaccuracy that is introduced by assuming a specific air resistance law.

To begin with, we assume a rectangular coördinate system with its origin, O , at the center of the earth, with its Y -axis through the muzzle of the gun, G , and with the X -axis at right angles with

¹ Hoar, "A Course in Exterior Ballistics," Ordnance Textbook, 1051, page 35.

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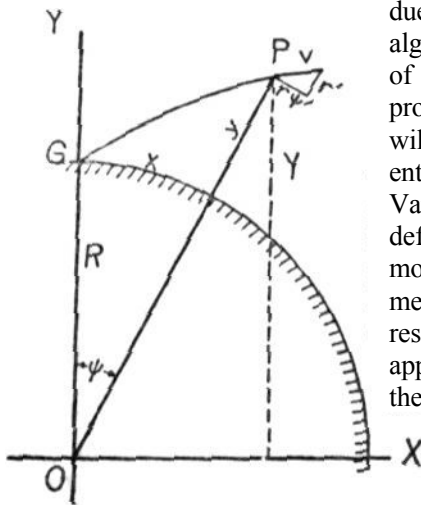
OG and positive in the direction of fire. The projectile, P , is at distance r from O . The angle GOP is indicated by Ψ . Then

$$\begin{aligned} X &= r \sin \Psi, \\ Y &= r \cos \Psi, \end{aligned} \tag{1}$$

The differential equations of motion of a projectile under the central force of gravitation, $g(r)$, are²:

$$\begin{aligned} X'' &= -gX/r = -g \sin \Psi, \\ Y'' &= -gY/r = -g \cos \Psi, \end{aligned} \tag{2}$$

where g is written for $g(r)$ and the accented variables indicate the time derivatives. However, in a resisting medium the components of acceleration



due to the resistance of the air must be algebraically added to the right members of equations (2). The acceleration of the projectile due to the resistance of the air will be given by $-Ev$, where E may be left entirely general for our present purpose. Various expressions for E have been defined; that due to Moulton³ is now the most commonly used and with modern means for observing the effects of air resistance better ones will undoubtedly appear. The components of acceleration in the X - and in the Y -directions due to atmospheric conditions and to the characteristics of the projectile are then $-EX'$ and $-EY'$, respectively;

consequently we may write for our purpose

$$\begin{aligned} X''' &= -EX' - g \sin \Psi, \\ Y''' &= -EY' - g \cos \Psi \end{aligned} \tag{3}$$

as the exact differential equations in place of the equations (2).

Differentiate equations (1) with respect to time, t ; then

$$X' = r' \sin \Psi + r \Psi' \cos \Psi, \tag{4}$$

$$Y' = r' \cos \Psi - r \Psi' \sin \Psi \tag{5}$$

Multiply (4) through by $\cos \Psi$ and (5) by $\sin \Psi$ and subtract the resulting equations; likewise multiply by $\sin \Psi$ and $\cos \Psi$, respectively, and add. This procedure gives the two equations:

$$X' \cos \Psi - Y' \sin \Psi = r \Psi'', \tag{6}$$

$$X' \sin \Psi + Y' \cos \Psi = r'. \tag{7}$$

² Moulton, "An Introduction to Celestial Mechanics," page 72.

³ Moulton, "New Methods in Exterior Ballistics," Univ. of Chicago Press, 1926.

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Differentiate these equations once more with respect to t ; then:

$$X'' \cos \Psi - X' \Psi' \sin \Psi - Y' \Psi'' \cos \Psi - Y'' \sin \Psi = r \Psi''' + r' \Psi'', \quad (8)$$

$$X'' \sin \Psi + X' \Psi'' \cos \Psi - Y' \Psi'' \sin \Psi + Y'' \cos \Psi = r'', \quad (9)$$

and because of (6) and (7) these become:

$$X'' \cos \Psi - Y'' \sin \Psi = r \Psi''' + 2r' \Psi'', \quad (8)$$

$$X'' \sin \Psi + Y'' \cos \Psi = r'' - r' \Psi'^2. \quad (9)$$

With the aid of the equations derived above we are able to eliminate X and Y and their derivatives from (3). This is most readily accomplished by multiplying the first equation of (3) through by $\cos \Psi$, the second by $\sin \Psi$ and subtracting the results, also multiply by $\sin \Psi$ and $\cos \Psi$, respectively, and add. In this way, we obtain:

$$X'' \cos \Psi - Y'' \sin \Psi = -E (X' \cos \Psi - Y' \sin \Psi),$$

$$X'' \sin \Psi + Y'' \cos \Psi = -E (X' \sin \Psi + Y' \cos \Psi) - g,$$

which because of (6), (7), (8) and (9) become:

$$r \Psi''' + 2r' \Psi'' = -Er \Psi'', \quad (10)$$

$$r'' - r \Psi'^2 = -Er' - g. \quad (11)$$

The latter equations are now in a form that can readily be transformed to new ones whose variables are those defined by Hoar.⁴ That is

$$\Psi = x/R \text{ and } r = R + y, \quad (12)$$

where x is measured along the spherical surface of the earth in the direction of fire, where y is measured vertically from the curved x -axis upward on radial lines through the center of the earth, and where R is the radius of the earth. From (12), we obtain at once:

$$\begin{aligned} \Psi' &= x'/R, & r' &= y'; \\ \Psi'' &= x''/R, & r'' &= y''; \end{aligned}$$

and consequently (10) and (11) become:

$$(R + y) \frac{x''}{R} + \frac{2x' y'}{R} = -Ex' \frac{(R + y)}{R}, \quad (13)$$

$$y'' - (R + y) \frac{x'^2}{R^2} = -Ey' - g. \quad (14)$$

The expression E is not effected by any of the transformations above, consequently it may be regarded as expressed in the present coördinate system without introducing any approximations. Likewise the gravity function, g , is readily given in these coördinates; that is,

$$g = g_0 \left(\frac{R}{R + y} \right)^2,$$

⁴ Hoar, *op. cit.*

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where g_0 is the magnitude at the surface of the earth and the direction is toward the center of the earth. Equations (13) and (14) may now be written to give the second derivatives of x and y thus:

$$x'' = -Ex' - \frac{2x'y'}{R+y}, \tag{15}$$

$$y'' = -Ey' + (R+y) \frac{x'^2}{R^2} - g_0 \left(\frac{R}{R+y} \right)^2, \tag{16}$$

as the exact equations⁵ of motion in the Hoar curvilinear coordinate system. Their accuracy is limited only by the accuracy with which the air resistance function is known and by the fact that the earth was taken as a motionless sphere and the effects of the rotation of the projectile itself are not taken into account. Later these equations will be considered further.

It remains now for us to find the expressions for velocity, v , at any point of the trajectory and for θ , the angle that the trajectory at P makes with a great circle through P and in the vertical plane of the trajectory. In the Cartesian coordinates defined at the beginning of this paper:

$$v^2 = X^2 + Y^2.$$

Square both members of (6) and (7) and add the resulting equations; then:

$$X^2 + Y^2 = r'^2 + r'^2 \Psi'^2,$$

and by (12) we have:

$$v^2 = y'^2 + \left(\frac{R}{R+y} \right)^2 x'^2. \tag{17}$$

For the angle θ we have:

$$\tan \theta = \frac{r'}{r\Psi'} = \left(\frac{R+y}{R} \right) \frac{y'}{x'}, \tag{18}$$

This formula may be obtained directly from the figure above, since the horizontal component (with respect to the curved surface of the earth at x) of velocity is $r\Psi'$ and the vertical component is r' ; or it may be obtained analytically as in calculus by regarding r and Ψ as the polar coordinates of the point P .

Equations (15) to (18) inclusive correspond to those ordinarily employed in exterior ballistic computations. It is of interest to note that the second derivative of x with respect to time is independent of g , as was to be expected in the Hoar coordinates. Equation (11) or its equivalent (16) shows that the vertical acceleration is composed of three distinct parts; namely, gravity downward, atmospheric resistance contrary to the direction of y' , and the centrifugal acceleration $(R+y) x'^2/R^2$ acting upward. The writer's

⁵ These equations are given by Hoar expanded in power series, but he was not aware of the exact form here derived. (See Hoar, *op. cit.*, p. 45.)

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attention was directed to this interpretation of the latter by Mr. J. J. Arnaud. These observations regarding acceleration indicate that the present work may quite readily be extended to apply for a rotating earth by merely considering the velocity of its rotation and the resultant acceleration upon the projectile.

We will now direct our attention to the task of putting equations (15) and (16) into forms that lend themselves more readily to numerical integration by a method similar to that given by Jackson.⁶ If equation (15) be multiplied through by $(R + y)^2/R^2$ and the result be written in the form:

$$\left(\frac{R+y}{R}\right)^2 x'' + 2\left(\frac{R+y}{R}\right) \frac{x' y'}{R} = -\left(\frac{R+y}{R}\right)^2 x',$$

we see at once that the left member is an exact derivative of $(R + y)^2 x'/R^2$ with respect to t , and if we let

$$Q' = \left(\frac{R+y}{R}\right)^2 x'; \tag{19}$$

then we have

$$Q'' = -EQ',$$

where Q'' is the derivative of Q' with respect to t . Hence

$$Q''/Q' = -E, \tag{20}$$

which when multiplied through by dt results in an equation whose left member is the differential of $\log_e Q'$. Consequently

$$\log_e \frac{Q'}{Q'_0} = - \int_{t_0}^t E dt, \tag{21}$$

where $Q' = Q'_0$ when $t = t_0$. By (19)

$$x' = \left(\frac{R+y}{R}\right)^2 Q', \tag{22}$$

and if this expression for x' and that for E resulting from (20) be substituted in (16), there results the equation:

$$\frac{Q' y'' - Q'' y'}{Q'} = \frac{R^2 Q'^2}{(R + y)^3} - g,$$

where g is the gravitational attraction at the projectile and is given by $g_0 R^2 / (R + y)^2$. Upon dividing this equality through by Q' the left member becomes the exact derivative of y'/Q' with respect to t ; that is

$$\frac{d}{dt} \left(\frac{y'}{Q'}\right) = \frac{R^2 Q'}{(R + y)^3} - \frac{g}{Q'}.$$

In the resulting equation obtained upon multiplying that here given through by $2y'/Q'$, the left member is again an exact derivative

⁶ Jackson, "The Method of Numerical Integration in Exterior Ballistics," Ordnance Textbook 984, 1919.

with respect to t and so likewise is the first term of the right member; consequently we have

$$\frac{d}{dt} \left(\frac{y'}{Q'} \right)^2 = -\frac{d}{dt} \left(\frac{R}{R+y} \right)^2 - \frac{2gy'}{Q'^2},$$

or

$$\frac{d}{dt} \left[\frac{y'^2}{Q'^2} + \frac{R^2}{(R+y)^2} \right] = -\frac{2gy'}{Q'^2}.$$

But according to equations (17) and (22)

$$v^2 = y'^2 + \left(\frac{R}{R+y} \right)^2 Q'^2, \tag{24}$$

therefore (23) becomes:

$$\frac{d}{dt} \left(\frac{v^2}{Q'^2} \right) = -\frac{2gy'}{Q'^2}.$$

To reduce the latter to a more convenient form for use with (21), we need merely divide both its members by v^2/Q'^2 ; this makes the left member the time derivative of $\log_e (v^2/Q'^2)$ and we have

$$d(\log_e v^2) + d \left(\log_{\frac{v^2}{Q'^2}} \frac{1}{Q'^2} \right) = -\frac{2gy'}{v^2} dt,$$

or evidently

$$d(\log_e v) - d(\log_e Q') = -\frac{gy'}{v^2} dt.$$

Upon integration from t_0 to t with the differentials as given above, we obtain

$$\text{Log}_e (v/v_0) - \log_e (Q'/Q'_0) = - \int_{t_0}^t \frac{gy'}{v^2} dt, \tag{25}$$

where $v = v_0$, when $t = t_0$.

The Napierian base, e , is not the most convenient to use in numerical work. To change equations (21) and (25) so that common logarithms may be used, it is merely necessary to multiply both of them through by M , the modulus of base 10 ($M = 0.43429$); accordingly the equations for trajectory computations are

$$\log (Q'/Q'_0) = -M \int_{t_0}^t E dt \tag{26}$$

$$\log (v/v_0) = \log (Q'/Q'_0) - Mg_0 \int_{t_0}^t \frac{y'}{A^2 v^2} dt, \tag{27}$$

$$y^2 = v^2 - Q'^2/A^2, \tag{28}$$

$$x' = Q'/A^2 \tag{29}$$

$$\tan \theta = y'/Ax' \tag{30}$$

$$A = (R + y)/R, \tag{31}$$

where g in (25) was replaced by its equivalent $g_0 R^2/(R + y)^2$ or g_0/A^2 to give the form in (27), and where the logarithms without the base index are to the base 10.

EXACT DIFFERENTIAL EQUATIONS OF A TRAJECTORY

When an expression for E is assumed and the variables and their first derivatives with respect to t are known for time t_0 , the equations (26) and (27) serve to determine Q'_1 and v_1 for time t_1 . Suppose by extrapolation with the known values of the variables at time t_0 for their mean values in the interval $t_1 - t_0$, we obtain Q'_μ, v'_μ, y'_μ , etc.; these when substituted in (26) and (27) determine the change in $\log Q'$ and $\log v$ for the interval $t_1 - t_0$, and since

$$\log Q'_1 = \log Q'_0 + \log (Q'_1/Q'_0)$$

and similarly for $\log v_1$, we are able to determine Q'_1 and v_1 for time t_1 ; then with these we are enabled to determine y'_1, y_1, x'_1 , and x_1 for the same time t_1 by means of equations (28) and (29). If the value v_1 , for example, and v_0 are such that by interpolation (using successive differences) a value v_r is obtained which differs so little from the value v_μ that its use, together with the similarly determined variables Q'_r, y'_r , etc., will give the same value for v_1 that was already determined (and also for Q'_1), then we are ready to enter a new interval $t_2 - t_1$; if not, then Q'_1 and v_1 must be redetermined, now using Q'_r, v_r, y'_r , etc., instead of Q'_μ, v_μ, y'_μ , etc., in the integrands of equations (26) and (27). This process is repeated until the desired accuracy is obtained before entering the next interval.

It has been found in actual calculation that the second differences of the computed values of $\log (Q'/Q'_0)$ and of $\log (v/v_0)$ are small and very regular, and that the trajectory may be computed to five places logarithmically where only four places are used in computing the logarithmic increments just mentioned. $\log Q'$ and $\log v$, instead of the variables themselves, are entered on the trajectory sheet; $\log (Q'/Q'_0)$ and $\log (v/v_0)$ are then also entered on this sheet as the respective first differences of the former. Because the altitude factor A enters into all exact computations, a table for $\log A^2$ may be prepared; for four-place work, a turn-point table is preferable. The expansion of $\log A^2$ to be used in the preparation of the table in any case is obtained as follows:

$$\begin{aligned} \text{Log}_e A &= \log_e (1 + y/R), \\ &= y/R - y^2/2R^2 + y^3/3R^3 - \dots; \end{aligned}$$

then in common logarithms

$$\log A^2 = 2M (y/R - y^2/2R^2 + y^3/3R^3 - \dots),$$

which reduces to

$$\log A^2 = 2My/R$$

for any altitude less than 21,000 meters in five-place computations, for greater altitudes the second order term of the expansion must also be kept. On the other hand, in four-place work A^2 is

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effective in the results obtained for a trajectory whose maximum ordinate is 300 meters or more.

It may be of interest to note in closing that the equations derived above hold in the tangent-plane coördinates provided that a slight transformation is made in our system. This is easily accomplished by letting R become indefinitely large, A then approaches unity, the curvilinear coördinates approach those employed by Moulton,⁷ Bliss,⁸ Jackson,⁹ and others as a limiting case, and the differential equations (15) and (16) become those commonly found in the literature on exterior ballistics. An equation corresponding to (27) seems never to have been derived for the tangent-plane coördinates even though it may be gotten directly from the differential equations of a trajectory in such a system.

⁷ Moulton, *op. cit.*, see footnote 3.

⁸ Bliss, "A Method of Computing Differential Corrections for a Trajectory," *Journal of the U. S. Artillery*, Vol. 51, 1919.

⁹ Jackson, *op. cit.*

THE RIGHT WORD

BY MARTIN GALE

"PULL up a chair, Casey," said the Colonel. "I have something to go over with you."

The Adjutant slid a chair close to the Colonel's desk and sat down. "Yes, Sir," he answered.

"It's this spy business. I've had another letter from Washington about it. They can't locate him."

"Do they send any particulars?"

"Yes," the Colonel tapped the letter with his pencil. "They send a description that might fit any one of a dozen men. Listen to this: 'Hair brown, eyes brown, weight about 150 pounds, height about 5 feet 9.' Why I can think of five men on my staff—including you—that the description fits."

"And these secret service men that they've sent to us, they can't find him?"

"No. I've had this man Plummer on my staff for weeks and a man in every battery and they've accomplished nothing—other than to trace him here. They're stuck. He got in one of the training camps and by some information they captured they traced him here. That's as far as they go. Damn these Germans!"

"We'll have to find him before we go overseas. We can't go to the front with a spy in our ranks."

"True, but how will we pick him out? At best we can leave half-a-dozen officers at home, hoping he's among them."

There was a gentle tapping at the door and at the Colonel's response an orderly stuck his head inside. "Lieutenant Plummer to see the Adjutant," he announced.

"Here's Plummer now," said the Colonel. "Send him in here, orderly, I want to see him." And as Plummer walked in and saluted, "Well, what luck? Have you anything to report?"

"Not much, Colonel. We've traced the spy to your staff but we can't pick him out."

"My staff! Why there are four men there that the description I got from Washington might fit. Casey, I leave you out. I've known you all your life and your father before you——"

Plummer smiled. "We've already investigated Captain Casey."

"But the four others, Riley, Maxon, Dies, and Clust—which of them is the spy? When we go overseas we'll have to leave them at home and that at least breaks up my staff. Have you investigated these men, Plummer?"

"Yes, we've looked into them all. They all came in through

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training camp and their credentials seem perfect, but then you know how clever the Germans are about planting spies. The best we can do is to keep them all at home and under observation. But that doesn't catch our spy. We've learned that he was in the German Army, that's as far as we can go."

"He was in the German Army? repeated Casey musingly. "Perhaps——
——"

But Plummer interrupted. "Yes, he was a Noncom in the Prussian Guard. We've tried to pick him out by his carriage but all four of them carry themselves well, and anyway the spy would avoid showing it. Now Colonel I'll go out and try once again. If we can't get anything further I'll recommend to-morrow that the four officers be left at home in a replacement battalion." He saluted the Colonel and walked out.

When they were left alone Casey hitched his chair closer to the Colonel. "Sir," he said, "I've a scheme that may work to uncover the spy. May I try it?"

"What is it?" asked the other.

"If you don't mind I'd rather not tell until I've tried it. If it fails it won't hurt anyone—it can be passed off as a joke—and if it succeeds we get our spy."

"Very well, I'll not ask any more about it? When are you going to try your scheme?"

"To-night in the Mess hall before staff school. If you can get the four of them together I can work it. They all sing, if you would ask them to sing a song I'll try it."

"Very well, but remember that I want no innocent man hurt."

"None will be," reassured the Adjutant as he rose to leave the office.

At the Mess that night as the Colonel looked over his officers assembled at the staff table he tried hard to find an indication which might show him the guilty man. Maxon and Casey were discussing the work of the day; Dies, Riley, and Clust who sat together were planning a forthcoming week-end trip to the nearby city. All seemed carefree, nor was there any evidence of guilt that he could determine.

"Colonel," said Clust breaking from his conversation, "I had it from a reliable source that we're going overseas within three weeks." All conversation ceased as the officers craned forward to better hear.

"Where did you get your information?" queried Casey.

"Why a fellow in the Department told a friend of mine." But the table roared with laughter as the Colonel rose and led the way out.

In the ante-room someone had left an old and battered piano

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which nightly did Trojan service in the hour between Mess and the regimental schools. The Colonel glancing back as the officers poured out behind him remembered Casey's request. "Maxon, Riley, Dies, Clust," he called. "Lead us in the Artillery song. Riley, you play it."

The four grouped about the piano started that swinging song that tells how:

"Over hill, over dale as we hit the dusty trail,
"And the caissons go rolling along."

Behind them full fifty officers scattered through the room rolled out the chorus. Even Plummer, not a soldier, joined in lustily.

Casey did not wait on the opportunity. Unperceived by the four singers he strolled to a position just behind them. As the last chords died away he straightened up and in stertorian tones bellowed "ACHTUNG."

Three of the singers swung around in amazement. On the fourth the effect was electrical. His heels clicked, his hands fell to his sides as Dies snapped to attention.

"There's your man, Plummer," said Casey.

ARTILLERY WHEELS

THEIR DEVELOPMENT AND CHARACTERISTICS

BY LIEUTENANT HAROLD C. RAYMOND, F.A.

THE year 1631 marks the turning point in the strategical and the technical history of light artillery. At that time Gustavus Adolphus equipped his artillery with wheels, and with less than 50 guns swept over most of northern Europe, drove his opponents into their fortified towns, where he besieged and captured them. This precedent changed the entire procedure of warfare, since prior to this time, owing to its lack of mobility, artillery matériel was not adapted for field work, and was used almost exclusively for siege purposes. When commanders found it necessary to transport their guns from one position to another, clumsy and cumbersome wagons were used. By the 18th century wheeled mounts were so mobile that they could accompany troops in the field, maneuver ahead of them, and break up formations of the enemy before his infantry attack could be developed.

During the past three hundred years there has been a gradual and consistent improvement in the artillery wheel. The original solid wood disk type and those made by joining separate planks and then cutting them into circular shape, have given way to the modern steel-tired, wooden wheels, as well as to the all-metal steel disk rubber-tired type that came into use during the World War.

The wheels now used on light artillery vehicles are a modified form of the Archibald pattern. They were first used on a gun carriage in 1881. Prior to that time the wheels had wooden hubs, spokes and felloes. The distinct features of the Archibald wheel are the hub construction, which consists of an inner flange integral with the hub box, an outer flange fitting around the cylindrical portion of the hub box and secured to the inner flange by bolts passing through the spokes, and the triangular metal dowels used at the joints of the felloes. The wheel, as originally constructed, had a diameter of 57 inches and was 3 inches wide. At first only 12 spokes were used, but later this number was found to be insufficient and four more were added. The felloes were made up of 7 sawed sections, and the total weight was 180 pounds, as compared with the present steel-tired wheel which weighs 209 pounds.

As the mobile guns of Gustavus Adolphus revolutionized the tactical use of artillery, so did the Archibald wheel increase the flexibility of our early modern matériel. This wheel was ideally suited for military purposes. It was sturdy, and had a greater resiliency

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than any other wheel that had been developed up to that time. Every joint in spokes and felloes was put together under a pressure twenty-five times greater than any weight it was expected to bear, which meant that it was practically impossible to crush it by overloading. This feature also eliminated movement of the spokes in the hub, and on account of the dowels used, the spokes could be replaced easier than in other wheels, a particularly valuable asset for field service.

From 1889 until 1902 various tests and experiments were conducted to secure a lighter and smaller wheel. Radical cuts were made in all elements of the wheel. The outside diameter was reduced to 48 inches. The diameter and thickness of the hub flanges were decreased and the number of spokes reduced from 16 to 14, the result being a decrease of 45.5 pounds, and a wheel that weighed 142.5 pounds. The objective, a reduction in weight had been attained, but numerous tests proved the wheel totally unfit for field service, as it was too small, too light, and the decrease in diameter resulted in increased tractive force, and consequent horse fatigue. In July, 1902, the wheels were again changed to a diameter of 56 inches, and two years later the spokes were increased to 16, while the tire thickness was again brought back to .5 inch, its present dimension.

Few changes were made during the period 1904–1916. However, the latter year stands out as a prominent one in the development of the artillery wheel. Bent felloes were used for the first time, and the tire steel was changed from 35,000 pounds per square inch to high carbon, having 50,000 pounds square inch elastic limit. Tests were ordered of 36 wheels which were made up especially for artillery purposes. Twelve had high carbon steel tires and grease cup lubrication; twelve had high carbon steel tires, grease cup lubrication, felloes reduced to 2.375 inches thick, and were equipped with the spoke shoe; and twelve were the same as the last twelve, excepting that they had a dish of .875 inch per foot of diameter, instead of .25 as has the standard wheel. The wheel having the large dish, carbon steel tire, bent felloes and spoke shoes gave the most satisfactory service, although the period over which the tests were conducted was not of a sufficient duration to make them as complete as it had been desired.

The greatest improvement in recent years to the present artillery wheel is the addition of the spoke shoe and the dish of the wheel. Prior to the adoption of the spoke shoe a great deal of trouble was experienced with wear and breakage of the tenons of the spokes in the felloes, and the crushing of the wood of the felloe by the shoulder of the spoke. The spoke shoe provides increased bearing between the spoke ends and eliminates practically all wear at this

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point. Also the felloe is strengthened due to the fact that the hole for the spoke tenon is not required. In order to make the wheels stronger and give them greater resistance to road shock and side thrust they are dished by setting the spokes at a slight angle with the axle, which results in the plane of the rim being outside the planes of the hub. The dish thus given to the wheels enables the vehicle to be used at more rapid gaits than otherwise, and also prevents crushing of the wheel in making sharp turns and rapid speed.

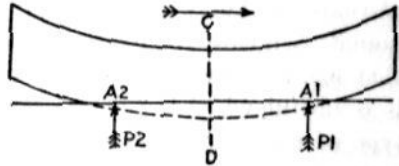
A comparison of the height of light artillery wheels used in our own and foreign services shows that the great majority of wheels do not exceed five feet. This height is determined by the width of the track, weight of the wheel, tractive force, and the rapidity with which the carriages are to move. Too small a wheel causes increased traction and resistance, and loss of strength, while one higher than five feet is impracticable due to the constant danger of capsizing the carriage, as well as the extra weight involved. The result is a wheel in the neighborhood of five feet, or as is the case of our own wheels, an outside diameter of approximately 56 inches.

Lubrication is essentially the most important element in connection with the upkeep and care of the light artillery wheel. The method of lubrication on the present wheel is accomplished by providing an oil reservoir in the axle which is filled through an oil valve in the hub cap. This filling can be accomplished without removing the wheel, which is especially valuable where long hauls are concerned. The oil from this reservoir gradually seeps out around the end of the axle and back in the bearing surface; dust is excluded from the bearing by the use of a leather and sheep skin dust guard strapped to the axle at the inner edge of the hub box. Wooden wheels are light, tough, strong, and easy to keep clean, although they do develop loose spokes. This may be remedied by soaking in water and by frequent washing. An occasional soaking in turpentine and linseed oil will do much to preserve the toughness of the split second growth hickory usually used. The wheel should also be kept well painted at all times.

For a great many years artillery carriages traveled on steel-tired wheels over the most varied terrain and roads. However, during the World War, due to the difficulty in obtaining satisfactory wood stock, the motorization of various types of matériel, and the event of the tractor, it was necessary to develop all-metal rubber-tired wheels. In addition to these, wooden wheels were also equipped with solid rubber tires. Many tests have been conducted to determine the advantages of the different wheels for the various calibers of matériel, and there seems to be at this time a general consensus of opinion that where the carriages are hauled by tractors or trucks, the use of rubber-tired wheels is essential. Solid rubber tires are

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objectional on the following grounds: first, initial expense; second, cost of upkeep, including consumption of valuable time and labor; and third, the increased weight of the wheels, which is quite serious, particularly in the case of the smaller calibers, where on account of being handled by hand, the weight element is most important. A comparison of the rolling resistance of the various types of wheels shows that of the steel tire to be the least, while that of the solid rubber tire is greatest. This is brought out quite clearly in the following diagram and explanation, which shows the resistance encountered by a tire: P1 and P2 are the intensities of the pressure at A1 and A2, at equal distances in front of and behind C. The geometrical point of contact; P1 opposes, P2 assists the rolling of the wheel. At usual speeds the opposing force P1 will be greater than the force of restitution, P2; the difference being a measure of elastic hysteresis of the material H at that speed. If the vertical compression CD of the tire be denoted by Y, the energy lost may be said to be



proportional to HY . Then comparing three tires of solid rubber, steel, and air respectively, rolling on a smooth hard surface, H is smallest for steel, and largest for rubber. Y is least for steel, greater for a pneumatic tire pumped hard, still greater for solid rubber, and for a pneumatic tire insufficiently inflated. The rolling resistance of the steel tire will, therefore, be least, next in order come the pneumatic tire inflated hard, and the pneumatic tire inflated soft, while the solid rubber tire has the greatest resistance. With this thought in mind and considering the various other disadvantages of the solid rubber tire, it is apparent that there is still room for further development of the artillery wheel.

It is improbable that it will ever be possible to move artillery, particularly of the heavier types at speeds greater than 15 miles per hour, and in fact it will be only under the most exceptional circumstances that it will be possible to move at that speed. This is due to congestion of the roads, which is unavoidable if large masses of troops or equipment are moving in the same areas, and to the increased road shock and resultant wear on the carriages. If the carriages are to be drawn by trucks and tractors at a speed greater than 8 miles per hour the present steel-tired wheel falls down, and lacking a better substitute a solid rubber-tired wheel is used. To meet this condition and provide a wheel for high speed trucks, the 56-inch wheel was cut to 52 inches, outside diameter, and equipped with a 3.5 solid rubber tire, making the outside diameter 57 inches. This wheel weighs 368 pounds, which is excessively heavy, and is known as the 57 by 3½-inch rubber-tired wheel. It is standard

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equipment for the 75-mm. gun carriages, Model of 1916, motorized. The hubs of these wheels and the general construction are identical with that of the standard 56-inch wheel. For the split-trail carriages, a wheel of this same construction, but 48 inches in diameter, and a 4-inch rubber tire is being used. It weighs 296 pounds; and even at that weight which is approximately 90 pounds more than the weight of the present wooden steel-tired wheel, will probably not stand hard field service. For the box-trail carriages, the wheel was reduced in weight by equipping it with a 3½-inch rubber tire, decreasing the thickness of the steel tire and felloe band, reducing the thickness of the felloe to 1.5 inches, and cutting down the spoke sections, thickness and diameter of the hub flanges. It weighs 233 pounds, which is the nearest approach to our present standard wheel that has been developed. As in the case of the split-trail wheel, it is doubtful whether the 233-pound wheel will stand up. Another type of wheel which was an outgrowth of the demands made upon motor transportation during the World War is the disk wheel. This wheel proved quite satisfactory for trucks, and passenger car use, but on account of its weight is not suitable for artillery purposes, although it may be possible to use wheels of this type, providing a light alloy possessing strength and the necessary resiliency is used with the steel.

The constant demands for increased artillery mobility, lack of suitable wood capable of standing a steady load and sudden road shocks, all point to the adoption of a metal or spring wheel. This problem has been solved in the case of wheels for corps and army artillery, but no satisfactory solution for the light wheels has been found. A new type called the resilient wheel, which depends for its action on the use of springs has been experimented with, but to date none of the wheels tested have had the shock-absorbing qualities of the wooden wheel, although it is believed such a wheel can be developed. Failing this then it would seem that it would be necessary to use a spring-supported mount, which would probably render unnecessary the use of rubber tires, with their many objections. In this case, however, matériel would undoubtedly be very noisy while on the road.

USE OF POLARIS FOR NIGHT FIRING

BY LIEUTENANT OTTO ELLIS, F.A.

ACCURACY and exactness being the first and foremost requisite of any method of calculation which may be employed for the delivery of fire on an objective, the steps or methods by which the initial data are obtained must have the least possible degree of error. The error which is in the final result will be an accumulation of many errors and may be exorbitant. The most important part of the initial data is the deflection or direction in which the gun is laid. The original deflection can be obtained in three ways: first, the quickest and best, by the aiming point method; second, by the compass; third, from true north or Polaris. At night an aiming point cannot be used so the original deflection must either be obtained by the compass or from Polaris. The compass will in general give a direction which is approximately magnetic north. The instrument used in the field artillery for laying on magnetic north is the French Aiming Circle and gives satisfactory results. The main objection to magnetic north is that large and uncertain errors are caused by local attractions, magnetic strains and unknown variation in local declinations and slight errors are caused by sluggishness of the needle and lack of coincidence between geometric axis and magnetic axis of the needle. This error may be as great as 5 mils. This error of 5 mils will be 25 yards at a range of 5000 yards, and greater than the probable error in deflection of any gun. For divisional artillery such as 75-mm., this error may be permissible though not desirable, but for medium and heavy artillery, shooting at ranges up to 20,000 yards, this error cannot be permitted since it would cause the expenditure of an exorbitant amount of ammunition. The time of firing this ammunition would allow the enemy time to withdraw or remove the objective. If this 5-mil error of the compass was constant as to direction, it could be corrected. However, it is neither consistent nor constant. It may be greater than 5 mils (it generally is), or less than 5 mils; and it may be plus or minus, that is, to the right or to the left. For accurate laying in direction of the battery at night the artilleryman has the Polaris Method which is laying from the true north line. True north is a line from any point on the ground to the north axis of the earth. This line is not variable but constant. The deviation of this line and the Y-north line is constant for any map. Thus the correction to be applied can be known for all sectors in any campaign. This is not true with magnetic north. The observation on Polaris is made with the transit which has a maximum error of .15 mil.

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The maximum error obtained when using Polaris in determining Y-north and, hence, the initial deflection, is less than one mil.

Reconnaissance and occupation of position will habitually be accomplished at night. In a moving situation, which is the aim of tacticians, this means that the field artilleryman must organize his position, occupy it and fire under the cover of darkness. To obtain an initial deflection rapidly and accurately and to fire his guns with this deflection will be his chief concern. The light artilleryman can get this with his compass (accepting the error above mentioned) if he knows the local declination and instrument error. But when he is going into a new sector where the declination is not definitely known and when the error of his instrument is not constant, the error in laying his guns may be as great as 30 to 40 mils. This is not true with Polaris, for the greatest error when using a transit with a Polaris attachment is not likely to exceed one mil.

The orientation officer of the battery or the battalion can perform this duty for his battery or battalion in from three to ten minutes, depending upon the dispersion of the command, the distance from the guns and the weather conditions. True north can then be calculated for the battery or battalion by the use of Polaris to within .3 mil. This will require about one hour, using the surveying method. An initial deflection which is within one probable error of the guns is thus secured before they are ready to fire. The executives of the various batteries thereby have a line on the ground from which they can lay their guns when data are given them. The error of this direction is small. Therefore, if the battery commander's data is correct, the probability of hitting the target is large.

With the medium and heavy artillery the range is large, generally over 8000 yards, so one mil error in deflection equals 8 yards at the target. Accuracy in laying the piece must be insisted upon at all times. This type of artillery will also occupy positions at night, even though reconnaissance is completed in the daytime and the gun's direction is staked out on the ground. This direction, in most cases, is obtained by the compass, since the locations of the most desirable aiming points are not known or the aiming points which are known are not visible from the battery. A traverse accurate enough to determine the approximate location of the guns is, however, not accurate enough to depend upon when shooting 18,000 yards if that traverse has more than two stations or is longer than 1000 yards. With the 155-mm. howitzer and 155-mm. G.P.F., occupation of position takes from thirty minutes to three hours. The battery orientation officer has sufficient time to make an observation on Polaris and to perform the necessary operation by the surveying method, thus giving the guns a direction on the ground

USE OF POLARIS FOR NIGHT FIRING

which has a minimum error. With the 240-mm. howitzer and the 8-inch howitzer the time that is at the disposal of the orientation officer is much greater, some five to eight hours, and he can therefore devote this time to accurately determining true north and his gun positions.

The transit used in making observation on Polaris is not at present an article of issue to field artillery units excepting the 155-mm. G.P.F. and the 8-inch and 240-mm. howitzers, but it is believed that a transit complete with Polaris attachment should be issued to all battalions. Provision should be made for the adjustment of the attachment at the proper times.

There are a number of methods of obtaining true north by means of Polaris. The required accuracy and rapidity of the determination, the equipment and tables available, and the correctness to which the time is known, are all factors in the selection of the method. An outline of one of the methods follows.

Brief Explanation of Method.—Polaris apparently moves in a small circle about the pole, its distance from the pole on a great circle being 90° minus the declination of Polaris. At the present time, the polar distance is about $1^\circ 6' 40''$. If Polaris could be followed through the telescope of a transit for twenty-four hours, and the plate and vertical circle reading recorded at frequent intervals and plotted, the resultant curve would be an ellipse. One-half the major axis would represent the azimuth at elongation and one-half the minor axis would represent the polar distance. The intersection of the axes would represent the pole. A few observations give only a portion of the ellipse and means that it would be impossible to locate definitely and accurately the position of the pole. An ellipse may be transformed into a circle having for its diameter the major axis of the ellipse by multiplying all ordinates by the ratio of the major axis to the minor axis. Since the radius is known it is always possible to locate the center of the circle when two or more points are known on the circumference.

Method of Observation.—The instrument must be in perfect adjustment. Set up over station, with plates set at zero, sight on reference point 300 to 400 feet distant. Clamp the lower motion and loosen the upper motion. Sight the instrument on Polaris. Read and record the altitude of the star and the amount and direction of the angle turned off. Immediately loosen the upper motion, plunge, swing the instrument through azimuth and take another set of readings. After correcting the second plate reading by 180° , the average of these readings will give the average altitude and angle between the reference line and Polaris.

At an interval of about one hour take another set of readings. These two sets of readings are sufficient, but if time is available

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a third set should be taken one hour after the second set, to serve as a check on the first two. In order to correct the altitude readings so as to throw the plotted positions of Polaris in a circle rather than an ellipse, it is necessary to multiply the altitude by the ratio of the azimuth at elongation to the polar distance. The declination of Polaris may be obtained from the "United States Government, Ephemeris of Polaris Table 1927." The polar distance is 90° minus declination. The latitude should be known within five or ten minutes as it is necessary to calculate the azimuth of Polaris by

$$\text{Sin azimuth} = \frac{\text{Sin polar distance.}}{\text{cos latitude}}$$

FOREIGN MILITARY JOURNALS A CURRENT RÉSUMÉ

ENGLAND

"The Journal of the Royal Artillery," July, 1927

"Duncan, Silver Medal Essay, 1926–1927," by Captain R. Hilton, M.C., D.F.C., R.A.

"Other arms have been re-organised, new arms and inventions have been introduced, but the post-war organisation of a divisional artillery differs little from that existing in 1914. It is a matter for consideration whether the artillery organisation of to-day admits of that arm carrying out its various functions to the best advantage.

"Even to one who is by no means revolutionary in matters of military progress, the above words must appear to state the case very mildly indeed. How can it be doubted that our present ideas of artillery are lagging woefully behind the times, when within nine years of the Great War (in which artillery became almost the paramount arm) it is possible to visualise such an insignificant future for our own regiment as was portrayed in the April number of this journal?

"Times are certainly changing, and we must change with them, or our place in the military machine will be taken by some other arm. But it cannot be seriously supposed that a regiment with traditions like our own will allow itself to become a back number in war merely through unwillingness to change."

The above introduction is enough to indicate the trend of this article which has been considered important enough and well enough done to win the award indicated.

We may have our own troubles in the field artillery. Every interested officer probably has some pet scheme which he feels would improve the efficiency of his branch. However, we can hardly complain as Captain Hilton does, that there is too little change in the organization of our field artillery.

One of the most interesting features of this article is the importance which is attached to tank offense and anti-tank defense. Undoubtedly one of the largest British contributions to the science of war during 1914–1918, was its development of the use of tanks. We can, therefore, profitably learn from a British artilleryman who plans to adopt his own arm to secure better defense against tanks. In general, his method seems to be to so conduct artillery defense against tanks as to force an extension and prohibit attack by mass of tanks.

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The use of anti-aircraft artillery is also briefly covered in this article without developing anything especially new.

Captain Hilton continues as follows:

"Undoubtedly tanks and aircraft are most powerful weapons, both of which are destined to modify the form of war very profoundly. Let us take comfort, however, by looking at the quaint old muzzle-loaders of by-gone days. They have gone, but our regiment has not lost its importance."

"The Maintenance of Our Fighting Forces in the Field," by Lieutenant-Colonel W. G. Lindsell, D.S.O., O.B.E., M.C., R.A. Lieutenant-Colonel Lindsell says:

"A study of the art of war, in all that principally relates to the administration of an army in the field, is unattractive and distasteful to the mass of our officers. The subject is dry and unpopular; when its principles are discussed or explained, they receive trifling attention."

However, he has much to say that is interesting on this subject. For instance, referring to the British campaign in Mesopotamia, he quotes this from the official history:

"It was not until after two years that our force, properly equipped and fed, was at last able to do itself justice in battle without apprehension of disaster from purely administrative defects or fear of undue suffering by its wounded and sick."

No experienced soldier can quarrel with such conclusions, which is not peculiar to the British forces in Mesopotamia. The most careful attention to tactics and training may prove fruitless if a simple and workable organization is not developed to take care of the forces in the field. In this connection, American officers will find a peculiar interest in Colonel Lindsell's statement that:

"The army of the United States at St. Mihiel was also brought to a standstill by maintenance failure; faulty organisation and a complete lack of traffic control had produced such a state of congestion behind their fighting troops that all roads in every direction were hopelessly blocked and the front line troops were without ammunition and were literally starving."

From our point of view, it is unfortunate that the author picked such an incident to point his argument. The traffic for a few days behind the St. Mihiel front was undoubtedly fantastic, due to the large number of troops employed and perhaps to some failures in organization. However, we all understand that the failure to advance further was caused by orders from the Allied High Command in furtherance of carefully worked out plans for the advance

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between the Argonne Forest and the Meuse. The troops on the St. Mihiel front could readily have advanced further if they had been allowed to do so and were never without ammunition or approaching starvation.

"Finesse at the O. P.," by Colonel F. Rainsford-Hannay, C.M.G., D.S.O. A good many of the articles in *The Journal of the Royal Artillery* are on broad general subjects and of interest only incidentally to field artillery. However, here is one which should attract the attention of every gunner, always concerned with trying to get the largest amount of effect from the fire at his disposal. Colonel Rainsford-Hannay imagines an enemy column of infantry, perhaps half of a battalion, marching along a road 2000 yards beyond our infantry firing line and visible to the artillery observer. He feels that in accordance with present practices the officer would range on the front of the column and search it in depth with the possible result that the infantry would scatter and that the number of casualties inflicted would be very few. His solution, however, would be to range over the target so as to retain visibility at all times, and to come back into the marching column. The author cites historical cases in which the accepted procedure of ranging short has failed to secure results and there is undoubtedly much to justify the viewpoint which he takes. The article is perhaps of principal value in that it points out that the conduct of artillery fire from an observation point is, and will probably always remain, a real art.

"A Camel Pack Battery (2.75 B.L.)," by Captain A. E. Tawney, M.C., R.A. This article should be of profound interest to all present, past, and future members of mountain artillery batteries. The army mule, and particularly the pack mule, has a bad reputation for pig-headedness and general devilishness. Everyone who has ever served with him will recall with emotion the difficulties of saddling out under field conditions. Animal authorities, however, are inclined to award the palm for general bad temper among beast of burden to the camel, and we can only imagine the difficulties confronting gunners serving with such an animal.

This article is principally a technical discussion as to the development of methods of packing. The photographs lend a certain picturesqueness.

"A Queer War," by One Who Was in It. The author was stationed at Aden during the World War and evidently feels chagrined of not having seen service on a more active front. This queer war consisted of the efforts of the British forces protecting Aden to accomplish a mission and incidentally to keep as many

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Turks as possible diverted from other more useful fronts. Probably the action of neither side had much to do with determining the issue of the war. However, the life of the individual officer or soldier was probably very much the same as that of their comrades in other Eastern sectors. The experience they gained was of just as much practical benefit as if it had been gained in France. The article makes good reading.

This issue also contains the following articles:

"Rôle of the Fortress in Modern War," by Major-General Sir Edmund Ironside, K.C.B., C.M.G., D.S.O.

"What Infantry Expect from Artillery," by Lieutenant-Colonel E. C. Anstey, D.S.O., R.A.

"The Combined Arms in Coast Defence," by Major Rodney H. Smith, C.A.C., of our own service.

This is a prize essay reprinted from the *Coast Artillery Journal*.

"Infantry Guns"—A translation from the French.

"Chasing"—This is a readable discussion of some of the successes of British gunners in English Steeplechasing.

FRANCE

"Revue Militaire Française," May–June, 1927

"Types of Artillery Fire Profitable to the Infantry," by Lieutenant-Colonel Menjaud, is an article which deals mostly with Artillery concentrations. Lieutenant-Colonel Menjaud enumerates the advantages and disadvantages of this type of fire and the circumstances favorable to its use.

Should there be only one target for several batteries the problem is, of course, simple. This case, however, is exceptional. Ordinarily, batteries are called upon to concentrate on several targets successively.

Various difficulties arise in this case. For batteries well advanced it is very difficult to shift from target to target over a wide sector. Since all batteries must fire simultaneously in a concentration, they require an excellent system of signal communication. Moreover, when several batteries are firing on the same target, it is impossible for each battery to observe and adjust its own fire.

To overcome this last mentioned disadvantage, it is necessary to observe various precautions to obtain accuracy. Before the successive concentrations begin, each battery should adjust on at least one of the targets or at least on a point near one of the targets. It would take too long for each battery to adjust on all the targets. Having adjusted on one target, the battery can prepare its firing data for the other targets by carefully locating their positions on a

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map. Of course these precautions are worthless if the targets cannot be correctly located topographically. In case the targets cannot be correctly located, the fire of the battery will reach only the one target upon which it has adjusted.

In such a case it is evidently better to give each battery a target and allow each battery to fire only on the target upon which it has adjusted. It can then observe its fire for effect.

From these considerations one can see that it is at times preferable to renounce the advantages, however important, of concentration. It is necessary in each case to study on one side the situation and needs of the infantry, and on the other the artillery situation.

On the other hand the advantages of concentrations are also numerous. Chief among the advantages is the great morale effect. An avalanche of shells arriving in a few minutes from different directions is particularly demoralizing. Troops feel that they cannot escape this concentrated fire. They don't know where to seek cover and haven't time to find cover. This demoralizing effect remains long after the fire is shifted to another objective.

In concluding, Lieutenant-Colonel Menjaud states, that only the artillery officer executing the fire knows if it is possible to fire by concentrations. Not even the artillery group commander can decide this question. The infantry commander is even less able to decide it.

In "**A Study of Shanghai**," Captain Givres studies the city, its history, commerce, and municipal government.

The treaty of Nanking in 1842 gave the English commercial rights in Shanghai. The following year a new treaty permitted the English to rent land and buildings from the Chinese in a limited quarter. In 1849, the Chinese designated another quarter to receive the French and a little after a third quarter for the Americans. In 1854, the three concessions were united and the various consuls drew up a common set of administrative regulations. A little later, however, the French withdrew from this union and lived separately. The English and Americans continued to reside together and territory that they occupied became, in 1869, the international concession.

In studying the commercial importance of Shanghai, Captain Givres remarks, that it is the seventh largest port in the world. It is near enough to the sea to be reached by almost any boat and is sufficiently distant to escape the typhoons. It also has the advantage of communication with a large river which flows through rich provinces.

Shanghai illustrates better than does any other Chinese city the beneficial results of European organization. Due to the efforts of the whites, Shanghai has grown to be the most beautiful and

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sanitary of eastern cities. Thanks to the order that foreign powers have established in Shanghai and thanks to their teachings, the Chinese have worked there in peace. In no other Chinese city have the Chinese developed industrially as they have in Shanghai. As an afterthought, Captain Givres remarks that Chinese agitators do not seem to appreciate these Occidental efforts toward an uplift in China.

The article by Colonel Lucas, "**Combat Capacity of Large Units,**" beginning in the June issue, describes the division organization before the war and traces the changes in division organization during the war.

From the very opening of the war, it was found necessary to support the infantry by machine guns. At the beginning of 1915, the infantry regiment received an additional section of machine guns which, with the three original sections, formed a regimental machine gun company. In August, 1915, each infantry brigade was also given a machine gun company. In the winter of 1915-1916, these regimental and brigade companies were doubled in number. In 1916, eight automatic rifles were distributed to each company.

As the infantry gained in matériel, it decreased in manpower. In July, 1915, the companies were already reduced from 250 men to 200 men and in September, 1916, to 194 men.

Even with the loss in manpower, these modifications in the infantry organization increased its fire power and its offensive capacity. Moreover, the infantry division increased its front.

The great change in divisional organization came in 1916. In May of that year, after Verdun, the battalion of infantry was reduced from four to three companies and each battalion was given a company of machine guns. To provide these companies, the regimental and brigade machine gun companies were suppressed. It was at this time that the regiment received three 37-mm. guns.

In August, the division was reduced from four to three regiments of infantry. The infantry brigade generals were replaced by one general commanding the infantry of the division.

As the infantry decreased, the artillery increased so that the proportion of the two arms which in 1914 was 87 per cent. infantry to 10 per cent. artillery, was in 1916 70 per cent. infantry to 20 per cent. artillery.

This reduction of the infantry division from four to three regiments was made not only for tactical reasons, but also because of the decreasing manpower in France.

"**The Campaigns of a Division of Infantry,**" by Lieutenant-Colonel Laure, continued in the May and June numbers, traces the history of the division from the end of 1917 to July 13, 1918.

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In preparing to withstand the German spring drives of 1918, the French High Command issued instructions for the conduct of the defense: "The defense should be prepared in each army on a field of battle of which the principal position of resistance cannot be fired on by adjusted artillery fire and minnenwerfers of the enemy." A commander had the right to consent in advance to the abandonment of several kilometers of terrain if necessary. This terrain was to be occupied only by advance posts. Every effort was to be made to occupy in force the principal position of resistance at the moment the enemy reached it.

Army commanders were very reluctant to accept these instructions to defend no longer their advance observation posts. Moreover, in many sectors, the principal position of resistance was confused with the advance post positions.

General Pétain visited all parts of the front to explain the instructions to his army commanders. His object was to avoid "a tactical surprise" in leaving enough terrain between the outposts and the position of resistance so that before attacking this position, the enemy would be forced to unmask its disposition and lose considerable time in crossing "no man's land." This policy also gave the French High Command the opportunity to rush reserves to the threatened points.

Other articles in the May and June numbers are:

"Strong Points and Centers of Resistance," by Colonel Chauvineau.

"Offensive Maneuver," by Colonel Mayrand.

"The Catastrophie of Tannenberg," by General Camon.

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Premature Explosions

AS CRITICISM is sometimes made of the requirement instituted by the Chief of Field Artillery that in firing shell, the battery personnel must be sheltered, he has recently caused an examination to be made of the records as to casualties caused by premature explosions.

The results are shown below.

The period covered is that from the entry of the United States into the World War up to the present time. This period may be divided into two parts—the first extending to the time the Chief of Field Artillery first prescribed the use of cover, and the second period being from that time on.

TOTAL PERIOD (APRIL 6, 1917, TO AUGUST 1, 1927)

Number of guns and howitzers destroyed by explosions	24
Total men killed in this period	6
Total men wounded in this period	10
Percentage men killed to total explosions	25%
Percentage men wounded to total explosions	48%

FIRST PART (APRIL 6, 1917, TO JULY 1, 1918)

Number of guns and howitzers destroyed by explosions	5
Total men killed in this period	6
Total men wounded in this period	10
Percentage men killed to total explosions	120%
Percentage men wounded to total explosions	200%

SECOND PART (JULY 1, 1918, TO AUGUST 1, 1927)

Number of guns and howitzers destroyed by explosions	19
Total men killed in this period	0
Total men wounded in this period	0
Percentage men killed to total explosions	0%
Percentage men wounded to total explosions	0%

If percentage of casualties shown in first period (no protection required) had continued in second period (protection required), the losses would have been:

Killed	23
Wounded	38
instead of: 0 killed and 0 wounded.	

Considering the 75-mm. guns only, about 82 per cent. of the prematures have taken place when using the Mark III fuse. The relative numbers of long and short fuses used during the period covered by the tabulation is not known.

The evidence relating to the prematures is such as to fully justify the conclusion that where these have occurred when using the long fuse, the cause in many cases may be laid to the removal of the spiral.

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GUNS AND HOWITZERS IN USE BY THE FIELD ARTILLERY DESTROYED BY
 DETONANATIONS IN THE BORE, AND CASUALTIES TO PERSONNEL SINCE
April 6th, 1917, IN THE UNITED STATES AND HAWAII.

Date	Cal.	Kind	Mod.	Place	Killed	Wounded	Remarks
Aug. 27, '17	3"	Gun	1905	Ft. Sill	1		
Feb. 6, '18	155-mm.	How.	1917	Ft. Sill	3	1	
Apr. 5, '18	3"	Gun	1905	Ft. Sill	1	2	
May 8, '18	6"	How.		Ft. Sill		2	
June 11, '18	6"	How.		Camp Fremont	1	5	
Aug. 26, '18	75-mm.	Gun	1916	Ft. Sill			From July 1, 1918, F. A. personnel were required to take cover when firing shell.
Oct. 9, '18	75-mm.	Gun	1916	Ft. Sill			
Nov. 20, '18	75-mm.	Gun	1916	Ft. Sill			
Dec. 10, '18	75-mm.	Gun	1916	Ft. Sill			
Sept. 17, '19	8"	How.	Vickers	Ft. Sill			
Aug. 30, '20	155-mm.	Gun	1918	Camp Lewis			
Sept. 3, '20	8"	How.	Vickers	Ft. Sill			
Sept. 4, '20	8"	How.	Vickers	Ft. Sill			
Sept. 14, '20	8"	How.	Vickers	Ft. Sill			
June 19, '22	75-mm.	Gun	1917	Ft. Bragg			
Nov. 21, '23	75-mm.	Gun	1897	Ft. Bragg			
May 6, '24	75-mm.	Gun	1897	Ft. Hoyle			
Nov. 6, '24	155-mm.	How.	1918	Ft. Bragg			
Nov. 14, '24	155-mm.	How.	1918	Ft. Bragg			
Dec. 24, '24	75-mm.	Gun	1917	Schofield Barracks			
Aug. 24, '25	75-mm.	Gun	1917	Schofield Barracks			
Nov. 9, '25	75-mm.	Gun	1897	Ft. Benning			
June 22, '26,	75-mm.	Gun	1897	Camp Sparta			
Sept. 6, '26	75-mm.	Gun	1897	Pine Camp			

A study of this subject clearly indicates that proper training and the enforcement of existing regulations greatly reduces the probability of prematures, and to an even greater extent reduces the probability of injuries to the personnel in the event of a premature.

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Lieutenant-General H. Rohne

With the November-December, 1926, number of the *Artilleristische Monatshefte*, this German periodical, devoted to the interests of artillery, closes a career of twenty years. During this entire period, its editor and principal contributor has been Lieutenant General H. Rohne, who retired from active service twenty years ago at the age of sixty-four. It is not often that we find a service journal that has enjoyed such continuity in its editorial policy. The *Artilleristische Monatshefte* has been conducted uniformly on a very high professional plane. Its character was entirely due to General Rohne. Upon his retirement, he saw the need of a journal devoted to the interests of the artillery. He also desired to have something to do. He brought to the journal the ripe experience of forty years of service in his branch in which he attained the highest rank and distinction. As a retired officer he continued his professional studies and gave his comrades the benefits of his ripe experience and brilliant mind. General Rohne was among the first German artillerymen to appreciate the revolution in the tactical employment of Field Artillery that followed the introduction of the quick-firing recoil gun. He was an open admirer of the French Field Artillery and never failed to bring to the attention of his comrades, those points in which the French excelled. His outstanding studies were those on "The Effect of Shrapnel Fire," and "High Explosive Shell Fire and Fragment Effect." The scientific manner in which he analyzed these problems, makes these studies classics of our profession. The conclusion arrived at are as sound to-day as when they were made.

Now in his eighty-fourth year, General Rohne finds himself constrained to lay down his editorial task and bid farewell to his readers and associates. The publishers in commenting on General Rohne's editorial retirement, pay a tribute to him when they say that without his guidance they see no value in the continuation of the journal. THE FIELD ARTILLERY JOURNAL takes this opportunity of also paying tribute to the high professional qualifications and fine character of General Rohne. Our best wishes accompany him in his retirement, and while we feel that he deserves a well-earned rest, we still cling to the hope that he will occasionally break forth into print when we need proper guidance.

Redesignation of Field Artillery Units

The following Field Artillery units are redesignated or constituted as indicated:

The Headquarters, Headquarters Battery and Service Battery,

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4th Field Artillery, is redesignated the Headquarters, Headquarters Battery and Service Battery, 3d Field Artillery.

The 1st Battalion, 4th Field Artillery, is redesignated the 2d Field Artillery Battalion.

The 2d Battalion, 4th Field Artillery, is redesignated the 4th Field Artillery Battalion.

The 1st Battalion, 14th Field Artillery, is redesignated the 2d Battalion, 3d Field Artillery.

The 1st Battalion, 2d Field Artillery, is redesignated the 2d Battalion, 16th Field Artillery.

The 1st Battalion, 9th Field Artillery, is redesignated the 2d Battalion, 18th Field Artillery.

The 86th Field Artillery is constituted as an inactive unit of the Regular Army.

The 9th, 14th, and 86th Field Artillery regiments will be carried as inactive units, allotted to the 7th, 6th, and 4th Corps Areas, respectively.

Reorganization of Divisions of Regular Army

In order to be prepared to make the best war use of the units of the Regular Army as they exist to-day, the War Department has just ordered a reorganization of the divisions of the Regular Army which is to be effected by a redistribution of the active fragments of the old divisions. In 1920 the Regular Army was organized into nine infantry divisions and two cavalry divisions. Through the gradual reduction of the strength of the military establishment since that time, all of these divisions have been reduced by making certain divisional units inactive. The process has had to be carried to the point where the prompt use of most of these divisions in emergency was seriously jeopardized by their fragmentary condition. The reorganization maintains the following three infantry divisions and one cavalry division which can be called out at once for active service:

First Division (infantry), Headquarters at Fort Hamilton, New York.

Second Division (infantry), Fort Sam Houston, Texas.

Third Division (infantry), Camp Lewis, Washington.

First Cavalry Division, Headquarters at Fort Bliss, Texas.

The remaining active divisional units of the Regular Army, scattered over the United States, will be organized into the Fourth, Fifth, and Sixth Infantry Divisions, and the Second and Third Cavalry Divisions. The organization of these divisions will comprise the following major elements, together with auxiliary units and trains:

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Fourth Division (infantry).

- 8th Infantry, Headquarters, Fort Screven, Georgia.
- 12th Infantry, Headquarters, Fort Howard, Maryland.
- 22d Infantry, Headquarters, Fort McPherson, Georgia.
- 34th Infantry, Headquarters, Fort Eustis, Virginia.
- 16th Field Artillery (partially inactive), Fort Myer, Virginia, and Fort Bragg, North Carolina.
- 85th Field Artillery (inactive).
- 13th Engineers, Fort Humphreys, Virginia.
- 22d Observation Squadron, Maxwell Field, Alabama.

Fifth Division (infantry).

- 5th Infantry, Headquarters, Fort Williams, Maine.
- 10th Infantry, Headquarters, Fort Thomas, Kentucky.
- 11th Infantry, Headquarters, Fort Benjamin Harrison, Indiana.
- 13th Infantry, Headquarters, Fort Andrews, Massachusetts.
- 3d Field Artillery, Fort Benjamin Harrison, Indiana and Fort Sheridan, Illinois.
- 19th Field Artillery (inactive).
- 7th Engineers (Company A, Fort Benning, Georgia).
- 88th Observation Squadron (temporarily inactive).

Sixth Division (infantry).

- 2d Infantry, Headquarters, Fort Sheridan, Illinois.
- 3d Infantry, Fort Snelling, Minnesota.
- 6th Infantry, Jefferson Barracks, Missouri.
- 17th Infantry, Headquarters, Fort Crook, Nebraska.
- 18th Field Artillery (partially inactive), Fort Des Moines, Iowa, and Fort Sill, Oklahoma.
- 78th Field Artillery (inactive).
- 4th Engineers (Company A, Fort Bragg, North Carolina).
- 15th Observation Squadron (temporarily inactive).

Second Cavalry Division.

- 2d Cavalry, Fort Riley, Kansas.
- 4th Cavalry, Fort Meade, South Dakota.
- 12th Cavalry, Headquarters, Fort Brown, Texas.
- 14th Cavalry, Headquarters, Fort Des Moines, Iowa.
- 3d Machine Gun Squadron (inactive).
- 4th Machine Gun Squadron (inactive).
- 4th Field Artillery Battalion (Pack), Fort McIntosh, Texas.
- 9th Engineer Battalion (mounted), Fort Riley, Kansas.
- 16th Observation Squadron, Fort Riley, Kansas.

Third Cavalry Division.

- 3d Cavalry, Headquarters, Fort Myer, Virginia.
- 6th Cavalry, Fort Oglethorpe, Georgia.

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- 10th Cavalry, Fort Huachuca, Arizona.
- 11th Cavalry, Presidio of Monterey, California.
- 5th Machine Gun Squadron (inactive).
- 6th Machine Gun Squadron (inactive).
- 84th Field Artillery Battalion (inactive).
- 12th Engineer Battalion (mounted) (inactive).
- 44th Observation Squadron (inactive).

The divisions listed above are reasonably complete in essential elements other than Field Artillery and plans have been made for promptly providing personnel for their inactive units. These five divisions will be available as fighting units in emergency but, of course, cannot go out at the "first alarm."

The Seventh, Eighth, and Ninth Divisions (infantry) have been completely stripped of their active units to effect the above reorganization and if needed will necessarily be reconstituted from their assigned inactive units.

An army headquarters and three corps headquarters, together with headquarters for a cavalry corps, have been provided as inactive units under the new reorganization and arrangements have been made for their prompt mobilization if need arises for their use.

This reorganization will not involve any changes in the present location of troops.

Revision of War Department Plans

The six field army program has not been abandoned by the War Department.

All war plans, including the mobilization plan, must be revised and adjusted from time to time to meet changes of conditions and the results of experience. For such a purpose the mobilization plan is to be revised in the near future. The readjustment will not occasion any reduction in the number of Reserve officers, nor will they be subjected to any injustice.

On the contrary, there recently were adopted policies which should effect an increase in the number of Reserve officers. Furthermore the regulations in conformity with those new policies are intended to provide a more healthy flow of promotion than formerly was possible.

Examination for Gunners

Training Regulation 430-175 is the new Field Artillery Examination for Gunners. This pamphlet, which became available since the last JOURNAL went to press, supersedes Special Regulation No. 53. It became effective in so far as applies to the examination of second-class gunners only on July 1, 1927, and will be effective in

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its entirety on January 1, 1928. Those to whom this pamphlet is not otherwise available, may obtain it from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents per copy.

Army Air Corps to Map Extensive Areas

Two aerial survey detachments, each composed of a commissioned officer of the Army Air Corps who is a photographic pilot, and an enlisted photographer, were recently authorized by the War Department for the purpose of assisting the U. S. Geological Survey in carrying out its extensive program for the present calendar year in mapping areas in various states throughout the country.

One of these detachments will photograph areas in Maine, New Hampshire and Vermont, approximating 8000 square miles. A great portion of these areas, particularly in Maine, have never been adequately mapped, and all existing maps are old and somewhat obsolete. The other detachment will begin operations on a 4000 square mile area in Illinois, and later will photograph areas in Michigan and Wisconsin.

One detachment of this kind, organized last year for a like purpose, photographed during a six months' period approximately 9000 square miles of territory in the States of Michigan, Wisconsin and Illinois. Through the work of this single detachment it is estimated that the saving to the Government was approximately \$100,000, thus demonstrating the efficacy and economy of aerial surveying.

Each aerial survey detachment is equipped with tri-lens camera and accessories, and furnished with two special photographic planes, one of which is held in reserve. The function of these detachments is to make aerial photographs which are in turn used in making topographic maps by the Geological Survey. The personnel of the detachments is relieved of all other military duties and assigned exclusively to aerial survey activities for a period of six months. It is placed under the direct control of the Chief of Air Corps, who is authorized to issue the necessary orders for its movement and employment, according to the program submitted by the Geological Survey.

Further Maneuvers to Test Problems of Motor Transportation of Troops

In conducting future maneuvers and larger tactical exercises the War Department will include therein problems and exercises which will test the capabilities and limitations of motor transportation

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in the movement of troops, equipment, matériel, and animals, including small Cavalry units. Motive power for field and combat trains, and light artillery, now mostly animal-drawn, will be put to exhaustive tests on all kinds of terrain.

It is contemplated that in two-sided exercises one side will use normal animal-drawn transportation and the other use motor-propelled equipment and matériel. These tests will bring out the comparative capacity, usefulness and endurance of the two types of transportation.

In connection with the September maneuvers of the First Cavalry Division, to be held in the vicinity of Marfa, Texas, the War Department has instructed the Commanding General, Eighth Corps Area, with headquarters at Fort Sam Houston, Texas, to arrange the maneuvers so as to permit careful study and tests involving the problems outlined above.

Polo

Intra-circuit and Inter-circuit Polo Tournaments—1927

The introduction of the Intra- and Inter-circuit Polo Tournaments by the United States Polo Association has done more to develop Polo among average players than anything yet attempted by our National Association. The great number of players and teams brought out by this competition are now becoming the feeders for the Junior Tournaments, and will eventually carry more and more players into the Senior Group, which had almost ceased to gain recruits a few years ago.

For the Intra-circuit competitions the United States has been divided into eight circuits: the Eastern, Southeastern, New England, Southern, Central, Rocky Mountain, Southwestern and Pacific Coast, each with a sub-committee to control its tournament. Teams not to exceed twelve goals in aggregate handicap, with six goals' individual limit, are eligible to compete in these tournaments. A proviso is also made that teams will play on handicap, but that no team will be required to give more than five goals' handicap under any conditions.

The winning teams of the Intra-circuit Tournaments (or if they are unable to play, the runners up) are eligible for the Inter-circuit Event which is competed for at Narragansett Pier, R. I., this year, beginning about the middle of August. The U. S. Polo Association assists the teams competing in this event by transporting 20 ponies and 4 grooms to the place of competition and return.

The results of the Intra-circuit Tournaments this year are as follows:

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1. Pacific Coast Circuit—April 15th to May 1st.—Teams competing: San Mateo Reds, Burlingame Blues, Midwick and the Eleventh Cavalry.

The final game was won by San Mateo from Midwick:

San Mateo, 6

Mr. W. S. Tevis, Jr.
Mr. Charles Christin
Mr. A. Elizalde
Mr. C. M. Weatherwax

Midwick, 5

Mr. E. G. Miller
Mr. Hal E. Roach
Mr. Neil S. McCarty
Mr. A. Paddock

2. Southwestern Circuit—Feb. 19th to Mar. 16th.—Teams competing: San Antonio, Stonewall, Second Division Infantry, Wichita Falls, Fredericksburg, Headquarters, Eighth Corps Area, Ninth Infantry, Houston, Fort Bliss, Fort Clark, Camp Marfa, Twelfth Field Artillery, Kelly Field, and Austin.

The final game was won by Fort Bliss from the Eighth Corps Area as follows:

Fort Bliss, 13

Capt. B. C. Bridges (1)
Capt. C. E. Davis (2)
Lieut. E. F. Thompson (1)
Maj. J. K. Brown (4)
Goals—Earned, 10; Hcp., 3.

Eighth Corps, 5

Capt. T. W. Hastey (0)
Lieut. E. McGinley (4)
Capt. J. A. Hettinger (3)
Lieut. M. M. Jones (4)
Earned, 5.

3. Rocky Mountain Circuit.—Teams competing: Kansas City, Fourteenth Cavalry, Fort Riley, Wakenda, Fort Leavenworth, Wichita, Second Cavalry, and Ponca City.

The final game was won by Fort Riley from the Second Cavalry as follows:

Fort Riley, 11

Capt. J. C. Short
Capt. C. C. Jadwin
Capt. L. K. Truscott
Maj. H. D. Higley

Second Cavalry, 8

Lieut. H. J. Thornborgh
Lieut. J. W. Wofford
Maj. E. L. Franklin
Maj. J. C. Rogers

4. Southern Circuit—June 15th to June 30th.—Teams competing: Sixth Cavalry, Fort Bragg, and Winston-Salem.

The final game was won by the Sixth Cavalry from Winston-Salem as follows:

Sixth Cavalry, 8

Lieut. L. K. Ladue (1)
Lieut. T. Q. Donaldson (2)
Lieut. H. G. Culton (1)
Capt. M. F. Meader (1)
Earned, 8.

Winston-Salem, 6

Mr. E. A. Darr (0)
Mr. R. M. Hanes (1)
Mr. Ralph Little (2)
Mr. J. G. Hanes (1)
Earned, 5; Hcp., 1.

5. Southeastern Circuit—Played in two preliminary matches, June 16th to 25th and July 12th to 16th.—Teams competing: War Department Whites, Third Cavalry, War Department Reds, Sixteenth Field Artillery; Old Oaks, Suneagles, Bryn Mawr, Elephants, Fort Monmouth, Norwood, Freebooters, and Rumson.

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The final game was won by the Old Oaks from the War Department Whites as follows:

Old Oaks, 15
 Mr. Cyril Carr (2)
 Mr. A. B. Borden (3)
 Brig.-Gen. Borden (3)
 Mr. H. W. Williams (4)
 Earned, 15.

War Department, 5
 Maj. R. S. Thomas (1)
 Maj. C. Parker (3)
 Maj. R. E. D. Hoyle (3)
 Col. N. E. Margetts (3)
 Earned, 3; Hcp., 2.

6. Eastern Circuit.—The following teams were eligible to compete in this tournament: Cooperstown, Crescent A. C., Great Neck, Meadowbrook, Orange County, Piping Rock, West Point, Governors Island, Fort Hamilton.

The final game was won by the Rockaway Hunt Club.

No. 1—J. W. Maitland
 No. 2—C. P. Beadleston
 No. 3—E. A. S. Hopping
 No. 4—W. T. P. Hazard

7. Central Circuit.—The following teams were eligible to compete in this tournament: Buffalo, Chagrin Valley, Cincinnati, Cleveland, Detroit, Grasmere Farms, Kirtland, Lake Shore, Miami Valley, North Shore, Oakbrook, Onwentsia, Rochester, Rocky Ford, St. Louis, Toronto, and Army teams in that circuit.

The final game was won by the Cleveland team.

8. New England Circuit.—The following teams were eligible to compete in this tournament: Dedham, Greenwich, Montreal, Myopia, Ox Ridge, Pt. Judith, Princemere, Springfield, Westchester, Ft. Ethan Allen, Madison Barracks.

The final game was won by the Pt. Judith team.

All of the above winning teams will compete in the Inter-circuit match, beginning on August 15th at Narragansett Pier, R. I., except San Mateo, which won the Pacific Coast Tournament.

Intercollegiate Polo

There was no western intercollegiate Polo match this spring, nor an intersectional match. Considering only eastern intercollegiate polo, remarkable strides forward have been made in the last few years as may be seen from the caliber of youngsters picked by the coaches and other officials at the conclusion of this season's play. The All-College Polo Team of 1927 is the following.

No. 1—Mr. A. B. Borden, Princeton, Handicap	3
No. 2—Mr. W. F. C. Guest, Yale, Handicap	6
No. 3—Mr. C. R. Barrett, Yale, Handicap	3
No. 4—Mr. Forrester Clark, Harvard, Handicap	4
Total Handicap	16

There is no doubt that this team could make a good showing against some of our veteran aggregations. Guest showed such dash

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and power in the tryouts for the American First Team that he is considered a possible choice on the team that will represent the United States against the challenge team from Great Britain—The Army Team in India, now in the United States.

Army Polo Center

The Army learns with much pleasure that Mitchell Field, Long Island, is to be developed into an Army Polo Center for the development of teams to represent the Army in Junior and Open Championships in the future. This has been brought about by the generosity of the United States Polo Association in coming to the aid of the Army in financing this project. The great drawback in developing fast play in the Army has been the deplorable lack of fast fields at Army Posts. It is now proposed to build two fast fields at Mitchell Field and suitable stables, etc., for this purpose. One of the great advantages of this site is that our fields will be within a few hundred yards of the Meadowbrook Fields, where keen competition can always be had.

International Polo

The Polo "fans" have displayed the keenest interest in the try-outs for the American and British teams which will represent their respective countries in the International Challenge Matches next month.

The American team in its preliminary workouts has lined up as follows:

No. 1—Mr. W. F. C. Guest
No. 2—Mr. Thomas Hitchcock, Jr.
No. 3—Mr. J. Cheever Cowdin
Back—Mr. Devereux Milburn

From this line-up it appeared for awhile that Youth had slipped in to replace the more seasoned players with only Milburn and Hitchcock of International fame left. This team was eventually held to an even break by a team composed of the following players:

No. 1—Capt. C. A. Wilkinson
No. 2—Mr. J. Watson Webb
No. 3—Mr. Malcolm Stevenson
Back—Mr. Louis E. Stoddard

This, coupled with the great improvement in the play of Webb and Stevenson of our last successful International Team has led to the probable appearance of the "Big Four" to again represent America as follows:

No. 1—J. Watson Webb
No. 2—Thomas Hitchcock, Jr.
No. 3—Malcolm Stevenson
Back—Devereux Milburn

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The tentative British Challenge team is believed to be the following:

No. 1—Capt. C. E. Pert
No. 2—Maj. A. H. Williams
No. 3—Capt. C. T. I. Roark
Back—Maj. E. G. Atkinson

It is with great satisfaction that the American Army sees Capt. C. A. Wilkinson selected as substitute on the American "Big Four," as it is the first time that a regular army officer has been so honored. Captain Wilkinson's game has greatly improved since his appearance on the winning Army team in the Junior Championship Tournament this spring.

Field Artillery Board Notes

Since the publication of the last notes, reports on the following tests have been submitted:

Rolling kitchen.
Chevrolet cross-country car.
DuPont NH powder for 155-mm. gun, M-1918.
75-mm. guns, M-1925E and M-1923E1.
Chevrolet cars, sedan and touring.
75-mm. shell, E-1, equipped with E-13 fuse.
Headsets, type TS-3.
Cost records system for motorized units.
Water tank and pump, mounted on Ordnance limber chassis.
Diaphragm gas masks.
Jacks vs. chain hoists for mounting and dismounting 240-mm. howitzer matériel, M-1918, Schneider.
Limbered ration cart on Ordnance caisson chassis.
Experimental hand wire cart.
Pistol cleaning rods.
Signal lamps.
Fuse wrench for Mark III, IV and V fuses.
Experimental spare wheel hub covers for 1334-mm. wheel.

Rolling Kitchen.—Pilot model of limbered rolling kitchen mounted on Ordnance caisson limber running gear, tested by the Board, was found to be unsatisfactory. Recommendations were made that a new kitchen mounted on the same running gear be constructed for test, total weight of the kitchen not to exceed 3400 pounds.

Chevrolet Cross-country Car.—This car was recommended as suitable for adoption as a standard cross-country car for field artillery use. If action is taken on this recommendation, it does not close the door to the new Ford for instance, which may be tested and classified as provided in A. R. 850–25.

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Considerable comment has been made as to why so much attention has been devoted to cars as low-priced as the Ford and Chevrolet. Briefly, from a field artillery viewpoint, this is the only type of car light enough and with sufficient ground clearance to give a satisfactory amount of mobility. Combined with these advantages are their potential production, sufficient ruggedness for a reasonable mileage life, and the fact that the use of the light trucks of the same makes for transportation of personnel and communications equipment, greatly simplifies number of types and servicing. Recommendations were also made to investigate, (1) the possibility of this vehicle as an auxiliary wire-laying vehicle, and (2) of this chassis as a light repair truck. A tentative basis of issue was also included in the report.

DuPont NH Powder for 155-mm. Gun, M-1918.—This powder was recommended as suitable for service use.

75-mm. Gun, M-1925E (Box-trail) and M-1923E1 and 2 (Split-trail).—This report carried the recommendation that the box-trail gun be not adopted, but that another model be built incorporating suggested improvements; that the split-trail gun is the most satisfactory of the models tested to date and that the latter be considered as having reached the point where it should be given a service test.

The box-trail gun was unsatisfactory in the following respects:

- Accuracy.
- Rapidity of fire.
- Ability to cover a sector.
- Ease of operation.
- Direct fire.

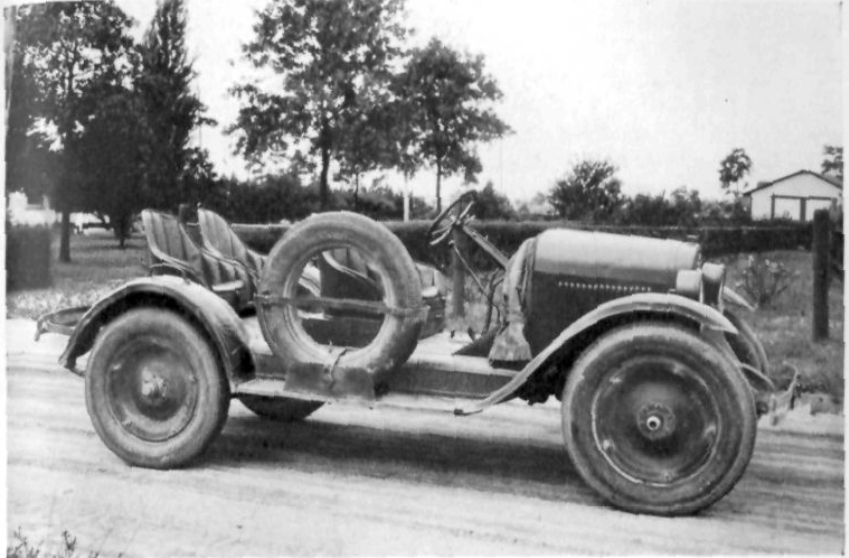
The Chief of Field Artillery's indorsement on this report directed that all future development be concentrated on the split-trail gun.

Chevrolet Cars: Sedan and Touring.—Test of these cars indicated their mobility was superior to other cars issued for similar purposes to date, due to their power, light weight and ground clearance.

It was recommended that to the extent the Cross-country Cars authorized are not available for issue, these cars be authorized for issue to each motorized brigade.

75-mm. Shell, E-1, Equipped with E-13 Fuse.—Report recommended that this shell and fuse be considered satisfactory except for the delay element of the fuse and the method of fastening of the projectile to the cartilage case.

Further, it was recommended that the ammunition be not adopted until these deficiencies were corrected.



CHEVROLET CROSS-COUNTRY CAR



WATER TANK AND PUMP, MOUNTED ON ORDNANCE LUMBER CHASSIS



THE WARNER SEVEN-TON TRAILER



ATHEY TRUSS-SHELL TRAILER, SIX TON

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Headsets, Type TS-3.—These headsets were of the regular TS-3 type except that they were equipped with push button cut-out block. The set can be used with the new type diaphragm gas mask and the helmet.

Cost Records System for Motorized Units.—A study was submitted providing for a practical cost records system and a discussion of measures to be taken to improve procurement, maintenance and retirement of field artillery motor vehicles.

Water Tank and Pump, Mounted on Ordnance Limber Chassis.—Pilot model of water cart was considered satisfactory by the Board. It was recommended that several water carts of this type be constructed and issued for extended service test, the cart when filled with water not to exceed 2200 pounds in weight, to be drawn by two horses, with mounted driver and artillery harness.

Diaphragm Gas Masks.—This type of mask, which does away with a mouth piece, was recommended as suitable for adoption for field artillery use.

Jacks vs. Chain Hoists for Mounting and Dismounting 240-mm. Howitzer Matériel.—This test included the use of hydraulic jacks, mechanical jacks, and chain hoists. Recommendations of the Board together with subsequent action by the Chief of Field Artillery have provided that the mechanical jacks be adopted and that the 240-mm. howitzers at Fort Bragg and Fort Sill be immediately equipped with these jacks. Also that development of the chain hoist system be continued.

Limbered Ration Cart on Ordnance Caisson Chassis.—Ration cart of this type was not recommended for adoption due to the method of distribution of rations within the infantry division.

Experimental Spare Wheel Hub Covers for 1334-mm. Wheel.—Type tested by the Board recommended for adoption with certain minor changes.

Experimental Hand Wire Cart.—An improved design of the RL-16 cart. The cart will carry either a commercial reel or two DR-4 spools. Recommendations were to the effect that pending development of a suitable hand reel with a light type field wire, the experimental hand wire cart with certain modifications be adopted for use for laying the battalion liaison officers' telephone line.

Pistol Cleaning Rods.—A wooden rod designed to clean the caliber 45 automatic pistol using the .30 caliber rifle cleaning patch.

It was recommended that this rod be not adopted since no provision was made for a brush.

Signal Lamps.—This test was to determine whether or not the EE-10 lamps should replace the EE-6 lamps pending development of improved light signaling equipment.

The EE-10 was not considered satisfactory on account of its

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weight and bulk. It was superior in many respects to the EE-6, however.

Fuse Wrench for Marks III, IV, and V Fuses.—The object of the test was to determine the suitability of one wrench for Marks III, IV, and V fuses when used with service shell of all field artillery calibers. Recommendations were to the effect that the wrench under consideration be considered satisfactory with certain modifications.

General.—Work with the different commercial trailers sent here for test with motorized batteries has served to bring out the limitations of the different types.

The Warner 7-ton trailer, employed in an attempt to find a commercial trailer which would carry the complete section equipment of a 240-mm. howitzer battery in one load, does not possess sufficient mobility and is too high for general loading.

The Athey truss-shell trailer, 6-ton, is an ideal trailer for a mud campaign. The question as to what extent we shall find it necessary to resort to this type is an important one and is being kept in mind for tests of this equipment that are scheduled for next fall and winter.

Hold-up Straps for Field Artillery Harness.—Sample hold-up straps submitted to the Board were tested. The Board considered that they were desirable but not essential under all conditions of draft. The design of these straps, together with a description of their attachment to the harness and their adjustment, will be incorporated in training regulation, in order that they may be made up by organization saddlers for artillery harness now in use. Suitable hold-up straps for traces will be a component part of all future manufactured harness. The Field Artillery Board has under test the several types of hold-up straps with the view of determining the most suitable for addition to the harness.