DESCRIPTIVE AND CALCULATED DATA FOR THE PRINCIPAL MODERN MILITARY RIFLES.

Rifle.	Country.	Cal.	$\frac{d^2}{w}$	Charge (grs.)	Bullet (grs.)	Cart. (grs.)	Length (inches.)	Twist (inches.)	Single Loader or Repeater.	Kind of Magazine. No. Cartridges.	Bolt or Block Mechanism.	Initial Velocity. (f. s.)	Muzzle energy per unit circum. (ft. lbs.)	Remaining energy per unit circum. 1,000 yards. (ft. lbs.)	Remaining energy per unit circum. 2,000 yards. (ft. lbs.)
Hebler	France	0.296	2.726	83	225	521	4.46	4.588	S. L.	.....	Bolt	1,968	2081.4	360.2	108.9
Lebell	France	0.315	1.799	83	225	521	4.46	4.588	S. L. & R.	.....	Bolt	2,034	3580.7	875.2	437.5
Frederi	Proposed for Italy	0.315	3.087	83	225	398	3.67	.....	S. L. mag. atch.	.....	Bolt	1,640	1358.1	256.8	85.8
Guedez-Kropatschek	Portugal	0.323	2.706	69.5	264	546	4.09	11.3	S. L. & R.	.....	Bolt	1,673	1617.4	336.1	126.2
Pierl	Experimental	0.323	2.572	83	284	.....	4.3	12.1	S. L. & R.	.....	Bolt	2,057	2637.7	460.5	183.6
Jarmann	Sweden	0.397	3.274	77	337	620	2.75	21.8	S. L. & R.	.....	Bolt	1,536	1415.8	262.0	80.3
Vitali Vetterli '70-87	Italy	0.414	3.845	62	312	468	2.24	26.28	S. L. & R.	.....	Bolt	1,430	1089.6	184.0	46.0
Vetterli	Switzerland	0.414	3.845	55	312	468	2.24	26.28	S. L. & R.	.....	Bolt	1,427	1084.9	183.7	45.8
Berdan	Russia	0.42	3.337	77	370	610	2.55	21.65	S. L.	.....	Bolt	1,444	1295.7	259.7	79.7
Mausier	Germany	0.433	3.4	77	386	663	2.42	21.66	S. L. & R.	.....	Bolt	1,571	1554.0	275.7	83.0
Kropatschek	French Navy	0.433	3.4	81	386	676	2.42	21.66	S. L. & R.	.....	Bolt	1,430	1288.7	254.9	76.6
Manlicher 1885	Austria	0.433	3.538	77	371	656	2.33	21.6	R.	.....	Bolt	1,575	1501.2	252.8	72.3
Gras 1874-80	France	0.432	3.4	80	386	676	2.42	21.66	S. L.	.....	Bolt	1,430	1288.7	254.9	76.6
Remington 1871	Spain	0.433	3.4	77	386	634	2.42	25.50	S. L.	.....	Block	1,340	1131.5	241.0	72.7
Martini-Henry	England	0.45	2.953	85	480	706	2.69	22	S. L.	.....	Block	1,315	1302.8	333.2	117.9
Springfield	United States	0.45	2.835	70	500	706	2.8	22	S. L.	.....	Block	1,301	1329.6	360.0	131.7

*The data upon which the calculations for the Lebell rifle were made were the best obtainable, but cannot be considered thoroughly reliable.

and an initial velocity of 2,007.9 f. s. instead of 1,301; and if we were then to change the bullet from one 2.8 to one 4.4 calibers in length, to correspond to the Hebler, our initial velocity would fall to 1,587 f. s., but our value for $\frac{d^2}{w}$ would also fall, and as low as 1.804, which would compare very favorably with the Hebler value of 2.726. This change in $\frac{d^2}{w}$ would give the new bullet a greater range, in spite of its loss in initial velocity.

Another striking fact is that, if we assume 4.5 calibers as the length of the bullet, we find the value of $\frac{d^2}{w}$ for a caliber of 0.35" to be 2.268, and for a caliber of 0.30", 2.648. This seems to indicate that for a bullet of a given number of calibers in length, a decrease of caliber causes an increase in retardation. Let us investigate this subject a little more in detail.

Assuming the bullet to be cylindrical in shape, the following equation holds for the Springfield service bullet, which is 1.26 inches in length and weighs 500 grains.

(1)
$$\frac{l \times \pi d^2 \times \text{weight 1 cu. in. lead}}{4} = 500.$$

And for any other bullet of the same material and shape we should have, representing its length in inches by l , its diameter in inches by d , and its weight in grains by w ,

(2)
$$\frac{l \times \pi d^2 \times \text{weight 1 cu. in. lead}}{4} = w.$$

Dividing (2) by (1), solving with respect to $\frac{d^2}{w}$, and multiplying both numbers by 7,000 in order to express the weight in pounds, we have

(3)
$$\frac{d^2}{w} = \frac{1.26 \times 0.45^2 \times 7,000}{500 l} = \frac{0.5529235}{l}$$

Substituting for l , $x d$, x being the length of the bullet in calibers, equation (3) becomes

(4)
$$\frac{d^2}{w} = \frac{0.5529235}{x d}$$

which shows that, for any value of d , the retardation decreases with an increase of the length of the bullet in calibers. The limit to the increase of x is found in the difficulty in giving rotation, and must be determined for any given motive force by experiment. According to the standard of the latest and most advanced experience, 4.5 is about the maximum value that can be given to x when gunpowder is used as the motive force. Making this substitution and reducing, equation (4) becomes

(5)
$$\frac{d^2}{w} = \frac{0.1228271}{d}$$

Regarding $\frac{d^2}{w}$ and d as the two variables, we recognize this as the equation of an equilateral hyperbola. The three curves shown by corresponding diagram correspond to values of x of 9, 4.5, and 2.8, respectively.

The ordinates are the values of $\frac{d^2}{w}$, and the abscissas of d , and from the rapid increase of the former in the ascending branch for small decrements in the latter, it will be seen that each reduction of caliber will be at the expense of a great sacrifice of power. The dotted lines

parallel to the axis of $\frac{d^2}{w}$ are drawn to show the relative sacrifice of power produced under the different suppositions, by a reduction of caliber from 0.45" to 0.30". It will be noticed that the longer the bullet in calibers, the smaller this sacrifice becomes.

When our motive force enables us to increase the length of our bullet, the obvious effect is to lower the retardation for equal calibers.

Since all these disadvantages must be the results of a reduction of caliber, why is it ever advisable to reduce it?

The rifle is a machine for doing work, and the work performed by the charge in giving a motion of translation to the bullet must be equal to the work performed by the man in overcoming the recoil of the gun. Now, work is the product of two factors, a force multiplied into a path.

When a soldier fires his rifle from the shoulder, the path is quite limited, and, since the amount of work is constant for a given charge bullet and barrel, the force must be comparatively great. It all hinges, then, upon the capacity of the man to take up the recoil. His limit in this respect constitutes the limit of muzzle energy of the bullet, and from this we can easily pass to the requisite caliber. The point to be insisted upon is that the caliber should always be as large as possible and the bullet as long as possible.

The old way of reducing recoil was to keep the caliber the same and reduce the charge or motive force. The present method is to keep the motive force as great as possible and decrease the muzzle energy and the recoil by reducing the caliber. This produces the necessary decrease with the minimum sacrifice of flat-

ness of trajectory and with the maximum increase of penetrating power. Every improvement, then, in the appliances for assisting the soldier to bear the recoil has the effect of increasing, and every improvement in the powder, or motive force, has the effect of decreasing the caliber of the theoretical gun.

The expedient of reducing the caliber in order to utilize an improved motive force should not be resorted to until exhaustive attempts have been made to increase our capacity for recoil work. After the limit of muzzle energy is fixed, there are several variables still to be determined, the principal one being the weight of bullet. The number of rounds of ammunition that the soldier is to carry, considered in connection with magazine guns, the relative value placed upon long and short range fire, and the limit to the increase of our motive force, are the three main points for consideration in fixing the weight of bullet. By substituting the selected value of w in equation (5), we obtain the best corresponding caliber.

To recapitulate, then, it may be said:

1. That European nations have made great improvements in their small arm cartridges, and, through a better control over the rate of combustion of their powders, have obtained a more efficient motive force.

2. In consequence of these improvements, they obtain an increase of muzzle energy, and this necessitates an increase of recoil.

3. There are two methods of meeting the difficulty of recoil: (1) to increase the soldier's capacity to overcome it by means of springs and buffers, thus retaining all the advantages of the increased motive force, and (2) to reduce the amount of the recoil by reducing the caliber, thus sacrificing part of the rifle's power.

B. W. DUNN, 2d Lt. 3d Artillery, U. S. Army.

THE JUPITER LIGHT.

The accompanying engraving illustrates a new "industrial" light now being introduced by the Harden

THE JUPITER LIGHT.

Star, Lewis & Sinclair Company, Cannon Street, London. It is intended to answer the same purpose as the well known Lucigen.

The principal feature of the Jupiter lamp is the mode of vaporizing the oil and preventing its escape in the form of spray, at the same time producing complete combustion, and giving a powerful and brilliant light. The lamp is lighted and controlled in the following manner: A small quantity of spirit is poured on the surface of the heavy oil contained in the well of the

lamp. This well is connected with the tank or reservoir of oil, which gives an uninterrupted supply; a light is then applied and the radiating covers put on. The compressed air is then turned on, which, passing by means of a small jet through the center of the flame and over the surface of the oil in the well, assumes a high temperature, and also produces an induced current, which raises the gas of the heated oil, and at the same time draws in the necessary supply of air to complete perfect combustion and produce a brilliant light.

It is claimed that this invention completely overcomes the defects of other systems, for the reason that, as there is complete combustion, no oil can possibly pass away in the form of spray, which in practice has been found to be a very serious matter, as oil spray has in a gale of wind been known to be carried many hundreds of yards, and damaging all property that came within its reach.

The power required to work the Jupiter consists of a compressor and receiver, 2 H. P. being sufficient to provide compressed air for lights equal to 10,000 candle power. The oil used for giving this brilliant light consists of common creosote oil, crude petroleum, or any other heavy hydrocarbons, which can be purchased at a very low price.

The photometric power of the Jupiter varies as required from 100 candle power to 2,500 candle power. The consumption of oil ranges from half to two gallons per hour.—The Engineer.

GAS FROM LIQUID FUEL.

By C. BROTHERHOOD, of Redland, Bristol.

THIS invention consists in apparatus constructed and arranged for the production, in an automatic manner, of gas from oil and other liquid fuel.

The oil for conversion into gas is supplied from a reservoir, A, situated at such a height as to afford a suitable head for the flow therefrom of oil to the retort,

and also to afford the required pressure of gas, by means of an adjustable stuffing-box and set screw below it. Or the cistern may be fixed, and a ball-cock employed governing the flow of oil through the pipe, D. By the siphon, E, the reservoir communicates with the retort, F, contained within the heating chamber, G. The pipe is fitted with a cock and with a "sight-feed" appliance, I, for observing the flow of oil to the retort. The heating of the retort is effected either by combustion of solid fuel placed on the fire bars, K, or by gaseous fuel in combustion supplied to a perforated burner, T; but when solid fuel is employed, the burner is withdrawn. The products of combustion escape preferably by two chimneys, L, situated at the opposite side of G. The gas generated in the retort passes out through the outlet pipe, M, by which it is conducted (either directly or through a receiver or collector) to the point of consumption. The pipe, M, is fitted with a safety valve, O, consisting merely of a siphon tube containing mercury. If, while the stopcock of the outlet pipe is closed, oil be admitted to the retort and subjected therein to the action of the fire, the pressure of the gas generated will, in due time, reach a point at which the column of oil is balanced, and the flow of oil to the retort thereby suspended; but on opening the cock, the gas escapes, and the equilibrium, of course, is destroyed. The oil then resumes its flow to the retort, and the production of gas is continued. Toward the lower end of the spindle, P, is a valve having an orifice extending through it. The spindle is connected at the upper end to the lever, Q, toward one end thereof. At that end of the lever is a balance weight; while at the other end it is connected to the spindle, R, extended into a chamber, and attached at the lower end to a flexible gas-tight web or diaphragm secured to the under side of the chamber. The chamber communicates with the receiver, S, to which gas is supplied by the pipe, M. As the pressure in the chamber, R, varies with the demand made upon the gas, the web or diaphragm is acted upon accordingly; and the valve is opened or

closed through the medium of the counterweighted lever, Q, the arrangement being such that a reduction in pressure in the diaphragm chamber causes a corresponding opening of the valve in P, and affords an increased supply of gas to the burner.

THE TREATMENT OF AMMONIACAL LIQUOR.

THE treatment of that by-product of tar distillation, ammoniacal liquor, has always involved many practical difficulties, which have been enhanced by the provisions of the alkali act prohibiting the escape into the atmosphere of gaseous combinations offensive to the public. At the Wear Patent Fuel Works, Sunderland,

maintaining settlers, E and E', and the saturator, C', form an independent arrangement in connection with the column, F. In case of need, however, both sets of saturators and settlers can be used for either the old or the improved process. After the settling process is completed, which usually takes about an hour, the clear liquor is passed into the evaporators, G and G', which are of the ordinary type, having in close conjunction drainers, H, on which the sulphate of ammonia deposited in the evaporators is afterward placed. Returning to the stripping process, the lime is introduced into the boiling ammoniacal liquor, as in the ordinary column process, in order to free the fixed ammonia, and one of the advantages of this improved method is that it facilitates the liming process, which is effected

FIG. 1.—FRONT ELEVATION.

various minor improvements have been made in the mode of treating the ammoniacal liquor for the purpose of extracting sulphate of ammonia, and since the beginning of last March a new method of dealing with the waste gases has been introduced. Through the courtesy of Mr. William Dixon, general manager of the Wear Patent Fuel Works, South Docks, Sunderland, and of the Redheugh Tar Product Works, Gateshead-on-Tyne, we are able to illustrate and describe this new process.

Prior to the date above mentioned, the "column" system was in vogue at the Wear Patent Fuel Works, and the plant is still retained, being made use of when the plant for the improved process is being repaired. The accompanying illustrations show in Fig. 1 an elevation and in Fig. 2 a plan of the complete plant. The first process through which the ammoniacal liquor passes is that of being boiled. This is effected in the "stripper," which is an egg-ended cylindrical boiler, A, 25 feet long and 6 feet in diameter, elevated above the ground, to allow the necessary connections of pipes to be made for carrying off the sedimental refuse to the drains. The boiling process is carried out by means of steam of 60 lb. per square inch pressure, which is passed into the stripper through a system of 2 in. copper pipes from the main boilers. The portions of the pipes inside the stripper are perforated, so that the steam comes into actual contact and mixes with the ammoniacal liquor. As soon as the latter has been raised

by injecting the lime by water pressure into the top of the stripper. Besides other minor advantages as compared with the column system, Mr. Dixon's improved arrangement obviates the necessity of heating the ammoniacal liquor prior to introducing it into the stripper. There is also a considerable saving of time, as the entire operation of treating 3,000 gallons of ammoniacal liquor is effected in the new plant in from eight to eighteen hours, according to the strength of the liquor, while in the old system ten to twenty hours were occupied in completing the process.

The disposal of the waste gases is also carried out by an improved method. The sulphureted hydrogen which accumulates in the saturators passes through suitable pipes, I, to the condensers, J and K. Previously these gases were discharged underneath the gates of the furnaces of the main boilers. This practice, however, had to be abandoned under the provisions of the alkali act. The gases are now conducted into the condensers, J and K, which are two flat-ended cylinders 12 feet high and 3 feet in diameter. They are connected together by a cast iron pipe, L, 8 in. in diameter, and placed at an angle so as to connect the bottom of the condenser, K, to the top of the condenser, J, as shown in Fig. 1. The gases enter J, and are therein partially condensed by the atmosphere and by a spray of water. After passing through the condenser, K, all the moisture in the gases is removed. The gases then pass through a 6 in. pipe into one of the two purifiers, M and

FIG. 2.—PLAN.

TREATMENT OF AMMONIACAL LIQUOR.

to boiling point, the supply of steam through the perforated tubes is cut off, and the boiling is continued by means of steam passing through a coil of pipes which is also located inside the stripper. The vapors from the ammoniacal liquor, which commence to evolve at a temperature of about 190° F., pass out of the stripper through metal pipes, B, to the saturators, C, situated in an adjoining building, where they are neutralized in the ordinary manner by means of sulphuric acid. As soon as the process of neutralization is completed the fluid is passed into the settlers, D or D', situated conveniently below the saturators; settlers, D and D', being in connection with the saturator, C, while the re-

N. Each of the condensers is provided with traps formed of 2 in. pipes for passing the retained moisture and the water used in condensing to the sewers. The purifiers shown are built of bricks, and are 7 feet square and 6 feet deep. Some distance above them is erected a substantial shed roof, O, to protect the oxide of iron with which the purifiers are filled from the weather. As already indicated, the gases from the condensers pass into the bottom of one of the purifiers, although two are provided, so that in case one becomes fully charged, the other is available while the sulphureted oxide of iron is removed and the purifier recharged.—*Industries.*

BUNSEN GAS BURNERS.

By C. AUER VON WELSBACH, of Vienna.

THIS invention relates to the construction of a Bunsen burner in such a manner as to produce a circular flame with internal as well as external air supply.

The gas, entering at the bottom, passes vertically through several small holes in a thin plate, G, into a cavity, A, into which air enters through lateral apertures, X. From the cavity the gas and air ascend a tube, T, which expands at its upper end to a diameter equal to that of the desired flame. The expansion is covered by wire gauze, W, which serves to mix the gas and air, and distribute the mixture uniformly through the enlarged part, B, of the tube. The mixture then ascends an annular passage, C, formed between the external tube, B, and an internal tube or thimble, D, which is closed at its lower end, and tapers to a larger diameter at its upper end. To the lower part of the thimble there lead several inlets, Y, for air from out-

side the outer tube, B; these inlets being formed by short tubes crossing the annular passage, C. At F (the upper end of the tubes) the mixture of gas and air issues from the annular mouth between them; and this mixture, being ignited, forms a circular flame, which receives air not only from the outside, but also from the interior of the thimble, D, to which the air is admitted by the inlets, Y. The upper part of the tube, B, and of the thimble, D, may be of metal, as shown. It is generally, however, preferable (says the author) to make the parts which are next the flame of steatite or such like material.

FAURE'S NEW SECONDARY BATTERY.

IN a patent recently issued to M. Camille A. Faure, the inventor describes a form of cell embodying several novel points. In the new battery, M. Faure employs two elements widely separated in the electromotive scale. They are composed of finely divided particles pressed together in a self-supporting mass or body, or composed of plates of metals having combined therewith finely divided and compressed particles of the same metal. Each element is inclosed by a diaphragm or septum of prepared asbestos, which consists of sheets one thirty second of an inch thick, dipped into a solution of soluble salt, such as the chloride of calcium or the chloride of barium. The sheet is then dried, after which it is dipped into a solution of a soluble silicate, such as the silicate of soda or a fluosilicate, which are capable of producing, with the first named substance, an insoluble compound.

The elements so prepared are placed in a cell containing an electrolytic solution, which must be of such a nature that in the process of electrolysis it forms an insoluble compound with the metal or metals composing either or both elements. Thus M. Faure takes zinc and copper, and combines with the zinc finely divided zinc and with the copper finely divided copper. The electrolytic solution preferably employed contains the phosphate of potash.

The accompanying cut (reproduced from the *Electrical World*) shows the cell diagrammatically. C and Z are copper and zinc plates, having combined with them the same respective metals in a finely divided compressed state. These are wrapped with asbestos, A, prepared in the manner described above, and immersed in the proper solution containing phosphate of potash.

On subjecting such a cell to the action of an electric current, phosphate of copper is formed upon the surface of the copper element, the phosphoric acid for this purpose being electrolytically separated from the solution, and combines with the copper to form an insoluble compound—i. e., the phosphate of copper. M. Faure then substitutes a fresh solution of phosphate of potash for the exhausted solution, and upon connecting the battery in a simple circuit for the purpose of discharge, phosphoric acid is transferred from the solution to the zinc, and from the copper to the solution, so that the solution remains unchanged as regards its constituent elements. Of course this preliminary