such bands in the red, lying on either side of the pair 7 and 8. . . . It might be well to state that the line, which I judge to be the auroral line, was in all cases the most noticeable, and especially so in discharges of heat electricity, which seemed to occur in the upper and more rarefied strata of the air."

SOLAR ACTIVITY.—Prof. Tacchini gives the following results of solar observations during the second quarter of this year (*Comptes rendus*, August 4):—

	No. of days of observation.	Relative frequence of spots.	Relative frequence of days without spots.	Comparative area of spots.	Comparative area of faculæ.	No. of groups of spots per day.
April	19	2·08	0·75	1·40	10·40	0·44
May	20	2·55	0·54	2·58	25·83	0·71
June	26	1·35	0·76	0·86	8·10	0·25

A comparison of these figures with those of the first quarter of this year shows that the spots are slowly increasing in magnitude, and that the number of days without spots is diminishing.

The following results have been obtained for the prominence:—

	No. of days of observation.	Mean number.	Mean height. ″	Mean extent. ″
April	19	1·90	35·2	1·5
May	20	1·55	37·9	0·9
June	26	2·42	27·7	1·3

DENNING'S COMET (*c* 1890).—Dr. A. Berberich has computed the following orbit of the comet discovered by Mr. W. F. Denning at Bristol on the 23rd ult., from observations made at Nice on the 24th and 25th, and at Strasburg on the 27th (*Astronomische Nachrichten*, No. 2982):—

$$T = 1890 \text{ Sept. } 24 \cdot 7573 \text{ Berlin Mean Time.}$$

$$\left.\begin{aligned} \omega &= 158^\circ\ 26'\ 64'' \\ \Omega &= 96\ 35\ 42 \\ \iota &= 99\ 37\ 67 \end{aligned}\right\} \text{Mean Eq. } 1890 \cdot 0.$$

$$\log q = 0 \cdot 12288$$

$$\Delta\lambda \cos\beta = +0' \cdot 08;\quad \Delta\beta + 0' \cdot 06.$$

Ephemeris for Berlin Midnight.

1890.	R.A. h.	m.	s.	Decl. °	′
Aug. 14	15	22	56	+52	45·7
15		23	42	51	22·0
16		24	29	49	57·4
17		25	16	48	32·0
18		26	4	47	5·9
19		26	52	45	39·2
20		27	41	44	11·9
21		28	30	42	44·3

Brightness = 1·82 on August 17, and = 1·95 on August 21, that at discovery being taken as unity.

The comet will pass perihelion about September 25, at a distance of 1·33 the mean distance of the earth from the sun.

From the ephemeris given it will be seen that the comet is between β Boötis and θ Draconis on August 15.

GEOGRAPHICAL NOTES.

THE Russian *Official Messenger* of August 1 gives the following news about the work done by M. Grombchevsky during last spring. On March 13 the expedition left Khotan for Niya. After having passed through the oasis of Keria, the travellers crossed the desert, where they met with a succession of *barkhans* (downs), reaching to the unusual height of 200 feet. From Niya they visited the Sougrak gold-mines, which are worked by nearly 3000 families living in caverns excavated in the loess and conglomerates on the slopes of the hills. Lumps of gold 2 lbs. in weight are sometimes found in these mines. Leaving Niya, the expedition crossed the border-ridge, which consists of several chains—the passes across them attaining heights of from 10,500 to 11,000 feet—and reached Polu, whence it returned to Keria. There M. Grombchevsky received the good news that the expedition would be allowed to continue its work till January 1, 1891, and that £200 had been granted for that purpose; so that M. Grombchevsky made arrangements to start for Rudok, in Tibet, in the first half of May.

THE following telegram about M. Grombchevsky's expedition, dated Marghilan, July 19, has appeared in the Russian *Official Messenger*. The expedition had reached Polu, but had been stopped there by the Chinese authorities, who insisted upon the immediate return of the expedition to Kashgar, and ordered the population to leave their settlements and to camp in the mountains. Brought to despair, M. Grombchevsky spent his last money in bribing some inhabitants, and, without a guide, left Polu in the night of May 17, going further south into the depth of the unexplored wilderness.

THE last number of the *Izvestia* of the Russian Geographical Society is of unusual interest, especially on account of its maps. It contains three reduced photographic copies of the hypsometric map of Russia, by General Tillo, and it is impossible not to admire the distinctness with which the two chief lines of upheaval, the south-west to north-east direction, and the north-west to south-east direction, appear on this map, even amidst the plateaus and the depressions of middle Russia. Another interesting map renders, on a scale of 7 miles to the inch, the surveys of M. Grombchevsky, made during his recent attempts to reach Tibet from the north. The map is accompanied by two letters from the explorer, written in December 1889, at the sources of the Khotan-daria and the Kara-kosh. The same issue contains a letter from the chief of the Tibet expedition, M. Roborovski, dated from Niya, December 11, 1889; a paper on the geodetical surveys in Russia; and a most interesting summary, by M. Kuznetsoff, of his several years' study of the flora of the Caucasus.

IN a communication to the Société de Géographie of Paris, M. G. Marcel, who is one of the librarians of the Bibliothèque Nationale, has given some particulars of Louis Boulanger, an astronomer, geometer, and geographer of the sixteenth century. In 1511 he published at Lyons a work, "Equatorii Cœlestis Motus," of which only one copy is known. It is in the Bibliothèque Mazarin, and is described by M. Marcel as hitherto ignored by bibliographers. In 1514 he brought out a piracy of Muller's "Cosmographiæ Introductio." The globe accompanying this is regarded as the first on which the word "America" is found. Another globe has been found by M. Marcel at the Bibliothèque Nationale, which he regards as having been made by one of the school of Schoener between 1513 and 1518, and on it the then new name of the New World occurs four times. It is therefore either the first or the second cartographic document in which America is mentioned.

THE SCIENTIFIC PRINCIPLES INVOLVED IN MAKING BIG GUNS.[1]

III.

PART III.—WIRE GUN CONSTRUCTION.

AN inspection of Fig. 5 (p. 307), and of the serrated edge of the curve of circumferential tension, *t*, shows that only the inner fibre of each coil is doing its full share of resistance when the gun is fired.

Great economy of material can be effected if we can make all the circumferential fibres take up a full uniform working tension (say of 18 tons per square inch) when the gun is fired; but to secure this condition only approximately, the number of coils would have to be largely increased, and the cost, complication, and time of manufacture of a gun would be enormous.

But, by adopting Mr. J. A. Longridge's plan of strengthening the inner tube A by steel wire, wound round with appropriately varying tension, we are theoretically able to make the curve of circumferential firing tension, *t*, a straight line for a determinate powder pressure; and now all parts of the wire coil are equally strained, and take an equal share in the resistance.

The subject has been investigated theoretically by Mr. Longridge, assisted by Mr. C. H. Brooks, beginning in 1855; and his theories are set forth in papers in the Proceedings of the Institution of Civil Engineers in 1860, 1879, 1884, em-

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[1] Continued from p. 334.

bodied in Mr. Longridge's "Treatise on the Application of Wire to the Construction of Ordnance," 1884 (Spon); and again in a paper in 1887, "Further Investigations regarding Wire Gun Construction."

Dr. Woodbridge, of America, claims to have originated the system of strengthening guns with wire, in 1850; but to Mr. Longridge belongs the credit of pointing out the proper mode of winding on the wire with initial tension so adjusted as to make the firing tension of the wire uniform for the maximum proof powder pressure.

Mr. Longridge's principle is applicable not only to engines of destruction, but also to peaceful purposes, such as strengthening the cylinders of hydraulic presses and lifts, and the copper pipes of steam-engines; for which a great, and, we hope, a profitable future is in store.

Returning to the application of the principle to artillery, the great object attained is the notable reduction in weight of the gun—a matter of importance in siege artillery, where the weight of the largest single piece of metal, the gun itself, is limited by the difficulty of transport over bad roads and rough country. By the use of Mr. Longridge's principle, the weight of a howitzer can be reduced from five tons to three and a half—quite sufficient to make all the difference between getting the gun into position, or being compelled to leave it behind.

It is also claimed as an advantage of the wire gun that the construction will be found cheaper and more expeditious, when once the appropriate machinery is erected; and that this machinery need not be nearly so elaborate and expensive as that required with the present system of construction with steel coils shrunk on over each other.

As we have seen in Part II., the appropriate initial state of stress is, in the coil gun, dependent on such delicate fitting as thousandths of an inch, and a slight irregularity in the texture of the metal may be sufficient to completely modify the initial stresses as designed. With the wire gun, on the other hand, the wire can be coiled on to the inner tube from an equal parallel coil of wire, and the appropriate tension given by means of a certain weight running on the free part of the wire, and incidentally testing the strength of the wire. Certain practical difficulties exist in securing the ends of the wire, and in providing for longitudinal strength, which experience will doubtless soon overcome.

Besides Mr. Longridge's "Treatise," the most important is a long article in the *Revue d'Artillerie*, on "Steel Wire Guns," by Lieutenant G. Moch, since published as a separate book, and also translated in the American "Notes on the Construction of Ordnance," No. 48, 1888.

Lieutenant Moch resumes Longridge's and Brooks's calculations, and presents the mathematical work in a more concise and elegant form; he applies his formulas to the design of the wire guns, proposed in 1871 by Captain Schultz, who was unaware of Mr. Longridge's previous work.

We shall attempt here to present the essence of Lieutenant Moch's article in a concise and geometrical form, depending on the method and formulas of Parts I. and II., and illustrated by the design of one of Schultz's guns; referring the reader who wishes to pursue the subject in all its practical details to Moch's original article, and to Longridge's "Treatise."

(44) Taking the cross-section of the gun across the powder-chamber, as composed of the inner tube, A, the wire coil, B, and an outer jacket, C, then in the ideal state, the firing stresses will be represented in Fig. 9, where the curve of circumferential tension, $t_1tt'_2$ is a straight line in the wire coil B.

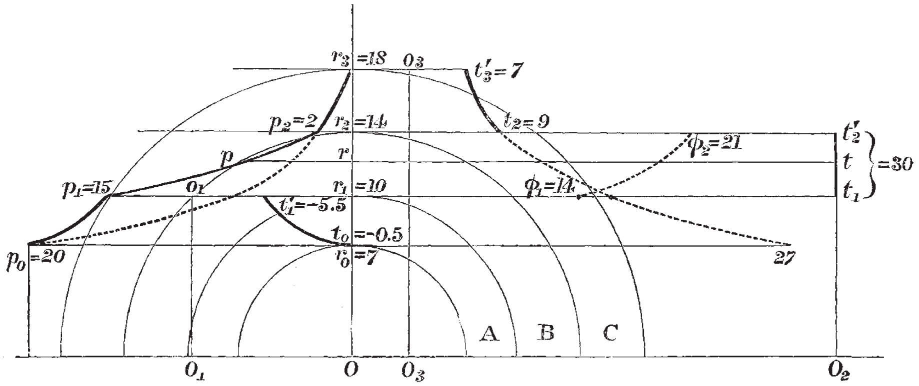

FIG. 9.

The outer jacket, C, is merely required for protection of the wire from damage by shot, so that it may be supposed fitted over the wire without any appreciable shrinkage; when the gun is at rest, the jacket C will then be in a state of repose free from stress; but when the gun is fired, we may suppose the stresses in C to be the powder-stresses (§ 12, p. 306), on the assumption that the gun behaves as if homogeneous.

We denote by r_0 the internal radius of the tube, by r_1 and r_2 the internal and external radii of the wire coil, and by r_3 the external radius of the jacket, all measured in inches in our units.

Then in the jacket C the curves t'_3t_2 of circumferential tension and r_3p_2 of radial pressure, representing firing stresses, will be Barlow curves, the reflexions of each other in their medial axis O_3o_3.

(45) The continuation of the Barlow curve r_3p_2 in the dotted line up to p_0 will give graphically the powder pressure p_0; but now the curve of firing radial pressure between r_2 and r_0 will be the broken curve $p_2p_1p_0$, of which p_1p_0 in the tube A is the portion of another Barlow curve, but of which p_2p_1 in the coil B is easily seen to be a portion of a hyperbola.

For the curve of firing circumferential tension in the wire being the straight line $t\mathrm{O}_2$, the condition of equilibrium of any cylindrical portion of the wire coil, bounded internally by the radius r, requires that the rectangle r_2t of circumferential resistance should be equal to the rectangle $\mathrm{O}p$ − rectangle $\mathrm{O}p_2$; or, in other words,

$$\text{the rectangle } p_2t = \text{rectangle } \mathrm{O}p,$$

or

$$\text{the rectangle } \mathrm{O}_2p_2 = \text{rectangle } \mathrm{O}_2p;$$

which proves that the curve p_2p is a hyperbola, with $\mathrm{O}_2\mathrm{O}$ and O_2t as asymptotes.

(46) The tangent at any point of this hyperbola—say at p_2—is drawn by joining the point p_2 with points on $\mathrm{O}_2\mathrm{O}$ or O_2t at double the distance of p_2 from O_2t or $\mathrm{O}_2\mathrm{O}$, by a well-known property of the hyperbola.

But to draw the tangent at p_2 of the Barlow curve r_3p_2, we must join p_2 with a point on $\mathrm{O}_3\mathrm{O}$ at a distance from O_3 treble the distance of p_2 from O_3o_3.

Similarly we can draw at p_1 the tangent to the hyperbola p_2p_1, and the tangent to the Barlow curve p_1p_0, when we know the position of O_1o_1, the axis of this Barlow curve, p_1p_0.

(47) The position of O_1o_1 is fixed by the condition that the curve of circumferential tension in the tube A is the reflexion of the curve p_1p_0 in O_1o_1; and the position of this curve of circumferential tension, $t_0t'_1$, is settled by the condition that the rectangle $\mathrm{O}p_0$ is equal to the sum of the areas of circumferential resistance, bounded by $t_2t'_3$ in the jacket C, by the straight line $t_1t'_2$ in the wire coil B, and by the curve $t_0t'_1$ in the tube A.

(48) It will be noticed in the diagram that, with the numbers given there, the curve $t_0t'_1$ lies to the left of the line r_0r_1, showing

that when the gun is fired the interior of the tube is still in a slight state of compression, so that the circumferential firing stresses of the tube are insignificant pressures, the chief stress being thrown upon the wire.

This theoretical result appears to be of great practical advantage in prolonging the life of the gun, as it is found that the tube of the wire gun has hitherto shown an unexpected vitality; a very gratifying result, when it is considered how short the life of our large guns is, in consequence of the erosion of the bore.

An empirical formula, $N = 2400 \div c - 50$, given by General Maitland (Proc. I.C.E., vol. lxxxix. p. 205) for the life of a gun, where c denotes the calibre in inches, and N the number of full charges that can be fired before the gun requires relining, will illustrate forcibly the comparative longevity of large and small guns: thus, if $c = 16$, $N = 100$; if $c = 12$, $N = 150$; but if $c = 0{\cdot}3$, as in the new magazine rifle, $N = 7950$.

We have now determined graphically the firing stresses in the wire gun, where the powder pressure, p_0, is exactly adjusted, so as to produce uniform t in the wire; a less powder pressure would obviously strain the inner fibres less, and less than the outer fibres; *vice versâ*, a powder pressure greater than p_0.

(49) But now the gun-maker has to determine the initial stresses in his gun from the above state of firing stress, by the operation of stripping off the powder stresses, assuming the gun to behave as if homogeneous.

As a first consequence, the initial stresses in the jacket C will be reduced to zero, as they should be; because we have supposed the jacket C slipped on with merely a mechanical fit.

Secondly, in the wire coil B, the state of initial circumferential tension will be obtained by subtracting the ordinates of the prolongation of the Barlow curve t'_3t_2 from the ordinates of the straight line t'_2t_1; whence we obtain the symmetrical Barlow curve $\phi_2\phi_1$, by reflexion of the Barlow curve $t'_3t_2 \ldots$, produced.

The curve of radial pressure $r_2\varpi_1$ in the wire coil B, obtained by subtracting the ordinates of the Barlow curve p_2p_0 from the hyperbola p_2p_1, is now easily plotted, but is of a more complicated analytical character.

Finally, we come to the state of initial stress in the tube A, obtained also by stripping off the powder stresses from the firing stresses; and consisting of the curve of initial radial pressure ϖ_1r_0, a Barlow curve, and its reflexion, $\tau_1\tau_0$, the curve of circumferential pressure in the tube A; the position of $\tau_1\tau_0$ being settled so as to make the area $r_1\tau_1\tau_0r_0$ equal to the area $r_1\phi_1\phi_2r_2$; and now the state of initial stress is represented in Fig. 10.

(50) We notice that τ_0 is considerable, and may with imperfect design become dangerously near the crushing pressure of the material of the tube A; practically, however, the great crushing pressure τ_0 is considered advantageous, as tending to improve the resisting power of the material against the great enemy, erosion.

In the Severn tunnel, as a different exemplification of these principles, the crushing effect in the brick tube, due to the head of water of the land springs, was not allowed for sufficiently; if the land water around the tunnel is not kept down by pumping, the head of water soon becomes sufficient to cause the bricks on the interior of the tunnel to crush and splinter; and until the interior is strengthened considerably with steel or cast-iron curbs, the expense of pumping cannot be avoided.

(51) There is considerable divergence of opinion as to the proportions to be given to the tube A and the wire coil B; Longridge preferring a comparatively thin tube, A, of some softer material, like cast-iron, while Schultz made his tube of steel, and considerably thicker in proportion, with the advantage of throwing the longitudinal strength into the tube.

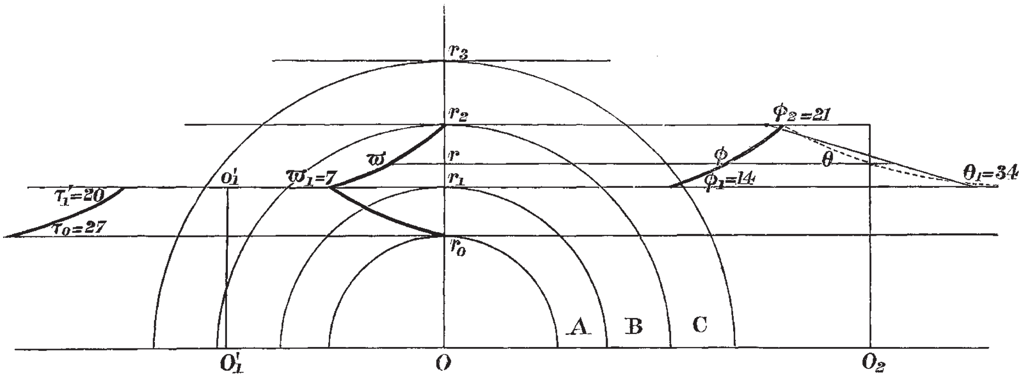

FIG. 10.

As the theory is considerably simplified if we take the tube A and the wire of the coil B of the same elasticity, we shall make Fig. 9 represent the design of one of the Schultz guns, as described by Moch, altering the dimensions and stresses to round numbers in inches and tons.

Now Figs. 9 and 10 represent the section across the chamber of the Schultz 34-centimetre ($13\frac{1}{2}$-inch) gun, in which we have made $r_0 = 7$, $r_1 = 10$, $r_2 = 14$, $r_3 = 18$, in inches, to the nearest integer.

(52) We assume that, under a powder-pressure, p_0, of 20 tons on the square inch, the wire coil is under a uniform circumferential tension of 30 tons on the square inch; a very moderate estimate for what steel wire is capable of sustaining, as 60 would not be excessive.

Numerical calculation by means of the formulas of Part I. gives the following values of the stresses, in round numbers:—$p_2 = 2$, $p_1 = 15$; $t'_3 = 7$, $t_2 = 9$, $t'_2 = t_1 = 30$, whence $\phi_2 = 21$, $\phi_1 = 14$; $t'_1 = -5{\cdot}5$, $t_0 = -0{\cdot}5$, all in tons per square inch.

In Fig. 10 the initial stresses are represented; and we find, as before, $\phi_2 = 21$, $\phi_1 = 14$, $\varpi_1 = 7$, $\tau'_1 = 20$, $\tau_0 = 27$, while the initial stresses in the jacket C are *nil*.

(53) There still remains an important practical detail to be settled theoretically—the formula for the varying tension with which the wire must be wound on the tube A, in order that when the coil is complete the curve of initial tension of the wire should become finally $\phi_1\phi_2$.

The formula has been investigated in all its generality by Mr. Brooks in Longridge's "Treatise," but we shall follow Moch in his article in considering the very much simplified case of uniform modulus of elasticity.

As we have already used the word *initial* to distinguish the stresses in a gun in a state of repose when finished, we shall call the varying tension with which the wire is wound on the gun the *winding tension*, and denote it by θ, in tons per square inch.

(54) Now, to determine θ for any radius, r, of the coil B, Moch assumes that the winding tension of the wire is equal to the initial tension, ϕ, increased by the circumferential tension (pressure) due to the initial radial pressure, ϖ, at the radius r, acting on the partly finished tube and coil between the radii r_0 and r; and thus

$$\theta = \phi + \varpi\frac{r^2 + r_0^2}{r^2 - r_0^2}.$$

In other words, it is assumed that the tension of repose, ϕ, is less than the winding tension, θ, by the amount due to the pressure ϖ at a radius r, and zero pressure at the radius r_0, treating the material as homogeneous.

Now, by the formulas of § 7 (p. 305),

$$\phi = t - p_0 \frac{r^{-2} + r_3^{-2}}{r_0^{-2} - r_3^{-2}},$$

$$\varpi = p - p_0 \frac{r^{-2} - r_3^{-2}}{r_0^{-2} - r_3^{-2}}$$

$$= (p_2 + t)r_2 r^{-1} - t - p_0 \frac{r^{-2} - r_3^{-2}}{r_0^{-2} - r_3^{-2}},$$

where

$$p_2 = p_0 \frac{r_2^{-2} - r_3^{-2}}{r_0^{-2} - r_3^{-2}},$$

so that

$$\varpi = t(r_2 - r)/r - p_0 \frac{r^{-2} - r_2^{-2}}{r_0^{-2} - r_3^{-2}};$$

and the expression for the winding tension, θ, finally reduces to the form—

$$\theta = A + \frac{L}{r} + \frac{M}{r - r_0} + \frac{N}{r + r_0},$$

where

$$A = \frac{p_0 r_0^2 (r_3^2 - r_2^2)}{r_2^2 (r_3^2 - r_0^2)} = p_0 \frac{r_2^{-2} - r_3^{-2}}{r_0^{-2} - r_3^{-2}} = p_2,$$

$$L = - t r_2,$$

$$M = t(r_2 - r_0) - p_0 r_0 \frac{r_0^{-2} - r_2^{-2}}{r_0^{-2} - r_3^{-2}},$$

$$N = t(r_2 + r_0) + p_0 r_0 \frac{r_0^{-2} - r_2^{-2}}{r_0^{-2} - r_3^{-2}},$$

after considerable algebraical reduction.

(55) A great simplification is introduced if we put $r_3 = r_2$, equivalent to supposing that the jacket C fits loosely over the coil B, so that the firing stresses do not extend into the jacket C, which, therefore, now contributes nothing to the strength of the gun; and now $A = 0$, $L = - t r_2$, $M = t r_2 - (t + p_0) r_0$, $N = t r_2 + (t + p_0) r_0$; and we thus obtain the formula (51) of Longridge's "Treatise," or formula (50) of Moch's article.

With the numbers of Fig. 10, we find $\theta_1 = 34$, while obviously we always have $\theta_2 = \phi_2$, as the winding tension of the last layer of wire is the same as the tension in repose.

Having plotted out by points the curve $\theta_1\theta_2$ for the winding tension θ, a curve of the fourth degree, it will be found practically correct enough to replace it by the most approximate straight line; and now in winding the coil, the difference of the tension weights destined for two consecutive layers of wire remains constant.

(56) We have now finished the theory of the wire gun, so far as the circumferential strength is concerned; and for its experimental verification, an interesting article in Note No. 38, on the Construction of Ordnance, "On Winding and Dismantling an Experimental Wire-wound Gun Cylinder," by Lieutenant W. Crozier (Washington, June 1886), may be consulted; and according to recent reports a 10-inch gun has been recently constructed in America by Captain Crozier, on designs based upon his experimental results.

The theory of the longitudinal stresses in the wire gun has not been touched upon, because it is still a point of dispute as to whether the tube alone should provide the longitudinal strength, or whether it should be partly borne by the outside jacket, the wire coil being obviously unable, except in Canet's double coning system, of giving any assistance in this direction.

Mr. Longridge's principle of strengthening a tube with wire, wound with appropriately varying tension, will be found useful in peace and in war: he can claim credit that a gun strengthened on this principle, the 9·2-inch wire gun, was chosen from its great strength to test the extreme range of modern artillery in 1888, with what were called the "Jubilee rounds"; when, with an elevation of about 40°, a range of 21,000 yards, or 12 miles, was attained, the projectile weighing 380 pounds, and the muzzle velocity being about 2360 f.s.

The dimensions in the diagrams have been purposely taken in round numbers, so as not to represent invidiously any particular gun; in some cases, inappropriate stresses have made their appearance; and now it is the art of the gun-designer to modify slightly the dimensions of the parts of his first rough sketch, so as to attain to more uniformity of strength and a better theoretical result.

There is no claim to originality in the theory that has been given above, and we fear that due credit has not always been properly assigned to the right investigator; but the attempt has been made to present the essential points of the theory in as simple a form as possible, with a minimum recourse to algebraical formulas. The subject has been written about so much of late years that the reader is apt to be confused with the variety of notation and treatment; and it is hoped that the graphical method presented here will enable the theorist to present his results to the practical gun-maker in a more intelligible and convincing form.

A. G. GREENHILL.

ON PUTREFACTIVE ORGANISMS.[1]

THE author said his difficulty was to decide in which way to treat his subject. He might summarize the investigations of twenty years, and endeavour to show the original motives which led to their being undertaken, and then contrast this with the new meaning which has been derived from the investigations founded on recent methods and instruments; or, secondly, he might show the results of a series of continuous observations on certain saprophytic organisms placed under increasingly adverse environments, so as to endeavour to discover their behaviour in regard to the great Darwinian law. He inclined to this last as the view of his work that might have the broadest interest to a Society like that he was addressing; but the value of the improvements in recent lenses led him to give the priority to the results so obtained. In the case of larger animals, it was well known that a change of environment produced changes in the organism; but that these changes were hard to follow up, owing to the few generations that come under the notice of the student or observer. But in the case of micro-organisms the generations succeed each other so rapidly that it is easy to follow the changes produced by environment. He could show the effect on certain micro-organisms of a gradual change of temperature, and how in from seven to eight years an organism arose which lived and multiplied at a temperature of 157° F., whose ancestors had lived at a temperature of 65° F., and would have died if exposed to temperatures above 100°. He said there was nothing harder than to carry an audience to a just appreciation of the lower forms of life, but nevertheless he hoped to point out some of the practical results due to the improvements in modern microscopes. If they took a glass of drinking-water and put in it some shreds of fish, or any other organic substance, it soon became turbid and charged with the minutest organisms. To illustrate the number of these organisms, Dr. Dallinger said that visible to the human eye in the heavens there were in all probability with our most powerful modern telescopes 100,000,000 stars; and if they supposed that each of these, like our sun, was attended by eight primary bodies and twenty secondary planets, there would be two thousand eight hundred millions of bodies in space accessible to human research. The same number of these minute organisms to which he had referred would lie in a space equal to one ten-thousandth of a cubic inch. Any such a molecule of even dead matter must arrest the attention of the human mind; but when we remembered that these were complex *vital* forms, they had a significance of a high order, and their inconceivably rapid multiplication would make the mind pause and think. A decomposing mass of matter was a mass of beings endowed with life, and producing definite products. The life of the organism was not even an incidental product, the organisms were there for a purpose. They break up the decomposing organic matter into its elements, and so make it ready again for the purposes of life. Dr. Dallinger went on to describe some of the organisms which he has observed and examined. He said, that if they took some putrescent fluid from different putrefactive material, and mixed them, then put a very minute quantity of sterilized fluid on the microscope slide, and put into this the point of a needle which had been inserted into the mixture of putrefaction, and examined it with a sufficiently powerful microscope, the field of view in the microscope became, as it were, charged with life in an instant. There were many kinds of organisms, and they had many movements. There were rod-shaped organisms, spiral forms, a perfect oval form with two flagella, or whips. Another would be like the calyx of a papilionaceous flower, and have four flagella. Another would have a delicate egg-shape, and another be shaped like a double convex lens, and move with a beautiful wave motion. The fluid speck seen under the microscope was densely peopled. What were these organisms, and what their functions amid the denizens

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[1] Abstract of an Address delivered before the Bristol Naturalists' Society, by the Rev. W. H. Dallinger, F.R.S.