tem, without regard to any doubtful questions which have been raised as to the exactness of their correspondence with their theoretic, or ideal, values."

Captain Kater, in 1818, determined with great care the value of the metre at a temperature of 32° Fahr., in inches of Shuckburgh's copy (made by Troughton) of Bird's standard yard at 62° Fahr. Kater found that one metre at 32° Fahr. equals 39.37079 inches at 62° Fahr. This will make the metre equal to 39.3685 United States standard inches at 62° Fahr. According to Kater's demonstration, the quadrant of the meridian passing through France contains 393,707,900 English inches.

From the standards of length are derived the standard weights, in this manner: A cylinder is very accurately constructed, and its volume is determined by making many measures of its height and of its diameter. The cylinder is now weighed in a vacuum at a known temperature. It is then weighed in distilled water at the same temperature. When weighed in the water it loses a portion of its weight which exactly equals the weight of its volume of water. Hence, as the volume of the cylinder is known in either cubic inches or cubic centimeters, and as the coefficient of expansion of water is known, we can readily compute the weight of a cubic inch or of a cubic centimeter of water at any temperature which may be decided upon as that at which the weight of a certain volume of water shall equal the standard of weight.

In our system of weight a cubic inch of water at 62° Fahr. weighs 252.456 grains troy.

In the metric system of weight, one cubic decimeter of water at 4° centigrade weighs one kilogramme. Hence, one cubic centimeter of water at 4° centigrade weighs one gramme. Our imperial gallon contains 10 pounds, 7,000 grains troy, of distilled water at 62° Fahr.

By act of Congress of May 19, 1828, the brass troy pound procured by the American minister to London in 1827, which is a copy prepared by Captain Kater of the English standard, was declared the standard troy pound of the United States mint, and is to be used in adjusting the weight of the United States coins.

In France there also exists a simple relation between their metric system and their coinage. "The weight of the silver franc is 5 grammes = $7\frac{7}{16}$ grains. It is composed of an alloy consisting of 9 parts by weight of silver and 1 part of copper. Twenty silver francs, therefore, weigh 100 grammes; and as the French law makes both the gold and the standard silver coins equally legal tenders for all sums, and fixes arbitrarily the relative value of the two metals for equal weights in the ratio of 1 to $15\frac{1}{2}$, it follows that 20 francs in gold weigh $6\frac{4}{100}$ grammes, very nearly; and this is the weight of the gold napoleon. But, inasmuch as the relative value of gold and silver bullion has been till recently represented by a ratio of about 1 to $15\frac{3}{100}$, it follows that 100 grains of silver in bullion have been during this period equivalent to $6\frac{4}{100}$ grammes of coined gold, that is to say, have been worth more than a gold napoleon. Silver bullion, therefore, brought more in the market of France than silver coin. Hence, silver coin of standard fineness long ceased in that country to be a part of the circulating medium. The standard silverfranc and half-franc have consequently ceased to be struck; and in order to provide a currency of small coin for daily use in petty transactions, the Government of France and the other parties to the quadripartite treaty (France, Belgium, Switzerland, and Italy), of 1865, resorted to a debased coinage, composed of alloy containing only 835 parts of silver in the thousand, instead of 900. This is a legal tender only for sums below 5 francs.

[NATURE.]

ELECTRICITY IN WAR.

By H. BADEN PRITCHARD.

THE important role played by electricity in modern warfare affords an excellent example of the influence which science has of late exerted in naval and military affairs. It is no isolated example of scientific warfare that we have here to deal with, for the electric fluid has in a great measure changed our whole practice of war, and bids fair to revolutionize it still more in the future. Every soldier or sailor, if he desires to make his mark, must be something of an electrician, for there seems to be no limit to the useful applications of the galvanic spark in battle. Broadly, we may divide these applications under three heads; namely, the employment of electricity for signalling, for the explosion of charges, and lastly, for illumination, both for the purposes of attack and defence, it being a difficult matter to decide in which connection the electric spark fulfils the most important duty.

To begin with the telegraph. All will agree that it is well-nigh impossible to overrate the advantages which this rapid means of communication gives to the general, in these days, when the line of battle sometimes extends for a dozen miles. Let the commander occupy the most central position, a long time must elapse before his aides-de-camp can communicate with one wing or the other. Assisted by the electric telegraph, however, the general is as close to his subordinates as if he were within shouting distance. Even a brigade of horse artillery, or a cavalry division advancing at a gallop, can carry its telegraph equipment with it, the operators accompanying a flying column of this nature with but very little difficulty. The wire drums are started off at a gallop, the cable being unwound as the carts proceed, and a sergeant on horseback with a "sounder" to his ear, in connection with one end of the wire, receives the general's commands as soon almost as they are spoken. The movement countermanded or a retreat ordered, the cable is again wound up as readily as it was laid down, and the telegraphers make good their return with the rest of the troops. Where ordinary movements are executed, use is of course made of the telegraph wagon, a comfortable little office on wheels, furnished with all things necessary for the receipt and dispatch of messages, but this convenience is naturally out of place where a rapid change of front, or some speedy flank movement has to be executed.

Coming next to the explosion of charges by means of the electric spark, we enter upon a phrase of war-science which bids fair to grow to infinite proportions. Both Franklin and Priestley suggested the employment of electricity in this connection more than a hundred years ago, but it is very recently indeed that we have been in a position to make proper use of this valuable agent as a means of firing charges at a distance. In fact, at the present moment we have by no means exhausted research in this direction, and we find scientific soldiers and sailors still at variance with one another as to the best plan of using the electric current for firing purposes. One of the first applications made of the

subtle fluid was in the removal of the wreck of the Royal George, at Spithead, nearly fifty years ago, when the explosion of the charge was brought about by what was termed a wire-fuse, or in other words a short piece of platinum thread stretched between two copper wires. The platinum bridge having less conducting power than the copper wires, presents a considerable amount of resistance to any current of electricity that passes, and, in doing this, becomes so heated as to be capable of igniting any particles of gunpowder in contact with it. A wire-fuse of this description has simply to be placed in the middle of a charge, and if then a current of electricity is passed from a battery along the wire in connection with the fuse, instantaneous ignition is the result. This simple method of firing charges under water was a vast improvement over the old one in use by our engineers, which consisted in leading up a metal pipe from the charge to the surface of the water; the outlet of the pipe was placed as far as possible from the charge beneath the water, and then a ladle full of red hot shot was emptied down it and so reached the gunpowder below, which thereupon exploded if the iron fragments had not become too cool in transit.

But for many purposes the wire-fuse is ill-adapted to the military and naval services. A voltaic battery is necessary to evolve the low-tension electricity required to yield sufficient resistance and heat, and such a battery made up of metal plates, and involving the use of acids, is an awkward apparatus to carry in the field. Already in 1853, this fact seems to have occurred to a Spanish officer, Col. Verdu, who determined to see what could be done in the way of exploding gunpowder by a spark, or in other words, by high tension electricity. Aided by a Ruhmkorff coil he succeeded in firing half-a-dozen charges simultaneously, and although the discharge was sometimes a matter of considerable uncertainty, to Verdu certainly belongs the credit of having been the first soldier to apply electricity in this way to the firing of one or more mines. Wheatstone and Abel followed in Verdu's footsteps; and while the former directed his attention to the construction of a frictional apparatus of a portable nature, which should be suitable for military use, the latter busied himself in the preparation of a fuse inclosing a compound more delicately explosive than gunpowder, a fuse, by the way, which still retains an important place among our warlike stores.

It was in the China war of 1860 that we first find an electric firing apparatus forming part of an army equipment. In this case the outfit was of a somewhat clumsy nature. A conveyance, in shape and size much resembling a baker's barrow, contained a monster horse-shoe magnet, and it was the sudden disruption of its armature from this magnet which generated the spark to fire the fuse. A few years afterwards, this ponderous conveyance gave place to a neat little mahogany box about a foot cube, which contained half a dozen small but powerful magnets, in the field of which the armatures were made to revolve with exceeding celerity; and it is by means of such an apparatus that to-day we are enabled to fire a score of charges at a time, the wires branching off from the instrument to a distance of a hundred yards or more. But, nevertheless, we have yet to devise, it seems, an efficient exploding apparatus capable of igniting low and high tension electric fuses.

As everybody knows, it is by reason of electricity being employed to fire explosive charges that torpedo warfare has of late attained to so important a position. In the Whitehead, or fish-torpedo, the electric fluid, it is true, plays no part, but this is the only notable exception. In the floating torpedo, the moored torpedo, and the spar-torpedo, electricity is the life and soul; at one moment the machine is but a floating buoy or sunken impediment, the next it is transformed into a terrible volcano. A feeble current of electricity flashing along the wire has on the instant sufficed to bring about the fatal change.

Passing from torpedo warfare and the recent attempts that have been made to turn electricity to account in the construction of self-steering launches, we come to a scarcely less important matter, that of firing guns by the electric spark. Not only are guns at proof and those under experiment so ignited, but on board the modern ironclad it is the custom now-a-days to fire broadsides in this wise also. By leading wires from every gun to one point, which is specially adapted for observation, the double advantage is secured of bringing about the firing at the most opportune moment, and of securing a simultaneous discharge. Some experiments made in Germany have proved beyond doubt that an armor plate struck instantaneously in this way by several shot, may be effectively broken up, whereas the ordinary broadside fire, brought about by gunners at word of command, is incapable of doing so. The wires may be led into an observing tower, or half way up the mainmast if need be, and here the firing officer can calmly concert his measures undisturbed by the smoke and noise, and bustle going on below him. He is provided with proper sights, and the guns being laid in accordance with his orders, he can watch the opportunity for firing as well as if he had his eye to the weapons themselves.

Finally, we have the use of the electric light in warfare. It is the most recent application of all this wonderful agent, and we should hesitate to say how extensive may hereafter be the employment of electricity in this connection. In the Franco-German war, the first use of this powerful source of illumination was made by the French engineers, and from the forts around Paris the electric rays were made to sweep in all directions, to watch for hostile troops engaged in the operation of mining. Bodies of soldiers upwards of a mile distant could be plainly seen by the vivid light of the electric lamp, and working parties were frequently compelled to abandon their object in the presence of this powerful detector. As a means of discovering the approach of torpedo launches at night, the electric light will obviously be of value, and already a trial of it has been made in several of Her Majesty's ships. The Alexandria, the flagship of the Mediterranean fleet, is provided with an electric lamp, worked by one of Wilde's powerful machines, so that the efficiency of the apparatus may be practically tested. Experiments, however, have already shown what the electric rays are capable of doing, and a low torpedo-launch cannot approach within a thousand yards without detection, while if painted of a neutral grey, so as the better to escape observation by day, the vessel, it appears, is all the more perceptible under electric illumination. Steamers, we are told, are peculiarly liable to be detected by an electric lamp, since the rays are reflected by the steam and smoke as effectively as if the latter were a solid screen. How valuable, too, the electric light on board ship must prove for signalling purposes may be gathered from the fact that the Dungeness light, which was the first one of an electric nature constructed in this country, can be seen on a clear night at a distance of thirty miles with all the brilliancy of a star of the first magnitude.

ELECTRIC NAVAL LIGHTS.

CAPT. S. B. LUCE, United States Navy, commanding the flagship Hartford, has been conducting a series of experiments with a patent magneto-electric machine and automatic lamp, which it was proposed to introduce in the Navy for distant signaling at night, for detecting the approach of boats, and signaling in a fog. The machine used consists of four permanent magnets coiled with large insulated copper wire. The armature is composed of cast iron, having 50 small magnets—25 on each side. These are coiled with fine insulated copper wire, each small magnet being in electrical connection with those on both sides of it; they are also connected with the commutator. This armature is attached to a horizontal spindle passing between the two pairs of magnets. The armature moves in a vertical plane. The spindle at each end has a band pulley by which motion of revolution is received from a driving engine. The commutators are peculiar, consisting of a skeleton brass frame around a portion of the spindle. This frame is composed of 100 divisions or bars running parallel to the axis of the frame and separated from each other by an interval of 1-20 of an inch. To each bar are attached the ends of two wires. The current is taken from the commutator by copper wire brushes, two for each one, thence to the binding screws.

The lamp used differed little from the ones in ordinary use, the distance of the carbon points being regulated by force of gravity and small electro-magnets. The direction of the current may be controlled by a switch at the bottom of the lamp. The lamp requires but little attention and is self-adjusting.

The driving engine was a Sewell's pump, connected with the auxiliary boiler. A steady light was produced without interruption for three and a half hours, when it was necessary to stop and replace the carbon points. As the steadiness of the light depends upon the regularity with which the engine runs, it is proposed to provide the engine with a governor. The posts of the machine showed but little wear and tear at the end of the trial. Signals by means of flashes, using a reflector having a screen over its face, with a sliding hood covering an aperture two inches in diameter through which the flashes were made, were read at a distance of eight miles on a bright moonlight night, and could have been seen at twice that distance. Other experiments made without a reflector, using a circular screen to interrupt the light, were equally successful. There was no opportunity for trial on a stormy night, or in foggy weather.

In a trial with the Coston signal, the electric light was readily discovered at a distance of 13 miles, while the signals by the Coston's lights could not be distinguished, only an occasional color being seen. At greater distances than 13 miles the electric light becomes less distinct; and at 15 miles it was dropped, being picked up again at 12½ miles. Fire rockets were used at these distances, only one of them being seen. It was found that, although the machine was well adapted to produce a clear, steady light, when geared to a good engine, and was valuable for distant signaling, yet on account of its expense and limited sphere of use in the Navy in time of peace, its further introduction, except in special cases, could not be recommended. The machine used on board the Hartford was furnished for trial free of expense, and has since been purchased for use in the Navy.

TREES AS ELECTRICAL CONDUCTORS.

By M. TH. DU MONCEL.

FIRST.—The trees are all more or less conductors, and their conductivity depends upon the quantity of liquid which they contain.

SECOND.—The roots of a tree play the role of electrodes, and their efficacy as agents of transmission is proportionate to the conductivity of the tree and to its development.

THIRD.—The value of the resistance of a tree through its leaves, supposing that good contact is only made upon some of them, varies from 2 to 400,000 kilometres of telegraphic wire (in round numbers). That of its trunk, for trees nearly full grown, at a height of 7 or 8 metres, is very rarely higher than 3,000 kilometres, down to the ground, and varies from 2,000 to 7,000 kilometres between small metallic electrodes.

FOURTH.—There is not, in consequence, much to be afraid of from contact of telegraph lines with the leaves of a tree, for it is from the insulators covered with smoke employed upon these lines that the resistance becomes low.

FIFTH.—The resistance of ordinary buildings being about from sixteen to twenty times greater than that of trees, we can believe that houses surrounded by trees could receive from them a protection against thunder-storm—at least, supposing that the height of trees was not less than the height of the houses; but as it rains in time of storms, and the rain, in covering the trees and houses with a wet film, lessens the difference of conductivity which they may possess, the protecting effect of trees can only result in the preponderance of their height.

ELECTRICITY APPLIED TO COTTON MANUFACTURING.

In the complicated machinery employed for cotton manufacturing, certain effects exist which cause much trouble to the manufacturer; thus the "spoons" in the drawing-frame very often get out of order, and allow the machinery to run without its proper complement of threads or cotton "sliver"; while the "single" of the intermediate-frame is a more defective point still. In the intermediate-frame the cotton begins to approach that stage of completion toward yarn when a single end being missed in the composition of the yarn spoils the work. Everything depends upon the reliability and care of the workman to pull off the spoiled work. This is not always done, and it is this defect which led to the application of thought on the part of Mr. Bullough and Mr. Smalley, his commercial traveler, which has resulted in the application of electricity to cotton manufacturing machinery, and for which a prize was given at the American Centennial Exhibition.

Its employment on a large scale is at the Victoria Cotton Spinning and Manufacturing Company, Limited, Rishton, where the machinery is in operation. In the cardmaster's cabin is fixed a small magneto-electro machine, from which electricity is generated by a miniature coil of insulated copper wire revolving in the sphere of six or eight permanent magnets. Attached to the two poles of this source of electricity are two copper wires, conveying one positive and the other negative electricity to the carding engine, drawing, or intermediate-frame to be operated upon. At the end of each machine is a small but powerful electro-magnet, which is the direct medium for obtaining the stopping motion. For the back-stop motion of the drawing-frame a long bottom