still not extinct, the forty-two working hours per week were given almost exclusively to classics. In any really good school these hours have now to hold at least an equal average of classical learning, beside English and French, sometimes German, as well as mathematics, geography, history, &c. The problem of doing much in the same time as used to be spent in doing little, is, to a great extent, solved by mere improvement of method. The old classical teaching was so clumsy and repulsive, that its results, so far as it suits the new system to strive for them, may be obtained in one quarter to one half of the time formerly allowed. In addition to this, there are some products of the old system which the new must almost perforce abandon. Latin verses demanded a minimum of ten hours per week out of a total of forty-two working hours. Now, it cannot be too clearly impressed on the minds of persons interested in education, that the time required for giving a well-grounded acquaintance with elementary science is four hours per week.

Second, it is often thought by parents that science, while valuable to boys about to pass certain examinations, or to enter certain professions, is merely of the nature of an "extra accomplishment," not affecting the rest of the educational course. Nothing can be less true. It would be nearer the fact to say that the especial importance of science-teaching in schools, is in its serving beyond any other known means to open children's minds, to stimulate their reasoning powers ; not to teach dull formulas, learnt by a *memoria technica*, but to start boys and girls on a course of realising and comprehending life and nature. This statement (as is right with a statement concerning physical science) is one to be tested by direct experiment. Take a class of children brought up to learn Latin and Greek, Geography and History, and Mathematics, but on whose minds the idea has scarcely dawned that these matters concern real places and people and things. Unfortunately, nothing is easier than to find such classes, grinding on, year after year, in the fond belief that, because school work is dull and toilsome, it must be profitable. Now, let an intelligent teacher give these unlucky children an elementary science lesson : for instance, how it is that bodies fall, what causes summer and winter, how the thermometer does its work. In half an hour's time it will be seen in the very faces of the children, that the lesson, independently of its value for itself, has actually repaid the time spent on it, in the newly-aroused attention and reflection it has gained for other studies. It is no exaggeration to say that four hours of really live teaching in science fully pays for itself in the improved quality of the rest of the week. For this cause it is that science is not made optional at the Taunton School. It is taught simply, and with inexpensive apparatus; but every boy is required to collect his own specimens, to perform his own experiments, and to show at every step that he knows what he is doing.

It seems to us that in some few of the really enlightened public schools, such as that we are now writing of, nearly the highest ideal of training has been attained to, compatible with the present habits of English life. When boys, fresh from an intelligent governess at home, or from a ladies' preparatory school of the best sort, go through the full school course from 11 to 17, working steadily on without flagging and without strain or hurry, at an education which they understand to be the direct and purposeful preparation for active business or professional life, such boys start with success in their hands. It is the result of such education that the professional "crammer" tries to simulate when he endeavours to make 12 months' over-work, ruinous to body and mind, produce at the examiners' table the semblance of seven years of steady mental growth. The examiner knows better, and the real business of after-life shows before many years are out the difference between cram and real education.

THE SCIENCE OF EXPLOSIVES AS APPLIED TO WARLIKE PURPOSES

II.—RECENT IMPROVEMENTS IN THE MANIPULATION AND FIRING OF EXPLOSIVE CHARGES

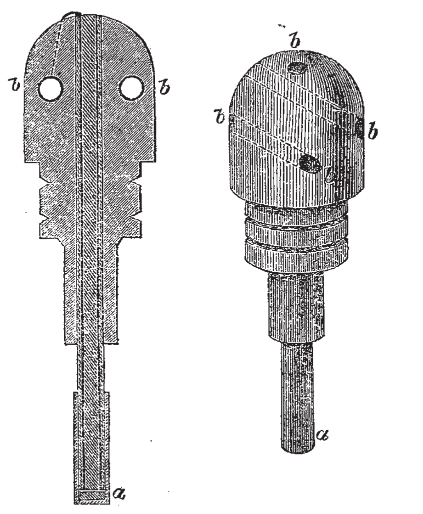
As we have already shown, the employment of explosive charges is a branch of warfare to which the attention of military engineers has been directed for some time past. For warlike purposes, as also for the destruction of wrecks or other submarine obstructions, explosions have been frequently applied in earlier times, but the methods resorted to for igniting them were, as may be supposed, exceedingly crude and primitive ; sometimes a clock-work arrangement was used, sometimes an encased slow match, and, occasionally, explosion was brought about by means of heated shot dropped down a metal tube. As would naturally be inferred, the difficulties and the frequently unsatisfactory results attendant on explosions of this kind rendered their profitable application a matter of considerable doubt, and few successful records of their employment are to be found.

During the past few years our knowledge of the science of explosives has been considerably enlarged. Not only has the subject of igniting charges been studied to such an extent as to form, at the present time, almost a science of itself, but the nature of the combustible material has likewise been changed and improved ; and military and naval engineers have thus been placed in possession of a source of power, of which we hardly know whether to admire more its unlimitable force, or its wonderful plasticity.

The first practical application of electricity to igniting gunpowder, although such a proceeding was considered possible both by Franklin and Priestley, was not made until about thirty years ago, when some French military engineers employed a voltaic battery as a means of explosion. The method used by these officers was the simple and well-known one of connecting the two conducting wires by a thin platinum thread, the resistance offered to the passage of the electric current by that metal causing its temperature to be raised to a degree sufficient to ignite any charge of gunpowder in contact with it. This manner of applying the electric current as a source of heat is both simple and practical, but it frequently lacks, besides other qualities, the essential virtues of certainty and instantaneity, and it was for this reason that further investigations of the subject have been from time to time carried on. Among others, Colonel Verdu, a Spanish officer, made some progress in the matter, and was successful by the aid of a Ruhmkorff induction coil in exploding several charges simultaneously. This officer's first attempt was to fire the gunpowder by simply allowing a powerful spark to pass from one pole to the other of two wires imbedded in the charge ; he found, however, that ignition in this manner was by no means to be relied upon, but that by covering the poles with fulminate of mercury, a substance more readily inflamed, the desired result was readily secured. Some successful results were also obtained about the same time by employing a particular electric fuze, known as Statham's.

A few years later, in 1856, Sir Charles Wheatstone and Mr. Abel devoted considerable time to the prosecution of further researches, and each of these gentlemen contributed an important discovery, which had the effect of perfecting this interesting application, and rendering it a practical and valuable aid to military science. The employment of electricity induced by magnetism was suggested by Sir Charles, who, after some preliminary experiments, constructed an exploding instrument in which the electricity was created by the rapidly revolving armatures of a compound magnet; and the successful application of this machine was effected through the agency of an electric fuze, devised by Mr. Abel, and of which a sketch is here given.

The chief condition to be fulfilled in the construction of an electric fuze was the preparation of a compound which should combine high conducting power with great susceptibility to ignition, and this, after patient and renewed investigation, was ultimately accomplished. A mixture of subphosphide of copper and subsulphide of copper with chlorate of potash afforded a composition which was exploded with perfect ease and certainty by a current from a small magneto-electric machine, a larger apparatus of the same kind being capable of igniting twenty or thirty of these fuzes almost instantaneously. The means at command afforded, under certain circumstances, by a Wheatstone Exploder and the Abel fuzes, can scarcely be valued too highly, and it has been stated that the Governor of Malta, if provided with these valuable aids, might by himself conduct the defence of Valetta Harbour from his own drawing-room window. This may indeed be a vainglorious boast, but as a matter of hard fact we may mention that the Time Guns at Newcastle, Edinburgh, and other northern towns, have been ignited for some years past from Greenwich Observatory, through many hundred miles of wire, by an Abel fuze with infallible precision and certainty.



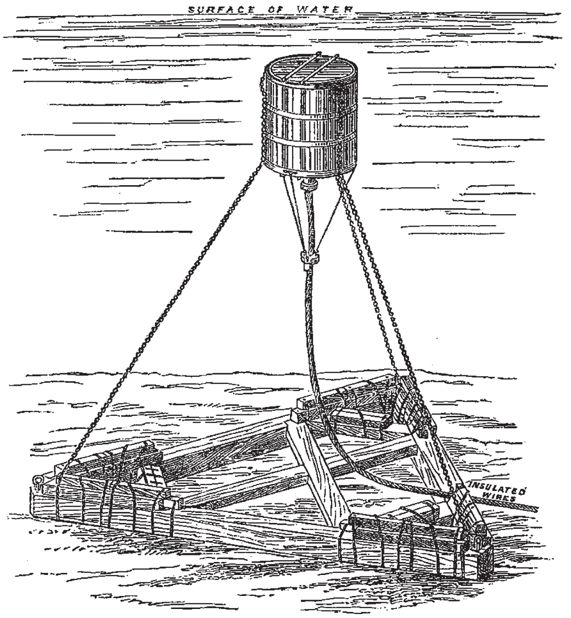
Section *Perspective view*

ABEL FUZE

a, cap of composition, into which the two poles of the wires are fixed.
bb, metal eyes for connecting the insulated wires with the fuze.

Since the date of these improvements, much further experience has been gained in regard to the most suitable description of apparatus to serve as exploders, frictional and dynamo-electric machines, as also miniature voltaic batteries taking the place of the Wheatstone instrument; the electric fuze has however stood its ground in spite of many rivals, and still continues to be used for the ignition of explosive charges, including torpedoes and submarine mines.

As mentioned in the first part of this paper, the Americans employed electricity for firing some of their torpedoes, but they are by no means the only nation who has done so. In the Austro-French war, when the capture of Venice was feared by the Austrians, a very ingenious system of electric torpedo defence was organised at that seaport by a distinguished officer of Engineers, Colonel von Ebner. A camera obscura was erected in proximity to the harbour in such a manner that the horizontal table of the instrument reflected the whole area of the channel. Large wooden cases, each containing 400 pounds of gun-cotton, were lowered at certain fixed distances into the water, and as these disappeared one by one, a small row-boat described at the time a circle round the spot to indicate the extreme confines of the distance at which the torpedo would prove effective; an observer was stationed in the camera as these operations were going on, carefully watching their reflection in the instrument, and as each torpedo disappeared into the water, he marked with a pencil its precise locality on the white table, tracing also the ring formed by the row-boat. Thus a series of circles was formed in the camera, each of which was marked with a distinctive number, and in this way a miniature, but exceedingly correct, plan of the obstructions in the harbours was prepared; the wires in connection with the torpedoes were afterwards led up into the camera obscura and furnished with numbers to correspond with the circles. By means of this arrangement a sentinel stationed in the apparatus might at once explode any one of the torpedoes, as soon as he observed the reflection of an enemy's ship pass within the limits of the circles marked upon the table. The channel itself was quite clear of any suspicious buoys and beacons, and appeared to the enemy wholly free from obstruction.



GUN-COTTON ELECTRIC TORPEDOES CONSTRUCTED AT VENICE IN 1859

In our own country the question of torpedo warfare has for some years past been the subject of study and investigation, and a system has lately been elaborated which owes its origin mainly to Mr. Abel, the scientific referee of the War Department, and which is at once so simple and practical that it cannot fail, in the future, to form a new and interesting branch of war science.

Mechanical torpedoes present so many serious defects (as for instance their liability to get out of order, the risk incurred in mooring them, and the danger they involve, when once sunk, to friend as to foe), that all idea of their employment was at once abandoned by our authorities, and the investigations confined to the devising of efficient electric torpedoes. Of these many descriptions have been designed, but the two kinds held most in favour are the self-exploding instruments, and those which are capable of sending a signal when touched by a passing vessel to indicate the proper time of effecting their ignition from the shore.

The self-acting electric torpedo is of very simple construction, the following being a general outline of one form of it. An Abel fuze is fixed in the torpedo, one pole of which is connected to a constant battery on shore by means of an insulated wire, while the other pole is in communication with an insulated metal plate fixed inside a pivot in the upper part of the machine. Upon this pivot swings a moveable hood, or cage, and the latter, though not affected by the motion of waves, will, upon being struck by a passing vessel, swerve round and come into metallic contact with the insulated plate above mentioned, thus completing the electric circuit with the earth, or, more strictly speaking, with the water. As will be readily perceived therefore, in this case, a single wire only is needed to connect one element of the battery with the fuze, the other element being of course allowed to pass to earth. In the other description of torpedo, a *circuit closer* of the same construction is used, and this on being struck furnishes a signal to the shore, whence a sentinel at once explodes any charge, or charges, which may be in the vicinity of the submerged machine. When disconnected from the batteries, these torpedoes naturally cease to be a source of danger, and herein lies one of the most valuable qualities of the electric exploding method. If considered desirable, the machines need in fact never be put into an active state except in a case of imminent danger. Thus, if a fleet of friendly vessels were pursued by hostile ships, the sentinel on the look-out would not connect his batteries until the former had passed over the torpedoes, and when the machines were well left behind, by simply turning a switch arrangement he would be enabled instantly to close the line of defence, and set up a formidable barrier not to be passed with impunity.

In the simplest form of electric torpedoes (such as the majority of those used in America) where ignition is brought about by simply sending a current through the circuit, one wire leading from the torpedo to the battery and another to earth, the employment of the Abel fuze presents one very important advantage. Explosive machines fitted with these appliances may, when in position, be tested at any moment to ascertain their state of efficiency, and the operator is thus made cognisant of the serviceableness or otherwise of his apparatus and batteries; this operation is effected by simply passing a weak current through the wire and fuze, which although insufficient to produce ignition, is yet powerful enough for the transmission of signals.

Where a large number of torpedoes are grouped together, it is found undesirable, except in special cases, to use either the frictional or dynamo-electric machines for exploding the fuzes, for the reason that a current sent from one of these instruments to ignite a specific charge, induces similar currents in adjacent wires and at once causes a wholesale explosion. Constant voltaic batteries or piles are therefore generally resorted to, and the construction of simple forms of these from rough, handy materials (some sheet zinc and copper, a few pieces of wood, and a little vinegar and common salt) is a favourite occupation among sailors who have received elementary instruction in this system of warfare.

By employing in torpedoes, instead of powder, a heavy charge of gun-cotton, and exploding this by the newly-discovered method of detonation, a force is developed which, it is no exaggeration to say, would prove fatal against a vessel of the strongest and most cunning construction.

NOTES

WE are glad to be able to announce that the arrangements for the Eclipse Expedition are progressing very rapidly and satisfactorily, and that there seems every chance of everything being done which can insure success. In response to their circular, the Council of the Royal Astronomical Society have received upwards of sixty applications from observers anxious to help in an examination of the phenomenon. It is proposed that, if possible, there shall be two expeditions; one to Spain, the other to Sicily. The desirability of this is obvious, as the chances of bad weather are thereby considerably reduced. Unfortunately, those who know Sicily well state that the region to be visited is so brigand-ridden that other precautions besides those usually employed in Eclipse Expeditions will be desirable. The Italian Government, which will also, we believe, send an expedition to Sicily, will, doubtless, look to this. The French Expedition will observe in Algeria.

OUR Berlin Correspondent writes that Baron Liebeg has recovered from his recent severe illness.

WE regret to learn that Mr. Archibald Geikie, who recently left England to investigate the Geology of the Lipari Islands, was prostrated by fever as soon as he arrived there, and is in such a weak state of health, that he has been ordered back to England.

AN Imperial decree has been published in Paris, ordering that the Minister of Fine Arts shall henceforth bear the title of Minister of Literature, Science, and Art, and also that his department shall include the superintendence of the Institut de France, Academie des Sciences, the libraries, learned societies, and the like. When shall we get *our* Ministry of Literature, Science, and Art?

THIS will be a week of Anniversary Meetings. On Monday the annual réunion of the Royal Geographical Society will be held at one o'clock, and of the Victoria Institute at four; and on Tuesday the Linnean Society will celebrate its anniversary at three, and the Ethnological at four.

THE *British Medical Journal* states that the chair of Physiology, in the University of Prague, vacant by the death of the celebrated Purkinje, has been filled by the appointment of Dr. Hering, of Vienna. It was offered to Professor Helmholtz, who, however, preferred to remain at Heidelberg.

AT the annual meeting of the Newcastle Natural History Society on the 10th inst., a discussion took place on the present position of the Alder Memorial Fund. It was stated that while the original intention was to raise 600*l*. to carry out the memorial scheme, only about 300*l*. had been collected since March 1867. After some discussion, it was agreed to make efforts to raise an additional 100*l*., which was considered a sufficient sum to carry out the objects proposed.

AT the recent general examination for women, held by the University of London, five passed in the "Honours" Division and four in the First Division. Of the seventeen candidates, five were from the Cheltenham Ladies' College, all of whom were successful, two being placed in the Honours and three in the First Division.

MR. J. W. ELWES, of King's College and the London University, and Mr. W. T. Sollas, of the Royal School of Mines, have been elected (equal) Exhibitioners in Natural Science, at St. John's College, Cambridge. There were eight candidates; the examiners being Prof. C. C. Babington (Botany), Prof. Humphry (Physiology), Prof. W. G. Adams (Physics), Mr. Bonney (Geology), and Mr. Main (Chemistry).

A RECENT number (94) of the German series known as "A Collection of Popular Scientific Treatises, edited by R. Virchow and Fr. von Holtzendorff," is a lecture on the Glacial Period (*Die Eiszeit der Erde*), by Alexander Braun. It gives a clear and concise history of the observations and arguments by which geologists have been led to the conclusion that a lengthened period of extreme cold overspread the greater part of Europe before the commencement of the historical epoch.

MR. C. P. SMITH reprints, as a separate publication, an epitome of a paper read before the Brighton and Sussex